8

SPECIAL TOPIC

Technology assessment and future warfare: The Good, the Bad, and the Ugly

Technikfolgenabschätzung und die Zukunft der Kriegsführung: Die Guten, die Bösen und die Hässlichen

Edited by Karsten Weber, Markus Bresinsky

https://doi.org/10.14512/tatup.7286

TATuP Zeitschrift für Technikfolgenabschätzung in Theorie und Praxis
Journal for Technology Assessment in Theory and Practice

oekom science

INTRODUCTION

The Good, the Bad, and the Ugly: The origin of the Special topic

Karsten Weber*,[1], Markus Bresinsky[2]

Abstract · In this introduction to the Special topic on future warfare from the perspective of technology assessment (TA), guest editors Markus Bresinsky and Karsten Weber describe how the idea for the Special topic developed, what contributions they expected, and why it seems important that the TA community reflects on its role in assessing the impacts and repercussions of weapons technology on individuals, societies, and the environment. This reflection on its own role, the authors argue, must be informed by the current state of global affairs. Regardless of whether TA is seen as an honest broker or an issue advocate – it cannot stand aside and ignore the many challenges posed by rapid change, or even massive deterioration, in international relations. In order to reflect on its own role, it must team up with scientists from other disciplines and practitioners from all professions.

The Good, the Bad, and the Ugly: Über die Entstehung des Special topic

Zusammenfassung · *In dieser Einleitung zum Special topic über die Kriegsführung der Zukunft aus Sicht der Technikfolgenabschätzung (TA) beschreiben die Gastherausgeber Markus Bresinsky und Karsten Weber, wie die Idee zum Special topic entstand, welche Beiträge sie erwartet haben und warum es ihnen wichtig erscheint, dass die TA-Community ihre eigene Rolle bei der Bewertung der Folgen und Auswirkungen von Waffentechnologien auf Individuen, Gesellschaften und die Umwelt reflektiert und sich dabei am aktuellen Weltgeschehen orientiert. Ob die TA als honest broker oder als issue advocate verstanden wird – sie kann nicht einfach daneben stehen und die vielen Herausforderungen ignorieren, die der rasche Wandel, um nicht zu sagen die massive Verschlechterung, in den internationalen Beziehungen mit sich bringt. Um ihre eigene Rolle zu reflektieren, muss sie mit Wissenschaftler*innen aus anderen Disziplinen sowie mit Praktiker*innen aller Berufsgruppen zusammenarbeiten.*

Keywords · *technology assessment, warfare, military technology, dual use, politics*

This article is part of the Special topic "Technology assessment and future warfare: The Good, the Bad, and the Ugly," *edited by K. Weber, M. Bresinsky. https://doi.org/10.14512/tatup.7286*

A somewhat personal note

This introduction to the Special topic at hand does not aim to simply describe its main theme and to summarize the contributions. To begin with, the contributions speak for themselves and don't need interpretation. But more importantly, given the state of global affairs, for us (Markus Bresinsky and Karsten Weber) as guest editors of the Special topic it seems mandatory to reflect on the emergence of the ideas and expectations regarding the contributions to this Special topic, in order to better contextualize the contributions that were actually received, but also to understand why the submissions that we were originally expecting did not materialize. With this introduction we also aim to think about the contributions that the technology assessment (TA) community might need or, better to say, should have provided in order to be able to inform public and/or political debates on the technological implications and impacts of the new security situation in Europe and worldwide. This situation is characterized by global challenges to institutions of collective defense (NATO) and international crisis management (UN, EU, or coalitions of the willing) as well as increasing risks of international armed conflicts as well as interstate and civil wars. At the same time the impact of technology on warfare has tremendously altered the way these conflicts are conducted.

We are strongly convinced that the European TA community should have a voice in often frantic, emotional, and sometimes poorly informed debates about the weapons that Europeans in

* *Corresponding author: karsten.weber@oth-regensburg.de*
[1] *Institute for Social Research and Technology Assessment, Ostbayerische Technische Hochschule Regensburg, Regensburg, DE*
[2] *Department of International Politics and Social Sciences, Ostbayerische Technische Hochschule Regensburg, Regensburg, DE*

https://doi.org/10.14512/tatup.7305
Received: 22. 01. 2026; revised version accepted: 25. 01. 2026; published online: 23. 03. 2026 (editorial peer review)

general and the Germans in particular allegedly would need to defend themselves against any external threats or meet the ambitions of strategic promises given to allies. When public debates take place, in which the acquisition of (tactical) nuclear weapons are discussed, there is an urgent need for a rational voice that points out the effects of their deployment (Jacobsen 2024), but also of the mere construction and possession of such weapons, and that assesses the political and social consequences as well as the expected costs of their acquisition, not only in terms of money, but also in terms of other resources.

Weapons and warfare as topics of science in general and technology assessment in particular never really took roots.

Developing the Special topic

When we pitched our idea for a Special topic of TATuP on the future of warfare from a technology assessment point of view we were met with affirmation, but also with some reservations and even dismissal.

In science, there is no problem with disagreement, quite to the contrary, but in this case, it was not only disagreement but something more fundamental. In our pitch, and later in the call for papers, we speak about the "the Good, the Bad, and the Ugly". Surely, this reference to a 'Spaghetti Western' filmed in 1966 seems a bit odd, particularly to younger scholars, but first, we thought that a bit of irony could help to deal with such serious matters, and second, we explained it: TA itself, and surely many of its methods are offsprings of the Cold War and the thinking about (nuclear) strategies and (nuclear) deterrence. Thomas Schelling's work "Arms and influence" (1966) and of course Herman Kahn's famous and at the same time notorious book "On thermonuclear war" (1961) come immediately to mind. These and many other scholars introduced to a wider scholarly audience game theory, scenario techniques, and many more methods that now are being used in TA.

Not only did the Office of Technology Assessment (OTA) employ these methods; among its many assessment projects one will find, for instance, a comprehensive study concerning the "The Effects of Nuclear War" (OTA 1979) of the size of a large-scale nuclear attack on U.S. military and economic targets. At that time in history, the assessment of the impact of weapons (of mass destruction) was not only considered indispensable, but good, since it helped, at least in some ways, to prepare for the worst, but first and foremost, it helped to inform politicians and the public about the utter destruction (not only) of all belligerent parties that would have to be expected if an all-out nuclear exchange would actually take place. Therefore, we call this phase of TA thinking about (future) warfare 'the Good.'

But such assessments are far from being first. In his book "The future of warfare: A history," Lawrence Freedman (2018, p. 18, italics in original) mentions that "[i]n 1902 he [H. G. Wells] also issued a manifesto, *Anticipation of the Reaction of Mechanical and Scientific Progress on Human Life and Thought*. This was the basis for his claim to be recognized as the first exponent of futurology. It included a chapter on 'War in the Twentieth Century'." Thus, if one considers futurology as a precursor of technology assessment, TA has always been concerned with the nasty business of war. It has to be stressed that the OTA conducted many more assessment studies concerning weapons and warfare, for instance about "Directed Energy Missile Defense in Space" (OTA 1984) and "The Defense Technology Base: Introduction and Overview" (OTA 1988), to name but two. Particularly the last-mentioned report might ring a bell because in light of the technological dependency of European countries regarding military capabilities, weapons technology as well as European parochialism, there are quite similar public debates going on currently (e.g., Meijer and Brooks 2021). In Europe, however, weapons and warfare as topics of science in general and TA in particular never really took strong roots, although there are some studies concerning the impacts of certain types of weaponry. In Germany, some universities formulated and put into effect so-called 'civil clauses' (in German: 'Zivilklausel') which are designed to prevent military-related research and development to take place at these universities (Altmann et al. 2025; Bornmüller 2023; Rieck 2024). It might be a bit over-exaggerated, but a bad odor seems to stick to military-related research and development. Or, to put it less colloquial, such research is often considered to be morally wrong or bad (for Germany, acatech 2025); that's why we call this phase of technology assessment thinking about (future) warfare 'the Bad.'

We understand that many of the reservations and rejections of our pitch might be linked to the line of thinking just outlined. It is to be respected that individual scholars do not want to be involved in any kind of military-related research; there can be no doubt about that (given this rather wide-spread reluctance, it might be surprising that studies in military history are prominent in Germany; similarly, peace and conflict studies are established and well received in the German scientific community). However, if one thinks this position through to its logical conclusion, then the only possible result is that science, and thus TA, becomes almost impossible. There is most likely no single field of knowledge that cannot be used for military purposes. Not only in technology assessment but in science in general, scholars must be aware of the possibility of dual use – and this is not only true regarding technology, but also, for example, for medicine, psychology, or sociology. It is by no means merely a coincidence that the Joint Committee on the Handling of Security-Relevant

Research of the German Research Foundation, DFG, and the German National Academy of Sciences Leopoldina does not draw any difference between scholarly disciplines in this regard. Consequently, if not for other considerations, even if one were convinced that military-related research in general and military-related technology assessment in particular is a nasty business better to be avoided, unfortunately it is still necessary (Lavoy et al. 2000) – today, given the current state of global affairs, possibly more than ever. Hence, we name this phase of TA thinking about (future) warfare 'the Ugly.' To some extent, that is what Martina Philippi argues for in her research article "TA in der 'Zeitenwende'", when she reflects on topics that were always relevant in TA, but which take on a new urgency with regard to possible future (and, of course, current) wars: How does TA respond to actors who deliberately act against the common good – for example, in inter-state disputes or in conflicts between different stakeholder groups? This becomes particularly virulent in the context of dual-use technologies, including research and development. Whether or not one agrees with Philippi's talk of the 'Anthropocene', given the blurring boundaries between civil and military technology, more stakeholders need to ask themselves and face up to the question of what kind of world they and we want to live in.

As if there were not sufficient motives to publish a Special topic on the matter already, there are unfortunately currently, and likely for the foreseeable future, far more urgent and probably also more practically relevant reasons to consider the topic of future warfare from a TA perspective.

Why it matters, what was expected, and what happened

It is very likely that many, if not most authors, whether of scholarly articles or belletristic texts, would at least like to have once the opportunity to begin a text with a phrase like this: 'When we talked about the future, we didn't expect that in a few months we would live in a completely different world. But here we are; everything has totally changed.' Well, be careful what you wish for. When we started to plan for the TATuP Special topic at hand in the midst of 2024, we certainly didn't expect that the world would change as dramatically as it did. It is true that already at that time it was rather unlikely that Kamala Harris was going to win the U.S. presidential election. But that Donald Trump would win the election rather clearly and that at the same time the 'Grand Old Party' would win the majority in both chambers of the Congress wasn't very likely either.

Yet, in 2026 as well as in the coming years we must face reality as it is. There is no real opposition to Donald Trump's reign. In the months following his inauguration as the 47th president of the United States he dismantled almost all political and judicial checks and balances that could limit his authority and power. Neither the Democrats as the party of opposition nor the Republicans show any sign of resistance that could make a difference. Even if there are objections, or some kind of resistance to his political decisions, policies, or his greedy and abusive behavior, Donald Trump uses all the power of all three branches of the American government, the executive, the legislative, and the judiciary – obviously in complete disregard of the separation of powers – to prosecute and silence his critics. He now even ponders to prevent the midterm elections from taking place. What the U.S. currently experiences is a coup d'etat in slow motion.

There is most likely no single field of knowledge that cannot be used for military purposes.

One could now argue that although all that is happening in the U.S. is deeply regrettable, given the human suffering as well as the political, economic, and societal fallout in the U.S. and abroad, but that from the point of view of TA in general and regarding this Special topic in particular, all this is of no concern. Yet, this would be utterly mistaken. Donald Trump's political decisions severely affect science: Climate and environmental research, medicine, and the humanities at large, as only three examples among many others, are cut off from funding, researchers are laid off, and scholars are threatened and silenced. When science is prevented from doing its work unimpeded, the most important and irreplaceable foundation of technology assessment is lost since it needs independent and objective research and researchers, not mouthpieces of the government.

Yet, even if one were willing to admit that this is true one could still argue that this development is of no concern regarding the issues discussed in this TATuP Special topic. But again, this would be outright mistaken since there are eminent challenging topics of technology in defense. Current developments in conducting armed conflict demonstrate the role of technological innovations. Additionally, long-range weapon systems, missile defense systems, unmanned vehicles, drones, not to mention cyber and disinformation campaigns, have taken politicians, other decision-makers, and the public – at least to some extent – by surprise, which gives a taste of the prospective implications of a lack of TA concerning future warfare and its various impacts.

This Special topic was intended to initiate a self-reflection of the TA community in the context of what German Chancellor Olaf Scholz had called the "Zeitenwende" (Scholz 2022), or post-postwar period. Just as the moral and political certainties of the post-1990s period have been undermined by the Russian Federation's attack on the Ukraine, we thought it necessary for

https://doi.org/10.14512/tatup.7305

the TA community to reflect on whether the new geopolitical conditions can justify or even demand a (partial) reorientation of its own activities, whether such a turn should be rejected, or whether this reorientation has already taken place, but under different labels than technology assessment – as the submissions to the Special topic might indicate. It is, however, most likely that we would have conceived the main theme of the Special topic quite differently if we had known what happened next.

If technology assessment is considered to be an honest broker of information concerning the various repercussions of technology, then there are a multitude of good reasons to assess the impacts of weapons, or ways to remedy these impacts.

Since we didn't have the benefit of foreknowledge, we expected contributions to the Special topic from a more historical and self-reflexive point of view, for example about the relationship of science and the military in the U.S. (Jacobsen 2016) as a kind of enabler of TA in the form of institutions like the RAND corporation (a U.S. research and development think tank for public military consultancy). In particular, we expected studies on funding policies, and comparative studies that examine what this relationship looks like in Europe and whether it exists at all (Newlove-Eriksson and Eriksson 2023). We also hoped for contributions that would outline a possible role of TA regarding future warfare – given the number of scholarly articles and essays on civil clauses for universities we expected determined pleas for a civil clause for technology assessment or, just to the contrary, a resolute call that the TA community should support the strengthening of the defensive capabilities of European countries. Nothing like this materialized, at least not as a contribution to this Special topic – instead, one can find such debates in newspapers like Frankfurter Allgemeine Zeitung where two legal scholars argue for more defense-related research at German universities.

We find this silence disturbing, Markus Bresinsky probably for other reasons than Karsten Weber. Without going into too much detail, at least this much should be said here: If TA is to be considered an honest broker of information concerning the various repercussions of technology, then there are a multitude of good reasons to assess the impacts of weapons, or ways to remedy these impacts. With this it is not meant that technology assessment should take an active role in weapons development; it means, among other things, that TA restates all the insights of former studies concerning the impacts of weapons of mass destruction in a densely populated region like Europe. Jürgen Altmann argues in his article "Military technology assessment and preventive arms control" along similar lines, but from the perspective of arms control debates as well as the respective research: An assessment of the impacts of new weapons technologies – and one might want to add, of dual-use technologies – is needed in order to enter into arms control negotiations on an informed basis. He believes that this is where TA, with its focus on technology and science, has a particular responsibility. Thomas Reinhold echoes this sentiment when he advocates in his research article "Artificial intelligence, semiconductors, and the new geopolitics of security" for early assessment of new technologies in general and computer chips in particular. TA must no longer focus solely on the kinetic effects of weapons; greater attention must be paid to their informational aspects, for example regarding dual use and hybrid forms of warfare.

When former military officers and other (alleged) experts publicly (for instance on LinkedIn and TV channel n.tv, or in German newspapers such as Süddeutsche Zeitung, Handelsblatt, Frankfurter Allgemeine Zeitung, and Wirtschaftswoche) call for tactical nuclear weapons for the German army they usually forget to mention where those weapons would probably detonate and bring utter devastation: either on the territory of our Northern and/or Eastern NATO allies–for instance Poland, the Baltic states, or Norway–or on German territory. As an honest broker, one does not have to take a stance in favor or against nuclear weapons, or any other weapon; it suffices to relay the information about the likely consequences of their deployment. The same argument can be made with regard to unmanned, or autonomous weapons systems and their implications for international law, especially for ius in bello (in a rather journalistic fashion Shane 2015). Furthermore, the war against Ukraine is a source and trigger of rapid innovation and technological development. Ukrainian expertise will dramatically shift the way how armed forces will be trained, equipped, and fight in future wars. It might be worthwhile to consider the short-, mid-, and long-term repercussions of that development on societies at large as well as on the environment. It might also be worthwhile to think about possible and plausible trajectories of technological developments that might blur the distinction between war and peace, combatants and non-combatants, and – for that matter –, civil and military-related research even more.

But there would be an even more important mission: Technology assessment could and probably should, for instance, think about ways to help rebuild Ukraine's war-torn utilities infrastructure in such manner that it will become the most sustainable, resilient, and cost-effective infrastructure possible. It is most ob-

vious that after the end of the war (which, hopefully, will come sooner than later) Ukraine will be heavily dependent on financial support and know-how provided by the EU and other states. If one accepts this assumption then it seems highly plausible and reasonable that the donor countries, together with all stakeholders in Ukraine, will not try to do business as usual, but to use the opportunity to create something much more appropriate in terms of environmental and social aspects. It might be a misperception on our side, but currently we cannot see such projects – at least not from EU countries. Hence it is of great importance that Miriam Läpple and Hanna Wüller highlight another rather neglected area of research in their article "Future warfare and robust healthcare", in which TA could and probably should play a greater role: The power outage in Berlin in early 2026 gave a foretaste of what happens when critical infrastructure fails – the causes of which can be manifold. The crucial point here is that many (vulnerable) stakeholder groups are hardly visible, if at all, in the planning of preventive measures – this is where TA, in collaboration with other disciplines and professions, could help to remedy such situations.

Above all, however, it is confusing that we did not receive any submissions that explicitly advocated a specific role, neither as honest broker, nor as issue advocate, for TA in this era of change, given our deliberately provocative call for abstracts – at least not from the technology assessment community in the narrower sense. We truly think that taking a stance in these matters is indispensable to kick-start a productive discussion about where technology assessment should be heading. Considering the discussions of TATuP's editorial board following the submission of our proposal, it is rather regrettable that there is no contribution that explicitly argues against the involvement of TA in military-related research. In these discussions there were not only honest brokers which informed us about possible repercussions of a Special topic of this kind, but issue advocates who took a firm stand against such an involvement – which is to be appreciated. Yet, without an open debate in the TA community instead of arguments behind closed doors there will be no resolution to the question. After the reelection of Donald Trump as president of the United States and in view of his barely veiled threats against NATO and Europe it seems more and more wishful thinking to expect that Europe will still be protected by the nuclear umbrella as well as the conventional might of the U.S. military. New ways of thinking are badly needed. Every decision that could be made in these matters will come at a price, whether it be a massive rearmament, some kind of appeasement, economic warfare, something in between, or something completely different. In this situation it is perfectly legitimate to act as an issue advocate, or as an honest broker, but ignoring the challenge will not work for sure. Yet, as Dana Mahr points out in her research article "Rethinking participatory technology assessment in security governance" in this Special topic, one must remain realistic: Participatory technology assessment, which has become an increasingly important form of TA in recent years, reaches its limits in the case of military-related technology for many reasons, one of which is secrecy. This poses challenges, for instance, with regard to the individual responsibility of researchers and developers, or the possibility of whistleblowing. TA must ask itself the critical question of what expectations of stakeholders are actually morally justified.

The submissions we thought about in advance did not materialize.

In short: Our original concept of a Special topic on future warfare from a TA viewpoint did not work as expected and hoped for. The submissions we thought about in advance didn't materialize. But all is not lost, as the submissions we actually received are better suited to a concept for the Special topic that we most likely would have developed if we had known in 2024 what would happen after Donald Trump's re-election. Yet, we feel that an opportunity to start an important discussion was missed (one can learn a lot about similar discussions concerning "transformative science" from Grunwald 2018).

Conclusion

The parallel development of the global political situation and of the Special topic is a showcase of indeterminacy and consequently unpredictability of the future. As in so many other instances of historic development, the causal arrow seems to point only in one direction – the global situation has had an impact on us as guest editors, on the Special topic, and on the achievement of the objectives associated with it, but conversely, it can be assumed that there will be no significant repercussions. Given this observation one could come to the conclusion that individuals may have a voice in such matters, but lack the capacity to change the course of action in any meaningful way because every single state of affairs determines what will follow. In such a conception of reality human beings are merely spectators of irrevocable events, and freedom of action is, at best, an illusion. Human beings might have free will but not the capacity to make a difference.

Most obviously, such a world view cannot be the foundation of technology assessment, let alone of life. If, on the one hand, TA researchers consider themselves honest brokers they must hope that relaying valid and reliable information makes a difference in decision-making. If, on the other hand, they think of themselves as issue advocates, they must expect that advocacy can change the decisions of others as well as impact public debates and initiatives concerning the creation and enforcement of norms, rules, and provisions to strengthen the international

https://doi.org/10.14512/tatup.7305

world order. Although currently this seems rather unlikely, history tells us that such aspirations are not in vain: At some point in time informed discussions will shape the agenda, form, and content of international agreements – the creation of a rules-based international order in the aftermath of the Second World War is the most obvious example. Yet, even if those hopes and expectations regarding the possibility to change the course of history are futile, we must stick to the illusion of being able to make a difference.

On that score, the TA community as a congregation of individuals should try to generate new opportunities to reflect on its role regarding the (study of the) future of warfare and thereby on its aim to make a difference. It should welcome contributions from scholars from other scientific disciplines as well as practitioners of all professions – the submissions to the Special topic at hand prove that to be worthwhile. Hence, in order to support debate it should be announced that at the next Network for Technology Assessment conference, taking place on September 21–23, 2026, in Regensburg, there will be a session on this issue since it seems worthwhile to discuss this intensely. Maybe the debaters will be able to affect the state of global affairs, or some decision-makers, at least to some extent.

Funding • This article received no funding.

Competing interests • The authors declare no competing interests except that author Karsten Weber is a member of TATuP's scientific advisory board. This did not affect the peer review process.

Ethical oversight • The authors confirm that all procedures were performed in compliance with relevant laws and institutional guidelines.

References

acatech – Deutsche Akademie der Technikwissenschaften (ed.) (2025): Technikradar. Schwerpunkt Digitale Transformation und KI. München: acatech. https://doi.org/10.48669/aca_2025-4

Altmann, Jürgen et al. (2025): Science for peace and the need for civil clauses at universities and civilian research institutions. In: arXiv. https://doi.org/10.48550/arXiv.2505.22476

Bornmüller, Falk (2023): Zivile Wissenschaft. Theorie und Praxis von Friedens- und Zivilklauseln an deutschen Hochschulen. Bielefeld: transcript. https://doi.org/10.1515/9783839464779

Freedman, Lawrence (2018): The future of war. A history. London: Penguin Books.

Grunwald, Armin (2018): Transformative Wissenschaft als honest broker? Das passt! In: GAIA – Ecological Perspectives for Science and Society 27 (1), pp. 113–116. https://doi.org/10.14512/gaia.27.1.4

Jacobsen, Annie (2016): The Pentagon's brain. An uncensored history of DARPA, America's top secret military research agency. New York, NY: Back Bay Books.

Jacobsen, Annie (2024): Nuclear war. A scenario. New York, NY: Dutton.

Kahn, Herman (1961): On thermonuclear war. Princeton, NJ: Princeton University Press.

Lavoy, Peter; Sagan, Scott; Wirtz, James (eds.) (2000): Planning the unthinkable. How new powers will use nuclear, biological, and chemical weapons. Ithaca, NY: Cornell University Press.

Meijer, Hugo; Brooks, Stephen (2021): Illusions of autonomy. Why Europe cannot provide for its security if the United States pulls back. In: International Security 45 (4), pp. 7–43. https://doi.org/10.1162/isec_a_00405

Newlove-Eriksson, Lindy; Eriksson, Johan (2023): Conceptualizing the European military-civilian-industrial complex. The need for a helicopter perspective. In: Defence Studies 23 (4), pp. 561–588. https://doi.org/10.1080/14702436.2023.2277434

OTA – Office of Technology Assessment (ed.) (1979): The effects of nuclear war. Washington, DC: U.S. Government Printing Office. Available online at https://ota.fas.org/reports/7906.pdf, last accessed on 26.01.2026.

OTA (ed.) (1984): Directed energy missile defense in space. Washington, DC: U.S. Government Printing Office. Available online at https://ota.fas.org/reports/8410.pdf, last accessed on 26.01.2026.

OTA (ed.) (1988): The defense technology base. Introduction and overview. Washington, DC: U.S. Government Printing Office. Available online at https://ota.fas.org/reports/8810.pdf, last accessed on 26.01.2026.

Rieck, Christian (2024): Zeitenwende? Zivilklauseln! In: Analysen & Argumente 529, pp. 1–12. Available online at https://www.kas.de/documents/d/guest/zeitenwende-zivilklauseln, last accessed on 29.01.2026.

Schelling, Thomas (1966): Arms and influence. New Haven, CT: Yale University Press.

Scholz, Olaf (2022): The global Zeitenwende. How to avoid a new Cold War in a multipolar era. In: Foreign Affairs, 05.12.2023. Available online at https://www.foreignaffairs.com/germany/olaf-scholz-global-zeitenwende-how-avoid-new-cold-war, last accessed on 23.01.2026.

Shane, Scott (2015): Objective Troy. A terrorist, a president, and the rise of the drone. New York, NY: Tim Duggan Books.

PROF. KARSTEN WEBER
is professor for Technology Assessment and AI-based Mobility since 2022 at OTH Regensburg. He studied Philosophy, Computer Science, and Sociology and earned his doctorate in Philosophy at the University of Karlsruhe (TH) and his habilitation in Philosophy at the EUV Frankfurt/Oder. His scholarly work focuses on effects of technology on individuals and societies.

PROF. MARKUS BRESINSKY
is professor for International Politics and Social Sciences since 2010. He has been working for more than ten years as analyst and consultant in the defense and security business. He currently advises medium-sized and large companies in the critical infrastructure sector, public authorities, and ministries. His research focus is on developing and training analytical skills for policy advice.

TATuP Zeitschrift für Technikfolgenabschätzung in Theorie und Praxis
Journal for Technology Assessment in Theory and Practice

oekom science

RESEARCH ARTICLE

Technikfolgenabschätzung in der ‚Zeitenwende': Ambivalenzen der Reflexion auf sicherheitsrelevante Technologien

Martina Philippi*,[1]

Zusammenfassung · Unter dem Schlagwort ‚Zeitenwende' werden neuartige geopolitische Erfordernisse an nationale Sicherheit und Resilienz verhandelt, durch die die Grenzen zwischen ziviler und militärischer Forschung zunehmend verschwimmen. Darüber hinaus wird die Kontrollierbarkeit sicherheitsrelevanter Technologien durch neue Technikentwicklungen erschwert. Diese Sicherheitserfordernisse kollidieren mit drängenden gesellschaftlichen Herausforderungen wie dem Klimawandel und der raschen, schwer einschätzbaren Entwicklung künstlicher Intelligenz. Dieser Situation kann durch einseitige Betrachtungsweisen nur schwer begegnet werden. Technikfolgenabschätzung kann dabei helfen, den Diskurs mit der nötigen Ambivalenz auszustatten, um diesen neuen Entwicklungen in der zivil-militärischen Zusammenarbeit Rechnung zu tragen.

Technology assessment in a time of historic change: On the ambivalence of a methodological reflection of security-relevant technologies

Abstract · *Under the buzzword 'Zeitenwende,' new geopolitical requirements for national security and resilience are being negotiated, increasingly blurring the boundaries between civilian and military research. In addition, new technological developments are making it more difficult to control security-related technologies. These security requirements collide with urgent societal challenges such as climate change and the rapid and difficult-to-assess development of artificial intelligence. This situation is difficult to address with a one-sided approach. Technology assessment can help provide the discourse with the necessary ambivalence to take these new developments in civil-military cooperation into account.*

Keywords · *global technology assessment, dual use, Zeitenwende*

This article is part of the Special topic "Technology assessment and future warfare: The Good, the Bad, and the Ugly," *edited by K. Weber, M. Bresinsky. https://doi.org/10.14512/tatup.7286*

Einleitung

Wir leben in einer Zeit des Wandels. Neue geopolitische Herausforderungen haben, so die Worte des ehemaligen Bundeskanzlers Olaf Scholz, eine ‚Zeitenwende' eingeleitet (BPA 2022), aus der die von Verteidigungsminister Boris Pistorius benannte Notwendigkeit folgt, verteidigungsfähig und wehrhaft zu werden (Tagesschau 2023). Insbesondere der von Pistorius gewählte Begriff ‚kriegstüchtig' löste eine Debatte über Aufrüstung, Wehrpflicht und Verteidigungsfähigkeit der Bundeswehr aus, an der sich wandelnde gesellschaftliche Haltungen ablesen lassen (Neitzel 2024; Graf 2025): Während die einen eine Notwendigkeit von Wehrhaftigkeit im Sinne der Durchführung des verfassungsrechtlichen Auftrags der Bundeswehr feststellen, befürchten andere eine Normalisierung von Aufrüstung (Bartscher et al. 2025). Normalisierung bedeutet im Allgemeinen, dass Situationen, Deutungen oder Praxen selbstverständlich werden; dies geht häufig mit einer erschwerten Thematisierbarkeit und einer schwindenden Sichtbarkeit von Ambivalenzen einher, deren Anerkennung für eine differenzierte Betrachtung des Themas jedoch unerlässlich ist. Die Befürchtungen im Kontext der Zeitenwende-Diagnose betreffen auch die Technikfolgenabschätzung (TA), insofern eine militärstrategische Nutzung ihrer Ergebnisse entgegen ihrer Intention denkbar ist und zudem eine dezidierte Hinwendung zu militärrelevanten Technologien zu einer Normalisierung beitragen könnte. Dieser Beitrag fragt danach, inwiefern eine Einbeziehung militärrelevanter Themen in den Gegenstandsbereich

* *Corresponding author: martina.philippi@hsu.hamburg*
[1] *Lehrstuhl für Politikwissenschaften, insbesondere Politische Theorie/Democratic Resilience Center, Helmut-Schmidt-Universität/Universität der Bundeswehr Hamburg, Hamburg, DE*

https://doi.org/10.14512/tatup.7254
Received: 10. 08. 2025; revised version accepted: 10. 12. 2025; published online: 23. 03. 2026 (peer review)

der TA vertretbar und sogar erforderlich ist, um ihrem eigenen Anspruch gerecht zu werden, demokratische Werte zu vertreten und zur Gestaltung eines ‚guten Anthropozäns' (Grunwald 2024) beizutragen. Adressiert werden Ambivalenzen mit Bezug auf Wehrhaftigkeit, wirtschaftlich-politische Verschränkungen und dem Wandel der Dual-Use-Landschaft. Anschließend wird skizziert, wie TA in ihren Ausprägungen als globale und hermeneutische TA ihre Potenziale einsetzen kann, um sichtbar zu machen und zu halten, was im Zuge der befürchteten Normalisierung verdeckt werden könnte.

Das ‚gute Anthropozän' nach der ‚Zeitenwende'

Die Leitidee des guten Anthropozäns besteht in Gestaltungsanforderungen, die daraus resultieren, dass im Anthropozän Wohlstand und technischer Fortschritt, aber auch globale Abhängigkeiten und katastrophale Umweltfolgen entstanden sind, die nur mit Verzögerung erkannt werden. Die ‚Zeitenwende' hat diese Problematik zugespitzt, denn ein Szenario, das nun aus menschheitlicher Sicht unbedingt vermieden werden muss, ist ein Zurückstellen der in der Aufgabe eines gut gestalteten Anthropozäns implizierten Werte zugunsten des Austragens von Konflikten. Dies betrifft unter anderem ökologische Kosten wie etwa die des hohen CO_2-Ausstoßes, der nicht nur im Konfliktfall, sondern bereits bei der Herstellung von Wehrhaftigkeit etwa im Rahmen von Übungen verursacht wird (Adolphsen 2025).

Eine normative Voraussetzung für ein *gutes* Anthropozän ist eine grundsätzliche, global getragene Bereitschaft zu Kompromissen und gemeinsamer Gestaltung, wie sie etwa in den Sustainable Development Goals der UNO formuliert sind. Diese global-menschheitliche Perspektive unterliegt jedoch einem Paradox: Auch wenn Werte wie Frieden und Erhalt von Lebensraum von allgemeinem Interesse sein müssten, handeln nicht alle politischen und wirtschaftlichen Akteure in ihrem Sinne, sondern nutzen temporale und soziale Strukturen der Ungleichverteilung von Ressourcen und Macht aus. So haben russische Machtinteressen mit dem Angriffskrieg in Europa zur eingangs erwähnten Situation der Zeitenwende geführt und überholt geglaubte geopolitische Erfordernisse auf den Plan gerufen. Da die menschheitliche Perspektive in diesem Sinne mit der Annahme, alle seien grundsätzlich an Frieden interessiert, als ‚kosmopolitischer Idealismus' (Šedivý 2025) naiv anmutet, erfolgt in der Debatte angesichts einer „Phase verstärkter Instabilität [. . .] innerhalb einer multipolaren Weltordnung" (Sailer 2024, S. 315) gleichsam ein *realistic turn*. Die Frage ist also, wie Akteure, die entgegen dem globalen Interesse des guten Anthropozäns handeln, als Problemfaktoren anerkannt und in die strategischen Überlegungen zu seiner Gestaltung einbezogen werden können.

Das Dual-Use-Potenzial der Technikfolgenabschätzung

Dabei steht die TA selbst vor zwei Ambivalenzen. Die eine ist ihre Instrumentalisierbarkeit. Wenn Technikfolgenabschätzung sich sicherheitsrelevanten Themen zuwendet, entsteht eine Art Dual-Use-Szenario für ihre Methoden und Ergebnisse. Einerseits werden dringend notwendige Analysewerkzeuge und Argumente entwickelt, die für eine Regulierung etwa autonomer Waffensysteme sowie für einen öffentlichen Diskurs erforderlich sind (Haner und Garcia 2019; Grünwald und Kehl 2020). Andererseits ist eine militärstrategische Ausbeutung des antizipatorischen Moments denkbar und entspricht der Einschätzung der Leopoldina-Empfehlung, dass auch geistes- und sozialwissenschaftliche Erkenntnisse sicherheitsrelevante Forschung darstellen können (Leopoldina und DFG 2022). Gerade Modellierungen und Vorhersagen könnten strategisch umgewidmet werden. Historisch lässt sich dies an den Schriften Herman Kahns zu den Folgen nuklearer Angriffe exemplifizieren, der eine Folgenabschätzung mit einer militärischen Strategie zur gegenseitigen Abschreckung und dem heute wie damals umstrittenen Modell einer Eskalationsleiter kombinierte (exemplarisch: Kahn 1970). Zwar würdigen die Vorworte und Klappentexte der Schriften Kahns insbesondere in späteren Ausgaben und den deutschen Übersetzungen ihn dafür, gezeigt zu haben, wie wenig wünschenswert ein nuklearer Schlagabtausch ist. Dennoch ist die am RAND Institute entwickelte, umstrittene Theorie der Eskalation noch heute Teil militärstrategischer Überlegungen (Sauer 2022). Im Fall einer solchen militärstrategischen Verwendung würden Ergebnisse der TA aus Modellierung und Antizipation in einer Weise genutzt werden, die ihrem Ziel, zu einer guten Gestaltung des Anthropozäns beizutragen, zuwiderlaufen.

Die Ambivalenz militärrelevanter Technologien

Die zweite Form von Ambivalenz bezieht sich auf die unmittelbaren und mittelbaren Zwecke von militärrelevanten Technologien. Bei der von Pistorius eingeforderten Wehrhaftigkeit geht es gemäß seiner Argumentation nicht um beabsichtigte Zerstörung, sondern um die Vermeidung eines militärischen Angriffs und die Verteidigung der Demokratie. Aus Sicht der Reflexion auf Technikentwicklung ergibt sich folgende Ambivalenz: Zerstörung durch militärrelevante Technologien, auch von Leben und Lebensgrundlagen, sind nicht unerwünschte Nebenfolgen dieser Technologien, sondern ihr *unmittelbarer* Zweck, auch wenn diese Zerstörung *mittelbar* als Potenzial zu Verteidigungs- und Abschreckungszwecken einkalkuliert wird. Daher bringt die Förderung von Wehrhaftigkeit im Sinne einer Verteidigung der Demokratie auch neue Waffentechnologien in die Welt, die potenziell nicht zu Verteidigung und Abschreckung, sondern auch zu Angriff und Bedrohung genutzt werden können.

Diese Ambivalenz adressiert auch die Nationale Akademie der Wissenschaften Leopoldina in ihren Empfehlungen zum Umgang mit sicherheitsrelevanter Forschung. Diese „ist eine wesentliche Grundlage für den Fortschritt der Menschheit. Sie dient der Wissensvermehrung und fördert Gesundheit, Wohlstand und Sicherheit der Menschen sowie den Schutz der Umwelt"; sie ist „dem Wohl der Menschheit sowie dem Schutz der Umwelt und anderer – vor allem verfassungsrechtlich geschützter – Güter verpflichtet" (Leopoldina und DFG 2022, S. 9–10). Hierin spiegelt sich das Interesse des guten Anthropozäns, jedoch auch der

verfassungsgemäße Schutz freiheitlicher Lebensbedingungen. Es mag zunächst nach klarer Abgrenzung klingen, wenn die Empfehlungen die Gefahr des Missbrauchs nützlicher Forschungsergebnisse thematisieren, vor allem im Sinne der besorgniserregenden sicherheitsrelevanten Forschung (Dual-Use Research of Concern), die potenziell „Wissen, Produkte oder Technologien hervorbringen [kann], die unmittelbar von Dritten missbraucht werden können, um Menschenwürde, Leben, Gesundheit, Freiheit, Eigentum, Umwelt oder ein friedliches Zusammenleben erheblich zu schädigen" (Leopoldina und DFG 2022, S. 10). Doch die Empfehlungen erkennen eine erschwerte Unterscheidbarkeit „von ‚guter' und ‚böser' Forschung, von Verteidigungs- und Angriffsforschung, von Forschung für friedliche und für kriminelle Anwendungen" (Leopoldina und DFG 2022, S. 10) an. Die Beforschung von Dual-Use-Themen kann im Sinne des Gemeinwohls sogar ethisch geboten sein: „Gleichzeitig kann die Unterlassung von Forschung erhebliche Risiken nach sich ziehen, wenn dadurch z. B. die Entwicklung von Schutzmaßnahmen blockiert wird oder Innovationen ausbleiben, die dem Gemeinwohl dienen." (Leopoldina und DFG 2022, S. 9) Und dies gilt auch für eine „Unterdrückung von Forschungsergebnissen", durch die gegebenenfalls ein „wirksamer Schutz gegen ihre missbräuchliche Anwendung durch totalitäre Regime, terroristische Gruppen, organisierte Straftäter oder Einzeltäter nicht möglich ist." (Leopoldina und DFG 2022, S. 17).

Obwohl die Leitunterscheidung der Empfehlungen *Technologien* als ‚beneficial' und ‚harmful' kennzeichnet, zählt letztlich der *Kontext* ihrer Verwendung: Forschung wird als sicherheitsrelevant beurteilt in Bezug auf malevolente Akteure, die sich kriminell bzw. völkerrechtswidrig verhalten. Forschung im Sinne von Verteidigung kann sogar ethisch geboten sein. Für die TA ergibt sich daraus eine Spannung zwischen dem Anspruch der Reflexion und verantwortungsvollen Mitgestaltung von Technikentwicklung und der Verteidigung von Demokratie und freiheitlichen Lebensbedingungen, auf deren Basis eine verantwortungsvolle und partizipative Technikgestaltung erst möglich ist.

Normalisierung als Vereindeutigung durch politische und wirtschaftliche Interessen

Diese Ambivalenz von Waffentechnologien als Angriffs- und als Verteidigungsinstrument kann durch ‚Vereindeutigung' (Bauer 2022) unsichtbar gemacht werden, etwa im Sinne einer Normalisierung von Aufrüstung, wie sie derzeit gesellschaftlich befürchtet wird. Eine solche Normalisierung geschieht häufig aus einem politischen Interesse heraus mit entsprechenden Narrativen (Creed 2013), doch sie kann auch wirtschaftlichen Interessen folgen. Ebenso wie in der zivilen Entwicklung und Beförderung neuartiger Technologien vermischen sich im Kontext sicherheitsrelevanter Technikentwicklung Akteure aus Politik, Wirtschaft und Wissenschaft und somit auch die Wechselwirkungen ihrer Tätigkeitsfelder. In seiner „Rede über die drei Weltkriege" beschreibt Günther Anders eine solche Vermischung und bezeichnet die Rüstungsindustrie als „Doppelindustrie" (Anders 1966): Sie funktioniert nach der Logik jeder anderen Industrie – um Umsatz zu machen, erzeugt sie nicht nur Produkte, sondern fördert auch den Bedarf, den sie bedient. Mit anderen Worten: Sobald politische Erfordernisse in Wechselwirkung mit anderen Funktionslogiken treten, erzeugen deren Erfordernisse eigene Dynamiken. Gerade die Forschung an anwendbaren Technologien ist vor dem Hintergrund von wirtschaftlichem und auch zunehmendem akademischen Konkurrenzdruck ihrer Natur gemäß nach vorne gerichtet und kann sich dann auch bei Dual-Use-Potenzial auf das Narrativ eines nationalen oder menschheitlichen Fortschritts berufen.

Auch wenn Werte wie Frieden und Erhalt von Lebensraum von allgemeinem Interesse sein müssten, handeln nicht alle politischen und wirtschaftlichen Akteure in ihrem Sinne.

Eine solche Spirale schießt nicht nur sprichwörtlich über das Ziel hinaus, sondern bedroht auch das Erreichen zweier dringender menschheitlichen Ziele, die bei der Verteilung begrenzter finanzieller und zeitlicher Ressourcen zurückgestellt werden könnten: die Schadensbegrenzung bei den Folgen des Klimawandels und die verantwortungsvolle, rechtzeitige Regulation neuartiger Technologien und ihrer Begleitfolgen, etwa künstlicher Intelligenz (KI). Eine solche von Funktionslogiken getriebene Dynamik ist jedoch nur ein Teil der ökonomischen Dimension. Zu beachten ist auch die Rolle der nicht auf Rüstung spezialisierten Privatwirtschaft, die bislang in der Debatte um Wehrhaftigkeit eine untergeordnete Rolle gespielt hat. Dazu gehören die private Kontrolle breit genutzter Technologien und Infrastrukturen (Dörr und Kowalski 2022) und der dadurch mögliche unmittelbare politische Einfluss von Wirtschaftsakteuren sowie deren Erlangen hoher politischer Positionen. Dazu kommt nun verstärkt die Möglichkeit, dass private Unternehmen durch zivil-militärische Kollaborationen in Forschung und Entwicklung zunehmenden Einfluss auf Regierung und Militär erhalten (O'Mara 2025). Es prallen also in den geopolitischen und ökonomischen Konstellationen der Gegenwart nicht nur das ‚Wir'-Narrativ des menschheitlichen Fortschritts und das in rivalisierende Nationen zersplitterte, abgrenzende ‚Wir'-Narrativ der Macht und des Bedrohungspotenzials aufeinander, sondern

https://doi.org/10.14512/tatup.7254

auch das des wirtschaftlichen Wettbewerbs, und dies durchaus ineinander verschränkt.

Rüstungskontrolle im Wandel: Dezentralisierung und Modularisierung Dual-Use-relevanter Technikentwicklung

Eine dritte Quelle von Ambivalenz besteht in der Dezentralisierung und Modularisierung sicherheitsrelevanter Forschung. Exemplarisch nennt die Leopoldina-Empfehlung solche zu pathogenen Mikroorganismen und Toxinen, in der molekularen Pflanzengenetik oder in Materialforschung und Nanotechnologie sowie Robotik und Cybersicherheit. Mit dem klassischen Szenario der Kernenergie haben diese Beispiele gemeinsam, dass sie Technologiefelder darstellen, in denen bereits einzelne Forschungsergebnisse und daraus entwickelte Technologien globale Risiken erzeugen können, sei es als unerwünschte Nebenfolgen einer zivilen Anwendung oder als direktes militärisches Zerstörungspotenzial (etwa im Sinne von Massenvernichtungswaffen). Was sie vom bekannten Szenario etwa der Kernenergie unterscheidet, ist die leichtere Zugänglichkeit vonseiten verschiedener Akteure bezüglich des Materials, der Arbeitsumgebung und der Fähigkeiten. Mit anderen Worten: Angereichertes Uran ist schwerer zu bekommen als natürlich entstehende Krankheitserreger; Arbeitsumgebungen wie Labore (Biotechnologie) oder leistungsfähige Computer (Hacking) stehen breit zur Verfügung, die entsprechenden Fähigkeiten lassen sich je nach Feld studieren oder aneignen.

Anders als im Fall Kernenergie entwickeln sich neuartige sicherheitsrelevante Technologien daher viel schneller, unkontrollierter und dezentral. Militärische Anwendungen waren vor einigen Jahrzehnten stark auf Forschungsinstitutionen angewiesen; um die ausschließlich friedliche Nutzung von Kernenergie voranzubringen, ohne damit in nukleare Waffenentwicklung und Aufrüstung verwickelt zu werden, etablierten Forschungseinrichtungen die Zivilklausel (Nielebock et al. 2012). Im aktuellen Szenario leichter verfügbarer Materialien und einer Verbreitung von Wissen und Anwendungsinteressen findet Entwicklung auch außerhalb von universitären und anderen nichtkommerziellen Forschungseinrichtungen statt; unter anderem betreiben Konzerne wie Alphabet oder OpenAI eigene Forschung, um Marktvorteile und Wissensvorsprünge zu sichern.

Zusätzlich zur Dezentralisierung führt eine zunehmende Modularisierung von Technikentwicklung zu breit verfügbaren, vielfältig kombinierbaren Komponenten und Fähigkeiten, die die Grenze von ziviler und militärischer Forschung verschwimmen lassen. Modularität ist nicht nur ein Nebeneffekt zunehmend arbeitsteiliger interdisziplinärer Kooperationen in Entwicklung und Forschung, sondern auch ein *Designziel*, um Erkenntnisse effizient und rasch auf andere Anwendungsfelder übertragen zu können (Kekec et al. 2013; Feng et al. 2024). Die Verbreitung der Ergebnisse, etwa Integrationswissen bezüglich KI und Sensorik gemäß dem Grundsatz von Open Science, führt zusammen mit der einfachen Erhältlichkeit von Komponenten zu Erschwernissen bei der Beherrschung von Dual-Use-Effekten (Riebe 2023; Rychnovská 2016), auch in Bezug auf nichtstaatliche malevolente Akteure (Grossman 2018). Besonders, aber nicht nur im Zusammenhang mit Sensorik und KI sind militärisch relevante Entwicklungen zunehmend verwandt mit zivilen Anwendungen, was die Dual-Use-Thematik zugleich verschärft und schwerer greifbar und regulierbar macht. Die Gefahr ist hier, dass die *Erschwerung* der Identifikation und Kontrolle von Dual-Use-Technologien die Reflexion nach alten Mustern so verunsichern kann, dass sie an Gehör und Wirkmächtigkeit verliert, obwohl sie in den Fällen dezentraler und modularer Technikentwicklung erst recht gefragt ist (Philippi 2025).

Zu beachten ist auch die Rolle der nicht auf Rüstung spezialisierten Privatwirtschaft.

Ambivalenzanalyse, globale und hermeneutische Technikfolgenabschätzung: das Verdeckte sichtbar machen

Die bisher aufgeworfenen Fragen lauten also: Wie kann TA Akteure, die entgegen dem globalen Interesse des guten Anthropozäns handeln, als Problemfaktoren anerkennen und in die strategischen Überlegungen zu seiner Gestaltung einbeziehen? Wie kann Technikfolgenabschätzung den geopolitischen Herausforderungen gerecht werden, ohne selbst, etwa im Sinne eines ‚ethics washing', für Deutungen vereinnahmt zu werden, die eine von Machtbestrebungen oder wirtschaftlichen Interessen vorangetriebene Normalisierung von Aufrüstung beinhalten? Und was ist der Gegenstand der TA, wenn nicht unerwünschte Technikfolgen?

Eine mögliche Strategie gegen eine Instrumentalisierung ist zunächst eine Verständigung über die eigenen normativen Grundannahmen, wie sie bereits stattfindet (Kollek 2019) und nach der Zeitenwende-Diagnose an die Motivation, Demokratie zu bestärken und zu erhalten (Grunwald und Saretzki 2020), zurückgebunden werden kann. Der Anspruch der TA, zu einer guten Gestaltung des Anthropozäns beizutragen, schafft einen Reflexionsrahmen, in dem auch Akteure, die entgegen diesen menschheitlichen Zielen von Wohl der Menschheit, Nachhaltigkeit und Menschenrechten handeln, als Problemfaktoren anerkannt und

in die strategischen Überlegungen zum globalen Gemeinwohl einbezogen werden können. Die Ambivalenz der Entwicklung von Verteidigungstechnologien, aber auch die Rolle der Wirtschaft kann gezielt gegenüber TA-eigenen Werten wie Nachhaltigkeit und Demokratie thematisiert werden. Dynamiken und verdeckte Strategien einer wirtschaftlich oder politisch getriebenen Normalisierung oder Priorisierung von Aufrüstung können so sichtbar gemacht und adressiert werden. Da TA sich an der Schnittstelle von Wissenschaft, Politik und Gesellschaft befindet, kann dieser Reflexionsraum über die wissenschaftliche Analyse hinaus helfen, auch die gesellschaftliche Debatte mit der nötigen Ambiguitätstoleranz (Bauer 2022) auszustatten. Dazu hat TA bereits gute methodische Mittel.

Anders als im Fall Kernenergie entwickeln sich neuartige sicherheitsrelevante Technologien viel schneller, unkontrollierter und dezentral.

Ihre Methodik und ihre Bindung an die gute Gestaltung des Anthropozäns befähigen die TA insbesondere als *globale* TA (Hennen et al. 2023), Wertkonflikte und damit verbundene problematische Vereinfachungen und Verdeckungen in der Beurteilung von Aufrüstung und intensivierter Militärforschung sichtbar und thematisierbar zu machen, ohne die globale Perspektive preiszugeben. Der *hermeneutische* Ansatz kann ebenfalls helfen, Narrative und Vereinfachungen aufzudecken. Schließlich geschieht das Handeln aus wirtschaftlichen Interessen, das eine Normalisierung von Aufrüstung vorantreiben kann, häufig grundsätzlich in gezielter Verdeckung kommerzieller Interessen unter einem vermeintlichen Menschheitsnutzen in einem solutionistischen Sinne (Daub 2020; O'Mara 2025). Gerade solche Verdeckungen können durch die TA adressiert werden, und zwar als Reflexion auf privatwirtschaftliche Interessen unter Aspekten der Demokratie (Frey et al. 2020). Unter Einbezug der Anthropozän-Perspektive bietet sich hier ein breites Tätigkeitsfeld auch in Bezug auf sicherheitsrelevante Technologien. Die Ambivalenzen selbst können durch eine *Ambivalenzanalyse* (Liebert und Schmidt 2018) adressiert und systematisiert und so im wissenschaftlichen und gesellschaftlichen Diskurs verankert werden.

Dieses Sichtbarmachen von Dynamiken sowie von systematisch und zielgerichtet verdeckten (wirtschaftlichen oder machtpolitischen) Interessen kann schließlich in die Perspektive des guten Anthropozäns zurückgespielt werden, nämlich mit der Frage, in welcher Welt wir leben wollen. Denn Forschungsgegenstände der TA können – in einem ganz eindeutig militärrelevanten Sinne – die Entwicklung und Regulierung sicherheitsrelevanter Technologien sein, insbesondere neuartige Waffensysteme im Kontext von KI wie etwa bewaffnete Drohnen (Koch und Rinke 2018), höhere Automatisierungsgrade (Stichwort: human-in-the-loop) und Cyberkriegsführung über digitale Angriffe auf zivile und militärische Infrastrukturen; es können jedoch auch die ökologischen Folgen von Kriegshandlungen sein, die eine neue Bedeutung gewonnen haben, insofern stärker als je zuvor CO_2-Ausstoß und Zerstörung von Natur den Erhalt unserer Lebensgrundlagen bedrohen. Diese Gegenstände können jedoch auch für die Einschätzung der Wirkmächtigkeit neuartiger Waffensysteme relevant sein, woraus sich das oben aufgeführte Dual-Use-Risiko ihrer Ergebnisse ergibt. Dies entspricht dem bereits etablierten TA-Bereich der Rüstungskontrolle (Bielefeld und Eurich 2005). Die Gegenstände einer TA, die sowohl den Anspruch der guten Gestaltung des Anthropozäns als auch die geopolitischen Erfordernisse der ‚Zeitenwende' adressiert, müssen daher nicht zwingend Militärtechnologien sein. Vor dem Hintergrund der durch Dezentralisierung und Modularisierung schwerer trennbaren zivilen und militärischen Technikentwicklung kann sie Technologien, die im Militärkontext als *Gamechanger* gelten, auf ihre menschheitlichen Folgen befragen und so den militärischen Kontext einbeziehen und zugleich überschreiten.

Neue Herausforderungen, bewährte Methodik

Eine der Demokratie verpflichtete Wehrhaftigkeit muss verantwortungsvoll und ambiguitätstolerant gestaltet sein. Denn nur wenn das Paradox der Wehrhaftigkeit, das in der Entwicklung potenziell destruktiver Technologien zum Erhalt von Frieden und demokratischen Lebensbedingungen besteht, als solches anerkannt wird, lassen sich gefährliche Vereindeutigungen wie die Normalisierung und Priorisierung von Aufrüstung, die einem politischen oder wirtschaftlichen Kalkül folgen, mit hinreichender Tiefe artikulieren und diskutieren. Insbesondere unter dem Aspekt der Resilienz ist Demokratie darauf angewiesen, Paradoxien auszuhalten (Schaal 2025). Eine verantwortungsvolle Arbeit an der Verteidigungsfähigkeit bedarf in diesem Sinne eines kritischen gesellschaftlichen Diskurses sowie der Konzentration auf das Notwendige im Sinne der Deeskalation und der größtmöglichen Vermeidung von Umweltfolgen. Aufgabe der Technikfolgenabschätzung ist es dann, Fragestellungen wie die Verteidigungsfähigkeit in politischer Instabilität, neuen Vulnerabilitäten und Abhängigkeiten sowie Visionen eines ‚future war' mit dem Ziel eines im Rahmen des (noch) Möglichen gut gestalteten Anthropozäns zu analysieren. Für diese Aufgaben ist der Selbstanspruch der Technikfolgenabschätzung relevant, Gestaltungsspielräume wahrzunehmen und für Verständigungsprozesse sichtbar zu machen, was nur aus verschiedenen Perspektiven gesehen

https://doi.org/10.14512/tatup.7254

werden kann und unter Umständen interessenbedingt verdeckt wird. Insbesondere für den Aspekt der rechtlichen Mitgestaltung mittels Information und Beratung wäre in weiteren Untersuchungen zu zeigen, wie auf Entwicklungen, deren Akteure sich nicht ethisch gebunden sehen, durch Regulierung Einfluss genommen werden kann.

Denkbar wäre hier etwa eine Mitwirkung global verstandener Technikfolgenabschätzung an der Aktualisierung des Völkerrechts bezüglich neuer Waffensysteme, menschheitlich-ökologischer Herausforderungen oder digitaler Kriegsführung. Hier besteht insbesondere für eine dezidiert globale TA (Hennen et al. 2023) die Chance, die genannten Fragen gesellschaftlich mit unterschiedlichen nationalen Perspektiven auszuhandeln und Empfehlungen auf globaler Ebene zu formulieren, etwa im Anschluss an und in Erweiterung von global ausgehandelten Zielen in menschheitlich-globaler Perspektive wie den Sustainable Development Goals der UNO. Das würde für eine ethische Abwägung von Kosten und Nutzen die Aufwendungen zur Sicherung von Wehrhaftigkeit explizit den menschheitlichen Kosten gegenüberstellen, die mit dem – ebenfalls menschheitlichen – Fortschritt auf bestimmten Gebieten disruptiver Technologien einhergehen. Die menschheitliche Perspektive, der sich die Technikfolgenabschätzung heute mit Werten wie Demokratie, Nachhaltigkeit und der guten Gestaltung des Anthropozäns verpflichtet, kann so in eine Zeit einer in potenzielle Konfliktparteien zersplitterten globale Menschheit gleichsam hinübergerettet werden.

Funding • This article received no funding.

Competing interests • The author declares no competing interests.

Ethical oversight • The author confirms that all procedures were performed in compliance with relevant laws and institutional guidelines.

Literatur

Adolphsen, Ole (2025): Militärische Emissionen in der internationalen Klimapolitik. Zur Konvergenz klima- und sicherheitspolitischer Ziele. Berlin: Stiftung Wissenschaft und Politik.

Anders, Günther (1966): Die Toten. Rede über die drei Weltkriege. Köln: Pahl-Rugenstein.

Bartscher, Michael; Hansen, Stefan; Rohschürmann, Michael (Hg.) (2025): Die Zeitenwende – sicherheitspolitischer Kulturwandel in der Bundesrepublik Deutschland? Implikationen einer ‚Normalisierung' auf Gesellschaft und Bundeswehr. Wiesbaden: Springer VS. https://doi.org/10.1007/978-3-658-48044-8

Bauer, Thomas (2022): Die Vereindeutigung der Welt. Über den Verlust an Mehrdeutigkeit und Vielfalt. Ditzingen: Reclam.

Bielefeld, Tom; Eurich, Christian (2005): Science Roadmapping für Rüstungstechnologie-Folgenabschätzung und präventive Rüstungskontrolle. In: TATuP – Zeitschrift für Technikfolgenabschätzung in Theorie und Praxis 14 (3), S. 128–134. https://doi.org/10.14512/tatup.14.3.128

BPA – Presse- und Informationsamt der Bundesregierung (2022): Regierungserklärung von Bundeskanzler Olaf Scholz am 27. Februar 2022. Online verfügbar unter https://www.bundesregierung.de/breg-de/service/archiv-bundesregierung/regierungserklaerung-von-bundeskanzler-olaf-scholz-am-27-februar-2022-2008356, zuletzt geprüft am 16.12.2025.

Creed, Pamela (2013): Ethics, norms and the narratives of war. Creating and encountering the enemy other. London: Routledge. https://doi.org/10.4324/9780203105023

Daub, Adrian (2020): Was das Valley denken nennt. Über die Ideologie der Techbranche. Berlin: Suhrkamp.

Dörr, Julian; Kowalski, Olaf (2022): Die politische Ideologie des Silicon Valley. In: Udo Di Fabio, Julian Dörr und Olaf Kowalski (Hg.): Made in California. Zur politischen Ideologie des Silicon Valley. Tübingen: Mohr Siebeck, S. 9–49.

Feng, Yongbing; Gao, Guohua; Wang, Pengyu; Zhang, Zihua; Liu, Kai (2024): Introducing reconfigurable manufacturing systems to agriculture. In: Flexible Services and Manufacturing Journal 37 (3), S. 816–868. https://doi.org/10.1007/s10696-024-09559-5

Frey, Philipp; Schneider, Christoph; Wadephul, Christian (2020): Demokratisierung von Technik ohne Wirtschaftsdemokratie? TA und die Frage demokratischer Verhältnisse in der Wirtschaft. In: TATuP – Zeitschrift für Technikfolgenabschätzung in Theorie und Praxis 29 (3), S. 30–35. https://doi.org/10.14512/tatup.29.3.30

Graf, Timo (2025): Zeitenwende ja, Pazifismus nein, Kriegstüchtigkeit vielleicht. Das verteidigungspolitische Meinungsbild im Wandel. In: Michael Bartscher, Stefan Hansen und Michael Rohschürmann (Hg.): Die Zeitenwende – sicherheitspolitischer Kulturwandel in der Bundesrepublik Deutschland? Wiesbaden: Springer VS, S. 69–100. https://doi.org/10.1007/978-3-658-48044-8_5

Grossman, Nicholas (2018): Drones and terrorism. Asymmetric warfare and the threat to global security. London: I.B. Tauris. https://doi.org/10.5040/9781350986169

Grünwald, Reinhard; Kehl, Christoph (2020): Autonome Waffensysteme. Endbericht zum TA-Projekt. Arbeitsbericht Nr. 187. Berlin: TAB. https://doi.org/10.5445/IR/1000127160

Grunwald, Armin (2024): Technology assessment for a 'good' anthropocene. In: Armin Grunwald (Hg.): Handbook of technology assessment. Cheltenham: Edward Elgar Publishing, S. 441–450. https://doi.org/10.4337/9781035310685.00061

Grunwald, Armin; Saretzki, Thomas (2020): Demokratie und Technikfolgenabschätzung. Praktische Herausforderungen und konzeptionelle Konsequenzen. In: TATuP – Zeitschrift für Technikfolgenabschätzung in Theorie und Praxis 29 (3), S. 11–17. https://doi.org/10.14512/tatup.29.3.11

Haner, Justin; Garcia, Denise (2019): The artificial intelligence arms race. Trends and world leaders in autonomous weapons development. In: Global Policy 10 (3), S. 331–37. https://doi.org/10.1111/1758-5899.12713

Hennen, Leonhard; Hahn, Julia; Ladikas, Miltos; Lindner, Ralf; Peissl, Walter; Van Est, Rinie (Hg.) (2023): Technology assessment in a globalized world. Facing the challenges of transnational technology governance. Cham: Springer. https://doi.org/10.1007/978-3-031-10617-0

Kahn, Herman (1970): Eskalation. Die Politik mit der Vernichtungsspirale. Frankfurt a. M.: Ullstein.

Kekec, Taygun; Ustundag, Baris; Guney, Mehmet; Yildirim, Alper; Unel, Mustafa (2013): A modular software architecture for UAVs. IECON 2013 – 39th Annual Conference of the IEEE Industrial Electronics Society, Vienna, Austria, 10.11.2013. https://doi.org/10.1109/IECON.2013.6699782

Koch, Bernhard; Rinke, Bernhard (2018): Der militärische Einsatz bewaffneter Drohnen. Zwischen Schutz für Soldaten und gezieltem Töten. In: TATuP – Zeitschrift für Technikfolgenabschätzung in Theorie und Praxis 27 (3), S. 38–44. https://doi.org/10.14512/tatup.27.3.38

Kollek, Regine (2019): Implizite Wertbezüge in der Technikfolgenabschätzung. Plädoyer für eine Praxis der reflexiven Normativität. In: TATuP – Zeitschrift für Technikfolgenabschätzung in Theorie und Praxis 28 (1), S. 15–20. https://doi.org/10.14512/tatup.28.1.15

Leopoldina – Nationale Akademie der Wissenschaften Leopoldina; DFG – Deutsche Forschungsgemeinschaft (2022): Wissenschaftsfreiheit und Wissenschaftsverantwortung. Empfehlungen zum Umgang mit sicherheitsrelevanter Forschung. Halle (Saale): Nationale Akademie der Wissenschaften Leopoldina.

Liebert, Wolfgang; Schmidt, Jan (2018): Ambivalenzen im Kern der wissenschaftlich-technischen Dynamik. Ergänzende Anforderungen an eine Theorie der Technikfolgenabschätzung. In: TATuP – Zeitschrift für Technikfolgenabschätzung in Theorie und Praxis 27 (1), S. 52–58. https://doi.org/10.14512/tatup.27.1.52

Neitzel, Sönke (2024): Kriegstüchtig? Zur Zeitenwende in Politik, Gesellschaft und Truppe. In: Aus Politik und Zeitgeschichte 78 (47–48), S. 4–10. Online verfügbar unter https://www.bpb.de/system/files/dokument_pdf/APuZ_2024-47-48_online_1.pdf, zuletzt geprüft am 16.02.2026.

Nielebock, Thomas; Meisch, Simon; Harms, Volker (Hg.) (2012): Zivilklauseln für Forschung, Lehre und Studium. Hochschulen zum Frieden verpflichtet. Baden-Baden: Nomos.

O'Mara, Margaret (2025): Code auf Kommando. In: human Magazin: Human Forward. Smart resilience – Defending Europe, S. 144–147. Online verfügbar unter https://human-magazin.de/wp-content/uploads/2025/09/humanForward_DefendingEuropeDE.pdf, zuletzt geprüft am 21.01.2026.

Philippi, Martina (2025): The ambivalence of multi-purpose design. On the dual-use and misuse risks of humanitarian UAVs. In: Research Ethics 22 (1), S. 17470161251344321. https://doi.org/10.1177/17470161251344321

Riebe, Thea (2023): Technology assessment of dual-use ICTs. How to assess diffusion, governance and design. Wiesbaden: Springer Vieweg. https://doi.org/10.1007/978-3-658-41667-6

Rychnovská, Dagmar (2016): Governing dual-use knowledge. From the politics of responsible science to the ethicalization of security. In: Security Dialogue 47 (4), S. 310–328. https://doi.org/10.1177/0967010616658848

Sailer, David (2024): Das Ende der Gewissheiten – oder: Zur Rückkehr des Leviathan. In: Felix Herkert, Jan Kerkmann und David Sailer (Hg.): Politischer Realismus I. Baden-Baden: Nomos. https://doi.org/10.5771/9783748942092-297

Sauer, Frank (2022): Nukleare Abschreckung. Theorie, Grenzen und Kritik. Online verfügbar unter https://www.bpb.de/themen/militaer/deutsche-verteidigungspolitik/508040/nukleare-abschreckung/, zuletzt geprüft am 16.12.2025.

Schaal, Gary (2025): Demokratie am Limit. In: human Magazin: Human Forward. Smart resilience – Defending Europe, S. 157–162. Online verfügbar unter https://human-magazin.de/wp-content/uploads/2025/09/humanForward_DefendingEuropeDE.pdf, zuletzt geprüft am 21.01.2026.

Šedivý, Miroslav (2025): „Kosmopolitischer Idealismus" und „nationale Realpolitik". Aspekte der Sicherheitspolitik der deutschen Liberalen zur Mitte des 19. Jahrhunderts. In: Historische Zeitschrift 320 (2), S. 308–45. https://doi.org/10.1515/hzhz-2025-0008

Tagesschau (2023): Haltung zur Bundeswehr. Pistorius fordert Mentalitätswechsel. Online verfügbar unter https://www.tagesschau.de/inland/innenpolitik/pistorius-bundeswehr-114.html, zuletzt geprüft am 16.12.2025.

DR. MARTINA PHILIPPI

hat 2020 in Philosophie promoviert. Sie ist seit 2025 wissenschaftliche Mitarbeiterin am Lehrstuhl für Politische Theorie der Helmut-Schmidt-Universität/Universität der Bundeswehr Hamburg. Ihre derzeitigen Arbeitsschwerpunkte sind Dual Use und Technikbewertung an der Schnittstelle von Ethik, Hermeneutik und Phänomenologie.

TA TuP Zeitschrift für Technikfolgenabschätzung in Theorie und Praxis
Journal for Technology Assessment in Theory and Practice

oekom science

RESEARCH ARTICLE

Military technology assessment and preventive arms control: Fundamental issues, natural-science peace research, and present challenges

Jürgen Altmann*,[1]

Abstract · Military technologies have so far been largely neglected in technology assessment (TA), even though they can have devastating consequences and their very purpose is to cause damage, injury, and death. While an individual state can establish and enforce rules for civilian technologies, in the anarchic international system there is no higher authority that can regulate military technologies – restrictions and prohibitions can only come about through voluntary agreements between states. Military TA starts with a natural-science/technical analysis, evaluates the results against a set of criteria, and then develops options for preventive restrictions. The article outlines examples from such past and current work, showing that emerging military technologies pose particular challenges for TA.

Militär-Technikfolgenabschätzung und präventive Rüstungskontrolle: Grundlegende Fragen, naturwissenschaftliche Friedensforschung und aktuelle Herausforderungen

Zusammenfassung · *Militärtechnologien wurden bisher in der Technikfolgenabschätzung (TA) weitgehend vernachlässigt, obwohl sie verheerende Auswirkungen haben können und ihr eigentlicher Zweck darin besteht, Schaden, Verletzung und Tod zu verursachen. Während ein einzelner Staat Regeln für zivile Technologien aufstellen und durchsetzen kann, gibt es im anarchischen internationalen System keine übergeordnete Instanz, die militärische Technologien regulieren kann – Einschränkungen und Verbote können nur durch freiwillige Vereinbarungen zwischen Staaten zustande kommen. Militär-TA beginnt mit einer naturwissenschaftlich-technischen Analyse, bewertet die Ergebnisse anhand einer Reihe von Kriterien und entwickelt dann Optionen für präventive Beschränkungen. Im Artikel werden Beispiele aus solchen früheren und aktuellen Arbeiten angeführt, die zeigen, dass neue militärische Technologien die TA vor besondere Herausforderungen stellen.*

Keywords · *military technology assessment, preventive arms control, peace research, emerging technologies*

This article is part of the Special topic "Technology assessment and future warfare: The Good, the Bad, and the Ugly," *edited by K. Weber, M. Bresinsky. https://doi.org/10.14512/tatup.7286*

Introduction: military technology – the neglected field in technology assessment

Usually, technology assessment (TA) is concerned about potential negative impacts from new technologies – affecting humans, the environment, society – and strives to provide information that can help decision makers and society to avoid these effects. Preventing or minimizing death, injury and damage is a routine task in engineering, even before TA, and they occur rarely, mainly in accidents and sometimes from intended misuse by single perpetrators. On the opposite, military technology – central for armed forces – is designed and developed to kill, injure, or destroy from the outset. Thus, it is odd that TA does not often take military uses of technology into view. Text books on TA neglect military issues.[1] But there are exceptions. The Office of Technology Assessment of the US Congress, which operated from 1972/1974 to 1995, had an International Security and Commerce (later: International Security and Space) Program that produced many

* *Corresponding author: juergen.altmann@tu-dortmund.de*
[1] *Experimental Physics III, TU Dortmund University, Dortmund, DE*

https://doi.org/10.14512/tatup.7257
Received: 08. 08. 2025; revised version accepted: 21. 11. 2025; published online: 23. 03. 2026 (peer review)

1 E.g. Paschen et al. 1978; Porter et al. 1980. Even the recent book on TA in a Globalized World (Hennen et al. 2023) does not mention military/war and peace issues.

highly relevant reports. In Germany, the Office of Technology Assessment at the German Bundestag (TAB) has done a handful of preliminary and full studies of military technologies.[2] In the 105 issues of TATuP since 1992 a few articles have covered military technologies.[3]

With the start of natural-science/technical peace research in Germany came important contributions. Following the intermediate-range missile debate and protests of the 1980s, some researchers in Germany turned to problems of disarmament and peace (Kronfeld et al. 1993). A major focus was military TA and preventive arms control – work was done, among others, for the respective TAB project (Petermann et al. 1996). Five groups collaborated to develop a general framework and study specific cases (Altmann et al. 2001). Such work was continued since then in several areas, e.g. biotechnology, plutonium disposition, nanotechnology, and ballistic missile defense. Recently, the acceleration of military technologies has led to increased activities in peace-research institutes and to new professorships in computer science and physics (Reuter et al. 2026).

This article discusses the purpose of military TA, explaining the differences between civilian and military uses. It presents approaches of military TA and methods how threats can be reduced by preventive arms control. Ballistic missile defense serves as an example of an enduring issue. Challenges from new technologies conclude the text.

Two ways of assessing military technologies

The assessment of new military technologies, new military uses of technologies, or new kinds of military systems can have the goal of increasing the combat strength of one's armed forces. Such analyses are routinely done in the planning of armaments as well as of military research and development. Such work much increased after 1945 and led to think tanks such as RAND (2025), long before TA began.

The other approach rather follows the general goal of TA, that is, to avoid harm. Since war consists of the systematic production of harm to overcome the will of an enemy by violent force, a main aim should be the avoidance of war, in particular nuclear war, or, if war cannot be avoided, to limit the damage and suffering. The first aim is enshrined in the UN Charter (Art. 2) and the German Fundamental Law (Art. 26), the second aim is covered by international humanitarian law (the laws of warfare), generally accepted by the states. These lay one foundation of the ethical framework for military TA. Thus, its first task is to investigate whether new military technologies or systems would increase the risk of war or would make war more horrible. The second then is to study ways of preventing such outcomes, possibly by preventive limits on technologies or on their military uses.

A main aim should be the avoidance of war.

There is no strict separation between both approaches. Firstly, analyses in both can come to similar results on a technical level. Secondly, if one accepts that armed forces exist – or if one even finds continued nuclear deterrence important to avoid nuclear war – preventing destabilization is a common motive, and each type of analysis can learn from the other.

Civilian versus military uses of technology

There is a fundamental difference between civilian and military uses of technologies. In civilian life dangerous technologies are regulated to prevent or at least minimize damage, injury, or death. Such regulation takes place within states (often with international co-ordination). Misuse is prohibited and accidents are precluded as far as possible by laws and other regulation; handling may require licenses. The state has the power, means, and personnel to enforce compliance with the set rules. Perpetrators can be prosecuted, brought to court trial, put into jail, etc. The state has far-reaching inspection rights, e.g. on suspicion of non-compliance. Such constraints on individual freedom are broadly accepted for the sake of safety and security of citizens and society.

Military technologies, on the contrary, are designed intentionally to destroy, injure, or kill, selectively or massively. In the international system, still basically anarchic, there is no overarching authority with a monopoly on legitimate violence that could guarantee the security of states, that would be legitimized to set and enforce rules for weapons and armed forces, which would include military uses of technology. Thus, to prepare themselves for aggression by another state, the states maintain armed forces. This creates the security dilemma (Herz 1950): As states strengthen their armed forces for defense against aggression, at the same time they increase the threats towards other states. While each state strives for its own security, the overall outcome at the system level is that the security decreases for all. One way out is arms control, that is, mutual limitation of armaments and forces (Bull 1961/1965). Arms control has three

2 Dealing with: preventive arms control, dual use, space, uncrewed systems, autonomous weapon systems (Petermann et al. 1996; Altmann 2000; Petermann et al. 2003; Petermann and Grünwald 2011; Grünwald and Kehl 2020). For comparison: The total number of TAB Work Reports, excluding annual activity reports, is 188 (TAB 2025a).

3 Found by search in the archive (TATuP 2025) using keywords "Krieg" and "milit*" and counting only the articles directly treating military uses. These covered drones/robots (Geser 2011; Koch and Rinke 2011), autonomous weapon systems (Nass 2022; Tzoufis and Petropoulos 2024), and preventive arms control (Bielefeld and Eurich 2005).

https://doi.org/10.14512/tatup.7257

goals: avoiding war (in particular nuclear war), limiting the damage should war nevertheless occur, and saving expenses. These goals are not automatically consistent, so the first goal should take precedence.

To make arms control legally binding, states conclude international treaties. To make it reliable, mechanisms of verification of compliance are included, by observation from outside or, cooperatively, by on-site inspections. There is a friction between limitations of the armed forces and their motive to gain victory in war, should it occur, and between transparency and military secrecy.

Thus, military uses of technology set a very different context for TA and the ensuing regulation: International agreements are needed, states have to enter them voluntarily, limiting one's armaments or forces is at odds with the motive for higher combat strength, and secrecy creates additional hurdles. Thus, agreeing to arms control can be a tedious process within and among countries.

Military technology assessment – criteria and preventive arms control

Assessment of a new military technology (or its new military uses) needs interdisciplinary research, proceeding in several steps (Altmann 2008). The first is prospective natural-science/technical analysis of the foreseeable applications – what would be the properties of the technology, how would a weapon effect propagate, what would be the effect on a target? In the second step, one investigates military/operational aspects – what would be probable uses, against which targets? How about unusual modes of use? Which collateral damages would be possible? In the third step, one studies potential consequences systematically. Would the technology undermine arms-control and disarmament treaties or violate international humanitarian law? Could it be used for weapons of mass destruction? Could it destabilize the military situation or lead to an accelerated qualitative arms race? Is there a potential for proliferation? Would it bring dangers for humans, the environment or society?

If the assessment is negative in at least one dimension, then in the fourth step options for potential limits need to be considered, including methods and means for the verification of compliance, and the required extent of inclusion of civilian uses. Ideally, then, states would take up such analyses and proposals and would start negotiations, optimally about a legally binding treaty.

Such preventive arms control concerns technologies or systems that are not (yet) introduced into the armed forces. Inclusion of preventive elements succeeded in several arms-control treaties. This is the case with the nuclear test ban treaties (partial 1963, comprehensive 1996), the Conventions banning biological (1972) and chemical (1993) weapons and environment modification (1977), the Nuclear Non-Proliferation Treaty (1968), the Anti-Ballistic Missile (ABM) Treaty (1972–2002, USA-USSR), the Antarctica (1959) and Outer Space (1967) Treaties and the Protocol on Blinding Laser Weapons (1995). Some treaties prohibit not only deployment and use, but also the earlier stages of development and testing, e.g. the Biological and the Chemical Weapons Conventions.

The fundamental situation is the same as sixty, or forty years ago.

Despite such partial successes of preventive arms control, the general qualitative arms race was not significantly slowed down – neither in the Cold War nor after it. Ballistic missile defense provides a case in point.

Ballistic missile defense – an example of military technology assessment

In the Cold War, several scientists advised the governments in the USA and the USSR on military-technical issues, mostly under secrecy rules. Motivated to prevent nuclear war and unintended escalation, some issued warnings to the public, built on technical analyses of the new kinds of weapons that were being researched and developed. An enduring issue has been defense against ballistic missiles. Explaining the technical properties of the intended anti-ballistic missile systems, Richard Garwin and Hans Bethe pointed out in Scientific American that protection from nuclear missiles could not be achieved and that ABM deployments would rather lead to an increase in offensive missiles on the US and Soviet sides (Garwin and Bethe 1968). At the same time Herbert York explained that the introduction of multiple independently targetable reentry vehicles (MIRVs) on ballistic missiles was inseparable from ABM and that "the military power of the United States has been steadily increasing while at the same time our national security has been rapidly and inexorably decreasing. The same thing is happening in the Soviet Union." (York 1970)[4]. Such arguments played a role in the 1972 conclusion by both countries of the ABM Treaty and the SALT I Interim Agreement. ABM systems were limited strictly, strategic missiles moderately, and MIRVs were not prevented.

When in 1983 US President Reagan proposed his "Strategic Defense Initiative" (SDI) in which ballistic missile defense by directed energy weapons in space should render "these nuclear weapons impotent and obsolete" (Reagan 1983), a big study from the American Physical Society (APS) assessed that crucial system elements would need improvements of several orders of magnitude and that space weapons would create threats against

4 Many early texts covering the full field are reprinted in Foradori et al. (2018).

 https://doi.org/10.14512/tatup.7257

satellites, including other space weapons (Bloembergen et al. 1987). This and the reports by the OTA (1985, 1988) – here under the explicit designation as TA –, as well as experiences in SDI research, raised fundamental questions about the feasibility and sensibleness of the program. They were important factors in the decisions of the late 1980s and the early 1990s to direct ballistic missile defense away from beam weapons and from the idea of full nation-wide protection against nuclear attack. Later APS studies investigated defense acting in the boost phase of intercontinental ballistic missiles (ICBMs) (Barton et al. 2004) and studied the effectiveness against ICBMs from North Korea (Lamb et al. 2025), both skeptical.

Recently, motivated by the apparent Israeli success in defense against the Iranian missile attacks of April (accompanied by drones) and October 2024, US President Trump has revived the concept of full defense of the US against all kinds of missiles (Trump 2025). According to independent analysis by experts in missiles and missile defense, Israel stopped only 80 to 85 percent of the (conventionally armed) missiles. Concerning complete protection of the much larger USA against nuclear missiles, the fundamental situation is the same as sixty or forty years ago: It is not a credible possibility for several reasons (Fetter and Wright 2025). It is noteworthy that according to the Executive Order the US "will guarantee its secure second-strike capability" (Trump 2025), that is, US missiles must to be able to overcome any Russian or Chinese missile defenses. But obviously Russia and China will do the utmost to maintain their respective capabilities in the face of increased US defense efforts; the US aspiration for complete asymmetry cannot materialize.

Scientists' warnings were partially heeded in the early 1970s: ABM systems and strategic weapons were limited, but missiles with multiple warheads (MIRVs) proceeded. Similarly, in the 1980s beam weapons in outer space were put on hold, but other defense technologies were pursued. Whether in the present situation rational arguments can again be at least partially successful, remains to be seen.

Challenges from new technologies

Military technologies are on the rise. When one looks at challenges to military stability, international security, and peace from them (Altmann 2020), some issues seem familiar; this holds for ballistic missile defense and military uses of outer space. Hypersonic missiles are related, but more recent. Cyber-war preparations, a subject of military research and development since a few decades, have been studied to quite some extent (Hansel et al. 2018), but open questions remain. The same holds for autonomous weapon systems, where ethical, legal, and stability problems come up (Bhuta et al. 2016; Altmann and Sauer 2017), and for additive manufacturing (Brockmann and Kelley 2018). There are more recent developments that deserve deeper scrutiny – one is synthetic biology including gene editing (Patrick and Barton 2024). Even more radical change could come from body manipulation, e.g., for enhanced soldiers (Matthews and Schnyer 2019). Military uses of artificial intelligence can change many aspects of warfare, in particular leading to much reduced times for warning and reaction, increasing escalation risks (Chernavskikh and Palayer 2025). The new field of quantum technologies raises special problems concerning breaking or securing encrypted information, the design of new biochemical warfare agents, or detection of strategic weapons, in particular submarines, possibly endangering the second-strike capabilities which are a central priority for nuclear-weapon states (Krelina and Altmann 2022).[5]

Technology assessment can help in increasing the weight of political and scientific arguments.

First considerations suggest that for these technologies some questions of the third preventive-arms-control step would be answered in the affirmative. Thus, systematic natural-science-/technological and interdisciplinary research should be done or deepened.

Designing preventive limitations in many of these areas poses significant challenges: one is dual use. Difficult trade-offs will need to be considered. Limitations, definitions, and verification means and methods need to be negotiated between states, in particular between potential enemies. But also, internal negotiations will occur between factions that favor military strength and those that see national security in a wider context, in a framework of international security. All such questions will thus be decided as much by political as by scientific arguments. TA can help in increasing the weight of the latter.

Conclusion

While most of TA focuses on civilian applications of technologies and largely neglects military uses, there are many reasons to widen the scope. One is that the very purpose of military technologies is to produce harm – damage to objects or injury and death to humans. Another is that even if preparations for war are motivated by concerns for one's own security, the combined

5 Note that the TAB has an on-going project on military applications of quantum technologies (TAB 2025b).

https://doi.org/10.14512/tatup.7257

actions in the international system intensify threats and increase the probability of war.

There are good examples of military TA in the Cold War when the main issues were nuclear weapons and their carriers, and arms-control treaties reduced the danger. But military-technology development has not stopped – many kinds of new weapons or other systems have been added or are at the horizon. Military TA is needed more than ever. Even though the present geopolitical situation is extremely unfavorable for preventive arms control, it is important to do this research soon – on the one hand to prepare for a future change for the better, on the other to contribute to such change.

Funding • This article received no funding.

Competing interests • The author declares no competing interests.

Ethical oversight • The author confirms that all procedures were performed in compliance with relevant laws and institutional guidelines.

References

Altmann, Jürgen (ed.) (2000): Dual-use in der Hochtechnologie. Erfahrungen, Strategien und Perspektiven in Telekommunikation und Luftfahrt. Baden-Baden: Nomos.

Altmann, Jürgen (2008): Präventive Rüstungskontrolle. In: Die Friedens-Warte 83 (2–3), pp. 105–126.

Altmann, Jürgen (2020): Technology, arms control and world order. Fundamental change needed. Available online at https://toda.org/assets/files/resources/policy-briefs/t-pb-89_jurgen-altmann.pdf, last accessed on 21.11.2025.

Altmann, Jürgen; Sauer, Frank (2017): Autonomous weapon systems and strategic stability. In: Survival 59 (5), pp. 117–142. https://doi.org/10.1080/00396338.2017.1375263

Altmann, Jürgen et al. (2001): Präventive Rüstungskontrolle. Erste Ergebnisse des Projektes „Präventive Rüstungskontrolle" des Forschungsverbundes Naturwissenschaft, Abrüstung und Internationale Sicherheit (FONAS). In: W&F 2001 (3). Available online at https://wissenschaft-und-frieden.de/dossier/praeventive-ruestungskontrolle/, last accessed on 21.11.2025.

Barton, David et al. (2004): Report to the American Physical Society of the study group on boost-phase intercept systems for national missile defense. Scientific and technical issues. In: Reviews of Modern Physics 76 (3), pp. 1–424. https://doi.org/10.1103/RevModPhys.76.S1

Bhuta, Nehal; Beck, Susanne; Geiß, Robin; Liu, Hin-Yan; Kreß, Claus (eds.) (2016): Autonomous weapon systems. Law, ethics, policy. Cambridge: Cambridge University Press.

Bielefeld, Tom; Eurich, Christian (2005): Science Roadmapping für Rüstungstechnologie-Folgenabschätzung und präventive Rüstungskontrolle. In: TATuP – Journal for Technology Assessment in Theory and Practice 14 (3), pp. 128–134. https://doi.org/10.14512/tatup.14.3.128

Bloembergen, Nicholas et al. (1987): Report to the American Physical Society of the study group on science and technology of directed energy weapons. In: Reviews of Modern Physics 59 (3), pp. 1–201. https://doi.org/10.1103/RevModPhys.59.S1

Brockmann, Kolja; Kelley, Robert (2018): The challenge of emerging technologies to non-proliferation efforts. Controlling additive manufacturing and intangible transfers of technology. Stockholm: SIPRI. Available online at https://www.sipri.org/publications/2018/policy-reports/challenge-emerging-technologies-non-proliferation-efforts-controlling-additive-manufacturing-and, last accessed on 19.01.2026.

Bull, Hedley (1961/1965): The control of the arms race. Disarmament and arms in the missile age. New York, NY: Praeger.

Chernavskikh, Vladislav; Palayer, Jules (2025): Impact of military artificial intelligence on nuclear escalation risk. Stockholm: SIPRI. https://doi.org/10.55163/FZIW8544

Fetter, Steve; Wright, David (2025): Can the iron dome be transmuted into a golden dome? In: The Washington Quarterly 48 (2), pp. 95–114. https://doi.org/10.1080/0163660X.2025.2514916

Foradori, Paolo; Giacomello, Giampiero; Pascolini, Alessandro (eds.) (2018): Arms control and disarmament. 50 years of experience in nuclear education. Cham: Springer. https://doi.org/10.1007/978-3-319-62259-0

Garwin, Richard; Bethe, Hans (1968): Anti-ballistic-missile systems. In: Scientific American 218 (3), pp. 21–31. https://doi.org/10.1038/scientificamerican0368-21

Geser, Hans (2011): Waffensysteme als „derivierte Akteure". Kampfroboter im asymmetrischen Krieg. In: TATuP – Journal for Technology Assessment in Theory and Practice 20 (1), pp. 52–59. https://doi.org/10.14512/tatup.20.1.52

Grünwald, Reinhard; Kehl, Christoph (2020): Autonome Waffensysteme. Endbericht zum TA-Projekt. Arbeitsbericht Nr. 187. Berlin: Büro für Technikfolgen-Abschätzung beim Deutschen Bundestag (TAB). https://doi.org/10.5445/IR/1000127160

Hansel, Mischa; Mutschler, Max; Dickow, Marcel (2018): Taming cyber warfare. Lessons from preventive arms control. In: Journal of Cyber Policy 3 (1), pp. 44–60. https://doi.org/10.1080/23738871.2018.1462394

Hennen, Leonhard; Hahn, Julia; Ladikas, Miltos; Lindner, Ralf; Peissl, Walter; van Est, Rinie (eds.) (2023): Technology assessment in a globalized world. Facing the challenges of transnational technology governance. Cham: Springer. https://doi.org/10.1007/978-3-031-10617-0

Herz, John (1950): Idealist internationalism and the security dilemma. In: World Politics 2 (2), pp. 157–180, 195. https://doi.org/10.2307/2009187

Koch, Bernhard; Rinke, Bernhard (2011): Der militärische Einsatz bewaffneter Drohnen. Zwischen Schutz für Soldaten und gezieltem Töten. In: TATuP – Journal for Technology Assessment in Theory and Practice 27 (3), pp. 38–44. https://doi.org/10.14512/tatup.27.3.38

Krelina, Michal; Altmann, Jürgen (2022): Quantum technologies. A new field that needs assessment. In: Die Friedens-Warte – Journal of International Peace and Organization 95 (3–4), pp. 267–289. https://doi.org/10.35998/fw-2022-0012

Kronfeld, Ulrike; Baus, Wolfgang; Ebbesen, Björn; Jathe, Markus (eds.) (1993): Naturwissenschaft und Abrüstung. Forschungsprojekte an deutschen Hochschulen. Münster: Lit.

Lamb, Frederick et al. (2025): Strategic ballistic missile defense. Challenges to defending the United States. College Park, MD: American Physical Society. Available online at https://res.cloudinary.com/apsphysics/image/upload/v1741185158/APS_BMD_Report_2025_qzgzaz.pdf, last accessed on 21.11.2025.

Matthews, Michael; Schnyer, David (eds.) (2019): Human performance optimization. The science and ethics of enhancing human capabilities. Oxford: Oxford University Press. https://doi.org/10.1093/oso/9780190455132.001.0001

Nass, Elmar (2022): Human dignity and lethal autonomous weapon systems. A Christian ethical positioning from a catholic point of view. In: TATuP – Journal for Technology Assessment in Theory and Practice 31 (3), pp. 58–64. https://doi.org/10.14512/tatup.31.3.58

OTA – U.S. Congress, Office of Technology Assessment (1985): Ballistic missile defense technologies. OTA-ISC-254. Washington, DC: US Government Printing Office.

OTA (1988): SDI. Technology, survivability, and software. OTA-ISC-353. Washington, DC: U.S. Government Printing Office.

Paschen, Herbert; Gresser, Klaus; Conrad, Felix (1978): Technology assessment – Technologiefolgenabschätzung. Ziele, methodische und organisatorische Probleme, Anwendungen. Frankfurt a. M.: Campus.

Patrick, Stewart; Barton, Josie (2024): Mitigating risks from gene editing and synthetic biology. Global governance priorities. Carnegie endowment for international peace. Available online at https://carnegie-production-assets.s3.amazonaws.com/static/files/Patrick_Barton-Biotech%20Governance-final.pdf, last accessed 21.11.2025

Petermann, Thomas; Socher, Martin; Wennrich, Christine (1996): Kontrollkriterien für die Bewertung und Entscheidung bezüglich neuer Technologien im Rüstungsbereich. Arbeitsbericht Nr. 45. Berlin: Büro für Technikfolgen-Abschätzung beim Deutschen Bundestag (TAB). https://doi.org/10.5445/IR/1000103310

Petermann, Thomas; Coenen, Christopher; Grünwald, Reinhard (2003): Militärische Nutzung des Weltraums und Möglichkeiten der Rüstungskontrolle im Weltraum. Sachstandbericht. Berlin: Büro für Technikfolgen-Abschätzung beim Deutschen Bundestag (TAB). https://doi.org/10.5445/IR/1000103294

Petermann, Thomas; Grünwald, Reinhard (2011): Stand und Perspektiven der militärischen Nutzung unbemannter Systeme. Endbericht zum TA-Projekt. Berlin: Büro für Technikfolgen-Abschätzung beim Deutschen Bundestag (TAB). https://doi.org/10.5445/IR/310084510

Porter, Alan; Rossini, Frederick; Carpenter, Stanley; Roper, Thomas; Larson, Rolan; Tiller, Jeffrey (1980): A guidebook for technology assessment and impact analysis. New York, NY: North Holland.

RAND Corporation (2025): Our history. Available online at https://www.rand.org/about/history.html, last accessed on 21.11.2025.

Reagan, Ronald (1983): Strategic defense initiative. President's backup copy. Address on defense, March 23, 1983. Available online at https://www.reaganlibrary.gov/public/2020-06/sdi-speech.pdf, last accessed on 21.11.2025.

Reuter, Christian; Scheffran, Jürgen; Kreutle, Manuel (2026): Naturwissenschaftlich-technische Friedens- und Konfliktforschung. In: Bettina Engels, Hans-Joachim Giessmann, and Bernhard Rinke (eds.): Handbuch Frieden. Wiesbaden: Springer VS.

TAB – Büro für Technikfolgen-Abschätzung beim Deutschen Bundestag (2025a): TAB-Berichte. Available online at https://www.tab-beim-bundestag.de/publikationen.php?tab=%5B962%5D#tabpanel-962, last accessed on 25.11.2025.

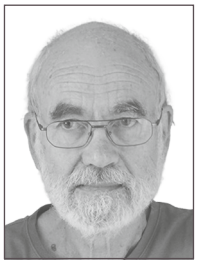
TAB (2025b): Militärische Nutzung von Quantentechnologien. Available online at https://www.tab-beim-bundestag.de/themenfeld-infrastrukturen-und-sicherheit_militarische-nutzung-von-quantentechnologien.php, last accessed on 25.11.2025.

TATuP – Journal for Technology Assessment in Theory and Practice (2025): Archives. Available online at https://www.tatup.de/index.php/tatup/issue/archive, last accessed on 10.07.2025.

Trump, Donald (2025): The iron dome for America. In: The White House, 27.01.2025. Available online at https://www.whitehouse.gov/presidential-actions/2025/01/the-iron-dome-for-america/, last accessed on 25.11.2025.

Tzoufis, Vasilios; Petropoulos, Nikolaos (2024): The commission of crimes using autonomous weapon systems. Issues of causation and attribution. In: TATuP – Journal for Technology Assessment in Theory and Practice 33 (2), pp. 35–41. https://doi.org/10.14512/tatup.33.2.35

York, Herbert (1970): ABM, MIRV, and the arms race. ABM and MIRV require and inspire each other; together they will lessen our national security. In: Science 169 (3942), pp. 257–260. https://doi.org/10.1126/science.169.3942.257



PD DR. JÜRGEN ALTMANN
is a physicist and peace researcher (retired) at TU Dortmund University since 1999, continuing lecturing there. Since 1985 he has studied scientific-technical problems of disarmament. An experimental focus is automatic sensor systems for co-operative verification and IAEA safeguards. Another focus is assessment of new military technologies and preventive arms control.

https://doi.org/10.14512/tatup.7257

oekom science

RESEARCH ARTICLE

Artificial intelligence, semiconductors, and the new geopolitics of security: Why technology assessment must engage in emerging military technologies

Thomas Reinhold*,[1]

Abstract · This conceptual research article examines the accelerating militarization of emerging technologies, particularly artificial intelligence (AI) and semiconductors, and its implications for technology assessment (TA). It highlights how quickly commercial innovation, especially in the field of AI, is integrated into military applications, thereby eluding traditional assessment methods. Drawing on examples from Russia's war against Ukraine and global semiconductor supply chains, the article argues for more agile, technically sound, and interdisciplinary TA approaches. It calls for assessment approaches that account for real-time deployment, dual-use dynamics, and geopolitical competition. Ultimately, it advocates further developing TA to remain relevant amid fast-moving security, technological, and strategic transformations.

***Künstliche Intelligenz, Halbleiter und die neue Geopolitik der Sicherheit**: Warum sich die Technikfolgenabschätzung mit neuen Militärtechnologien befassen muss*

Zusammenfassung · *Dieser konzeptionelle Forschungsartikel untersucht die zunehmende Militarisierung neuer Technologien, insbesondere von künstlicher Intelligenz (KI) und Halbleitern, und ihre Auswirkungen auf die Technikfolgenabschätzung (TA). Es wird aufgezeigt, wie schnell kommerzielle Innovationen, vor allem im Bereich der KI, in militärische Anwendungen integriert werden und sich dabei traditionellen Bewertungsmethoden entziehen können. Anhand von Beispielen aus dem russischen Angriffskrieg auf die Ukraine und den globalen Halbleiter-Lieferketten plädiert der Artikel für flexiblere, technisch fundierte und interdisziplinäre TA-Ansätze. Er fordert Analyseansätze, die den Einsatz in Echtzeit, die Dynamik des doppelten Verwendungszwecks und den geopolitischen Wettbewerb berücksichtigen. Letztlich empfiehlt er eine Weiterentwicklung der TA, um inmitten der schnelllebigen sicherheitspolitischen, technologischen und strategischen Umwälzungen relevant zu bleiben.*

Keywords · *artificial intelligence, semiconductors, technology assessment, emerging technologies*

This article is part of the Special topic "Technology assessment and future warfare: The Good, the Bad, and the Ugly," *edited by K. Weber, M. Bresinsky. https://doi.org/10.14512/tatup.7286*

The challenge of the militarization of emerging technologies

The landscape of technological innovation is undergoing a profound transformation. So-called emerging technologies (Rotolo et al. 2015) are not just incrementally advancing; they are reshaping the tempo, scope, and unpredictability of change – for example, the advancements in robotic autonomy (Knuhtsen et al. 2025) – thus calling upon the field of technology assessment (TA) to explore how to analyze the impact of this development. This article approaches the issue not from the perspective of a traditional TA scholar but from a practitioner at the intersection of technological foresight and political consulting for the areas of military cyber and artificial intelligence (AI) capabilities and the development of arms control measures. This vantage point is based on monitoring defense contractors' demonstrations, strategic white papers, research and grant proposal tenders, or the technical specifications of chips, drones, and AI systems rather than an application of formal TA frameworks. And yet, the core question is comparable: What are the social and political implications

* *Corresponding author: thomas.reinhold@prif.org*
[1] *Peace Research Institute Frankfurt (PRIF), Frankfurt am Main, DE*

https://doi.org/10.14512/tatup.7248
Received: 23. 07. 2025; revised version accepted: 09. 10. 2025; published online: 23. 03. 2026 (peer review)

of specific technologies, and what are policy recommendations for their responsible management?

Nowhere are the challenges posed by emerging technologies more apparent than in military applications, where a qualitative content analysis and comparison of strategic and national security doctrines (Schörnig et al. 2024) reveal, that military realities have partially already overtaken theoretical considerations. Examples are the deployment of small (autonomous) drones or the real-time development and battlefield testing of AI enabled weapon systems. This dynamic of 'on-the-fly' militarization innovations underscores a critical shift. Emerging technologies are no longer being gradually integrated into military systems after long periods of assessment, prototyping, and strategic debate. Instead, they are often pushed into deployment amid ongoing conflicts (Slusher 2025), with a pace that outstrips existing methods for evaluating their broader implications. Meanwhile, normative debates like the discussion on meaningful human control of autonomous weapon systems (Sauer 2020) or the responsible use of military artificial intelligence (Afina and Persi Paoli 2024) are evolving alongside these innovations with the idea of keeping a 'human in the loop' as a guiding normative principle. Yet, especially as such systems grow more capable, these discussions are increasingly outpaced by developments on the ground, where semi- or fully autonomous systems are already being deployed in ways that blur the line between human judgment and machine execution (Watts and Bode 2023).

This pace of contemporary technological change compresses the window of reaction time, which raises fundamental questions for the future of TA: If the goal is to inform decision-making and shape governance before technologies become entrenched, what does this mean when those technologies are already fielded before assessment begins? What kind of methodologies can remain relevant when the frontier of innovation is constantly shifting? And how can TA assess the impact of this development in a way that includes and considers parallel technological progress and inter-technological dependencies and influence?

The following chapters use AI and semiconductor technologies as case studies to conceptually highlight the role of emerging technologies in shaping contemporary geopolitics and security. AI raises questions of autonomy, agency, and algorithmic opacity, while semiconductors underpin modern infrastructure and are increasingly central to global power competition. Together, these cases prompt us to consider whether new forms of anticipatory or adaptive assessment are needed to keep pace with technologies that evolve faster than our understanding.

The impact of commercial artificial intelligence on military transformation

AI has rapidly become one of the central pillars of contemporary military innovation as it plays a foundational role in areas such as surveillance and threat detection (King 2024), real-time support for battlefield decision-making (Nadibaidze et al. 2024) and especially autonomous military systems with or without weapons (Mozur and Satariano 2024). This acceleration of AI into operational relevance is doing more than enhancing military capabilities. It is altering the tempo of warfare itself (Zeff 2025) and pushing decision-making toward real-time responsiveness, often supported or even initiated by machines. A key factor in this rapid integration is the dominant role of large, global technology companies in AI development. These firms – spanning the U.S., China, and, to some extent, Europe (Merle 2024) – drive progress in AI research. Although primarily aimed at consumer markets, their pace in funding and release cycles outpaces military research and development (Maslej 2025), making them natural feeders into defense applications. The dual pressure of return on investment and high demand from military and security organizations leads to the rapid embedding of successful AI models into security-relevant systems. Military planners are increasingly turning to commercial off-the-shelf solutions (Reuters 2025) and adapting them rather than building from scratch.

The war in Ukraine offers vivid examples of this transformation. Both Ukrainian (Matlack et al. 2025) and Russian forces (Stepanenko 2025) have employed swarms of small drones for reconnaissance, targeting, and direct strikes. Many are equipped with autonomous navigation systems and, in some cases, rudimentary target identification or loitering behavior. Ukraine has launched successful drone attacks deep into Russian territory using modified commercial technologies, targeting strategic assets such as long-range bombers, airfields, and logistical hubs. These innovations are not developed through traditional procurement pipelines but are improvised, deployed, and iteratively improved on the battlefield (Bondar 2025). This cycle is measured in weeks, not years, with companies gathering hands-on experience directly in conflict zones (Loh 2025).

One of the key drivers of this evolution is autonomous functionality (Suckau 2024), which – even when limited or semi-supervised – lets machines operate without direct human control. These autonomous vehicles, like unmanned/uncrewed aerial vehicles, unmanned/uncrewed ground vehicles or unmanned/uncrewed underwater vehicles are often introduced for pragmatic reasons, such as reducing response time, resisting electronic warfare, or extending the operation radius beyond reliable accessibility via traditional radio connections. Such capabilities rely heavily on AI and machine learning (Garikapati and Shetiya 2024) to provide the necessary degree of flexibility and adaptability of the vehicle's operation in order to avoid obstacles, react to situational conditions, select and track targets, or engage them. Both Ukrainian and Russian forces have incorporated AI-driven systems in agile and adaptive ways. Ukraine has retrofitted commercial drones with AI (Collett-White et al. 2024), sometimes based on publicly available tools (Rudra 2025) whereas Russia is experimenting with AI-enhanced Shahed drones to improve target selection and tracking. A second major driver is the use of AI for decision-making and support (Bovet 2025). AI systems aggregate and process intelligence data at a scale and speed far beyond human capabilities. In Eastern Ukraine, trench warfare

https://doi.org/10.14512/tatup.7248

is increasingly complemented by AI-powered surveillance tools that scan enemy movements, simulate courses of action, and manage logistics (Ministry of Defence of Ukraine 2025). Algorithms coordinate drone patrols, optimize supply chains, and assist with casualty evacuation. AI is now embedded at every level of combat – from tactical ground operations to strategic command centers.

The convergence of commercial innovation and military application presents a challenge for technology assessment.

Similar dynamics can be observed in Western defense initiatives like Germany's 'Zeitenwende.' Start-ups such as Helsing have partnered to integrate AI in real-time combat systems, including drone coordination and jet dogfights (Sprenger 2025). U.S.-based Anduril builds autonomous drones, surveillance platforms, and intelligent sensors powered by AI to automate threat responses (O'Donnell 2024). These companies, structured like start-ups with flat hierarchies and agile processes, can rapidly meet military needs and often embrace the concept of 'software defined defense' (BMVg 2023), using off-the-shelf hardware with updatable software, which accelerates innovation.

This convergence of commercial innovation and military application presents a challenge for TA. Traditional approaches – relying on long-term forecasting and stakeholder dialogue – struggle under the compressed timelines of AI development and deployment. TA must now function amid real-time testing and iteration and must address military AI not as a derivative of civilian tech but as co-developed through civilian market dynamics and military urgency.

Semiconductors: the backbone of artificial intelligence and subject of geopolitical competition

While much of the public debate around artificial intelligence focuses on software, algorithms, and data, this explosive growth of AI would not have been possible without the underlying hardware: semiconductors. These microelectronic components are the backbone of AI, especially for current generation AI systems like large language models (LLM), as their training as well as their application requires huge quantities of computer chips. ChatGPT 5, for instance, the current state-of-the-art LLM from OpenAI, has – according to estimates – needed 200.000 processing chips just for training the system (Moss 2025) and uses even more for providing the system to end users and business applications over the coming years (Caswell 2025). Regardless of the exact amount, these numbers point to a clear direction, as nearly every advancement in machine learning, computer vision, autonomous navigation, or military IT applications like battlefield decision-support systems depends on processing vast volumes of data at high speed and low latency – something only possible through cutting-edge semiconductor technologies. In this sense, any discussion about the development of autonomous systems, AI, and its implications is also a discussion about semiconductors. From an analytical standpoint, semiconductors could serve as a prime focus area for TA. It offers the advantage of a specific technology with measurable and quantifiable parameters whose technical progress is relatively visible and public due to the intense competition among companies for market dominance in this domain.

Semiconductors are among the most technically complex artifacts ever produced. The latest chips feature billions of transistors etched onto nanometer-scale silicon wafers using extreme ultraviolet (EUV) lithography – a process requiring a level of precision and purity that only a handful of actors worldwide can achieve. These chips enable AI computation, whether in the form of general-purpose graphics processing units designed for parallel computation, specialized tensor processing units optimized for AI workloads, application-specific integrated circuits custom-built for particular tasks, high-bandwidth memory chips, or ultra-fast networking semiconductors. Advances in these types of hardware – alongside breakthroughs in cooling systems, networking, and energy optimization – are occurring on ever-shorter cycles. A powerful illustration of this acceleration can be found in the evolution of AI models themselves. In late 2022, ChatGPT 1.0 demonstrated the potential of LLM for general-purpose dialogue and reasoning. Since then, the landscape has advanced dramatically: OpenAI's Veo-3 brings AI-generated video closer to photorealism; Meta's Llama 3 and other frontier models now approach multi-modal understanding; and reasoning agents have started to move beyond static responses toward complex situational decision-making (Delovski 2024). Sam Altman, CEO of OpenAI, and others now openly discuss pathways toward artificial general intelligence – a form of AI capable of performing any intellectual task a human can, reflecting a generalized, human-like understanding and cognitive flexibility (Frazier et al. 2024). This step, although controversial in terms of technical feasibility, would redefine the boundaries between human and machine cognition. These leaps result in qualitative transformations – 'capability jumps' that redefine what is technologically possible.

But these technological capabilities and their underlying complexity come with strategic fragility. The production of advanced semiconductors relies on highly globalized supply chains (Sullivan 2025), involving the design capabilities of U.S.-based firms like NVIDIA, AMD, and Intel; fabrication facilities concentrated in Taiwan, like Taiwan Semiconductor Manufacturing Com-

pany Limited; EU-based suppliers like the advanced semiconductor materials lithography (ASML) Holding, which produces the world's only EUV lithography machines; and raw materials sourced from politically unstable regions, including rare earths from Africa and noble gases from Ukraine. This fragmented yet tightly interdependent supply chain means that geopolitical tensions can quickly disrupt the production and distribution of critical hardware. At the forefront of this competition are the United States and China (Frazier 2025), locked in a rapidly escalating technological rivalry. Both countries view dominance in AI and semiconductors not merely as a pathway to economic growth but as a national security imperative (Allen 2025). The U.S. has introduced sweeping export controls on high-end chips, chip design software, and semiconductor manufacturing equipment and pressured key equipment suppliers such as the Dutch company ASML to restrict maintenance and support for advanced lithography machines previously sold to China (Allen and Goldston 2025). These measures aim to limit China's access to the technologies essential for training large AI models and building advanced military systems. In response, China has poured billions into developing a domestic semiconductor ecosystem and launched numerous state-supported AI labs and companies (Chang et al. 2025).

An example of this high-stakes contest is DeepSeek, a Chinese AI company that frequently draws attention for publishing models claimed to rival Western competitors (Baptista 2025). While the technical success behind such models remains debated (Rubstov 2025), this underscores the aggressiveness and volatility of the AI race, as models emerge rapidly – often backed by massive state or private investment – only to fragment, pivot, or vanish under geopolitical pressure, hardware constraints, or commercial hurdles. A particularly notable case occurred when DeepSeek announced its R1 model in early 2025, claiming competitive performance at significantly lower hardware costs. Nvidia's stock price dropped approximately 17–18 % in a single day (Mortimer and Page 2025), as investors feared DeepSeek's breakthroughs might reduce demand for Nvidia's expensive hardware. Even though the loss was quickly offset, it illustrates the financial pressure created by high development costs and the influence of technical disruption in the AI ecosystem.

Between the U.S. and China, Europe faces a complex challenge. It is deeply dependent on technologies across the global AI and semiconductor stack, from fabrication to cloud infrastructure. However, it also hosts some of the most critical chokepoints in global chip production. Companies like ASML in the Netherlands and Carl Zeiss SMT in Germany (key optical suppliers for ASML's chipmaking machines) have become geopolitical actors due to their irreplaceable technologies (European Court of Auditors 2025). As the U.S. restricts exports to China, these European firms are drawn into compliance regimes reflecting U.S. interests over EU sovereignty, while simultaneously gaining leverage to strengthen Europe's strategic position.

For Taiwan, the main site of advanced chip manufacturing, these dependencies are not just economic – they are central to national security, forming what is known as the 'Silicon Shield' (Wu 2024). This concept, which highlights Taiwan's centrality to global chipmaking, illustrates the interplay between technology and security policy, where the island's semiconductor role acts as a deterrent to aggression, given that disruptions could trigger global crises and geopolitical escalation.

These technological capabilities and their underlying complexity come with strategic fragility.

Layered on top of these dynamics is the issue of rare earths and critical materials, which form the invisible substrate of both AI systems and chip production. China dominates the extraction and processing of many key inputs, including neodymium (used in magnets), gallium, and germanium – vital for semiconductors and sensors (Teer et al. 2024). The U.S. and Europe have responded with strategies to diversify supply chains, build processing capacity, and invest in recycling technologies. However, these efforts trail behind the scale and integration of China's supply chains. Even with design and fab capacity in place, a material bottleneck could paralyze production.

In sum, the AI-semiconductor-nexus is a geopolitical pressure point where technological evolution, economic rivalry, and military strategy converge. The 'chip war' is not only about industrial competition – it is about strategic autonomy, resilience, and first-mover advantage in future security architectures.

Recommendations for an effective and relevant technology assessment

Being not a classic TA scholar, I rather approach technologies as a technician and analyst: focusing on what they can do now, where they're headed, and how quickly these developments proceed. My analysis is based on qualitative content analysis of relevant national doctrines (Schörnig et al. 2024) and grounded in capability tracking, the assessment of technical limits, deployment timelines, and the identification of starting points for regulatory measures rather than an application of formal TA frameworks. That said, my vantage point reinforces the growing importance of TA as we are living through rapid technological shifts. AI, once seen as speculative, is starting to inform military decisions, and chip development outpaces procurement cycles. Conflicts like Ukraine's are not only exposing these tools – they

are actively shaping them. The key issue isn't just capability, but speed of change and emerging strategic turning points.

The problem I observe is the current mismatch between this pace and nature of innovation and the methodological tools used to assess them. Many analytical frameworks remain too slow, too linear, and too disconnected from the systems they aim to evaluate. They often rely on models of risk anticipation and societal deliberation that presuppose a certain amount of time, stability, and clarity of trajectory – all of which are increasingly absent in the domains of AI and semiconductors. What kind of assessment, then, might be better suited to this reality?

First, analytical frameworks must be agile and more technologically grounded. This can be achieved for AI, for instance, by including the analysis of the technological architectures, the source code of systems, hardware constraints, and data dependencies. Taking these aspects into account could help to keep track of swift innovations that can shift the development directions or a change in the meaning of individual components of a technical system as a whole. For example, a currently cutting-edge AI system may become quickly obsolete through changes in chip efficiency, bandwidth limitations, or model advancements of competitors. These are deeply technical issues, but their consequences can have a strong impact in terms of geopolitical power and the necessary policy adjustments.

The key issue isn't just capability, but speed of change and emerging strategic turning points.

Second, assessments must actively engage with security policy and defense strategy, taking into account the dual-use nature of emerging technologies. As discussed earlier, technologies developed for consumer purposes – such as image recognition or predictive analytics – are getting adapted by military companies, weaponized, or integrated into military decision-making systems. The current AI ecosystem underlines, that commercial companies are no longer just a part of a bigger picture, but the core innovator, driver, and provider of security-relevant technologies, thus becoming the rule-setter of what capabilities and limitations exist.

Third, analytical assessments need to draw on interdisciplinary expertise. This includes fields that are often underrepresented in such contexts: computer science and semiconductor engineering. Only the collaboration between these disciplines can track the full lifecycle of a technology, from initial development to deployment and adaptation in scenarios – including their impact analysis. This also enables the identification of critical supply-chain dependencies, such as those discussed in the context of chip manufacturing or rare earth supplies – dependencies that may be invisible to purely social or ethical assessments but decisive in times of crisis. Of course, interdisciplinary work is no one-way responsibility but requires an equal willingness to cooperate on the part of the engineering and natural sciences. This includes finding a common language, understanding and accepting the concepts and constraints of politics, and the willingness to evaluate one's own scientific achievements in a social and security-related context. Within this context, TA has a unique opportunity to help classify and prioritize emerging technologies by providing structured analysis that highlights critical chokepoints, infrastructure bottlenecks, or design vulnerabilities – insights that are urgently needed for political decision-making.

Finally, this means that TA should adapt its principles to a new landscape. Participatory and normative approaches still matter, especially in defining acceptable use conditions and governance frameworks. But these approaches must be integrated with real-time capability tracking, technical scenario modeling, and system-level diagnostics, thus becoming more iterative, more exploratory, and more strategically aware.

I do not claim to have the methodological blueprint for this transformation, nor come these recommendations from an empirical study. What I can offer are insights from my fieldwork and technical analysis, hoping that these fragments might help to point out where TA might need to stretch, collaborate, and evolve in a world where emerging technological changes are no longer incremental but exponential – and where their consequences are being written in real time on the battlefield, in code, and in silicon.

Funding • This article received no funding.

Competing interests • The author declares no competing interests.

Ethical oversight • The author confirms that all procedures were performed in compliance with relevant laws and institutional guidelines.

References

Afina, Yasmin; Persi Paoli, Giacomo (2024): Governance of artificial intelligence in the military domain. A multi-stakeholder perspective on priority areas. Geneva: UNIDIR. Available online at https://unidir.org/publication/governance-of-artificial-intelligence-in-the-military-domain-a-multi-stakeholder-perspective-on-priority-areas/, last accessed on 24.11.2025.

Allen, Gregory (2025): DeepSeek, Huawei, export controls, and the future of the U.S.-China AI Race. Washington, DC: CSIS. Available online at https://www.csis.org/analysis/deepseek-huawei-export-controls-and-future-us-china-ai-race, last accessed on 24.11.2025.

Allen, Gregory; Goldston, Isaac (2025): Understanding U.S. allies' current legal authority to implement AI and semiconductor export controls. Washington, DC: CSIS. Available online at https://www.csis.org/analysis/understanding-us-allies-current-legal-authority-implement-ai-and-semiconductor-export, last accessed on 24.11.2025.

Baptista, Eduardo (2025): Explainer. What is DeepSeek and why is it disrupting the AI sector? In: Reuters, 28.01.2025. Available online at https://www.reuters.com/technology/artificial-intelligence/what-is-deepseek-why-is-it-disrupting-ai-sector-2025-01-27/, last accessed on 17.10.2025.

BMVg – Bundesministerium der Verteidigung (2023): Software defined defence. Positionspapier des BDSV, BDLI, Bitkom und BMVg. Berlin: Bundesministerium der Verteidigung. Available online at https://www.bmvg.de/resource/blob/5711942/6fb70a45412601fdf03f63aeebf72451/cyber-defined-defence-papier-data.pdf, last accessed on 24.11.2025.

Bondar, Kateryna (2025): Ukraine's future vision and current capabilities for waging AI-enabled autonomous warfare. Washington, DC: CSIS. Available online at https://www.csis.org/analysis/ukraines-future-vision-and-current-capabilities-waging-ai-enabled-autonomous-warfare, last accessed on 24.11.2025.

Bovet, Peter (2025): Exploring decision advantages. Improving speed, precision and efficiency in military targeting by applying artificial intelligence. Stockholm: Swedish Defence University. https://doi.org/10.62061/leiy7136

Caswell, Amanda (2025): Why OpenAI wants 100 million GPUs – and how it could supercharge ChatGPT. In: Tom's Guide, 22.07.2025. Available online at https://www.tomsguide.com/ai/sam-altmans-trillion-dollar-ai-vision-starts-with-100-million-gpus-heres-what-that-means-for-the-future-of-chatgpt-and-you, last accessed on 17.10.2025.

Chang, Wendy; Arcesati, Rebecca; Hmaidi, Antonia (2025): China's drive toward self-reliance in artificial intelligence. Berlin: Mercator Institute for China Studies. Available online at https://merics.org/en/report/chinas-drive-toward-self-reliance-artificial-intelligence-chips-large-language-models, last accessed on 24.11.2025.

Collett-White, Mike; Dutta, Prasanta; Zafra, Mariano (2024): How Ukraine pulled off an audacious drone attack deep inside Russia. Months of planning went into a covert operation that relied on cheap, short-range drones. In: Reuters, 05.06.2025. Available online at https://www.reuters.com/graphics/UKRAINE-CRISIS/DRONES-RUSSIA/mypmjzayyvr/, last accessed on 17.10.2025.

Delovski, Boris (2024): A brief history of GPT models. Available online at https://www.edlitera.com/blog/posts/gpt-models-history, last accessed on 17.10.2025.

European Court of Auditors (2025): The EU's strategy for microchips. Luxembourg: Publications Office of the European Union. https://doi.org/10.2865/0902427

Frazier, Kevin (2025): What comes next in AI regulation? In: Lawfare, 28.07.2025. Available online at https://www.lawfaremedia.org/article/what-comes-next-in-ai-regulation, last accessed on 17.10.2025.

Frazier, Kevin; Rozenshtein, Alan; Salib, Peter (2024): OpenAI's latest model shows AGI is inevitable. Now what? In: Lawfare, 23.12.2024. Available online at https://www.lawfaremedia.org/article/openai's-latest-model-shows-agi-is-inevitable.-now-what, last accessed on 17.10.2025.

Garikapati, Divya; Shetiya, Sneha (2024): Autonomous vehicles. Evolution of artificial intelligence and learning algorithms. In: arXiv. https://doi.org/10.48550/arXiv.2402.17690

King, Anthony (2024): Digital targeting. Artificial intelligence, data, and military intelligence. In: Journal of Global Security Studies 9 (2), p. ogae009. https://doi.org/10.1093/jogss/ogae009

Knuhtsen, Reyk; Patel, Dylan; Ciminelli, Niko; Ryu, Joe; Ghilduta, Robert; Ontiveros, Jeremie Eliahou (2025): Robotics Levels of Autonomy. SemiAnalysis, published on 30 July 2025. Available online at https://newsletter.semianalysis.com/p/robotics-levels-of-autonomy, last accessed on 04.02.2026

Loh, Matthew (2025): Western arms makers can now live-test their prototype weapons on the battlefield against Russia's forces. In: Business Insider, 18.07.2025. Available online at https://www.businessinsider.com/ukraine-testing-western-weapon-prototypes-russian-forces-combat-2025-7, last accessed on 17.10.2025.

Maslej, Nestor (ed.) (2025): Artificial intelligence index report 2025. Stanford, CA: Stanford Institute for Human-Centered Artificial Intelligence (HAI). Available online at https://hai.stanford.edu/ai-index/2025-ai-index-report, last accessed on 24.11.2025.

Matlack, Jon-Wyatt; Schwartz, Sebastian; Gill, Oliver (2025): Ukraine's drone ecosystem and the defence of Europe. Lessons lost can't be learned. London: LSE IDEAS. Available online at https://www.lse.ac.uk/ideas/publications/Research-Reports/Ukraine's-Drone-Ecosystem-and-the-Defence-of-Europe-Lessons-Lost-Can't-be-Learned, last accessed on 24.01.2025.

Merle, Quentin (2024): Chips supply chain. Bifurcation and localization. In: CSS Analyses in Security Policy. https://doi.org/10.3929/ETHZ-B-000680146

Ministry of Defence of Ukraine (2025): Enemy equipment detected in 2 seconds. The ministry of defence showcased delta and Avengers systems at the London defence conference. Available online at https://mod.gov.ua/en/news/enemy-equipment-detected-in-2-seconds-the-ministry-of-defence-showcased-delta-and-avengers-systems-at-the-london-defence-conference, last accessed on 17.10.2025.

Mortimer, Ian; Page, Matthew (2025): How has DeepSeek affected the AI market for investors? In: Guinness Global Investors, 24.02.2025. Available online at https://www.guinnessgi.com/insights/how-has-deepseek-affected-ai-market-investors, last accessed on 17.10.2025.

Moss, Sebastian (2025): OpenAI says its compute increased 15x since 2024, company used 200k GPUs for GPT-5. As company releases its latest generative AI model. In: Data Center Dynamics, 07.08.2025. Available online at https://www.datacenterdynamics.com/en/news/openai-says-its-compute-increased-15x-since-2024-company-used-200k-gpus-for-gpt-5/, last accessed on 17.10.2025.

Mozur, Paul; Satariano, Adam (2024): A.I. begins ushering in an age of killer robots. In: The New York Times, 02.07.2024. Available online at https://www.nytimes.com/2024/07/02/technology/ukraine-war-ai-weapons.html, last accessed on 17.10.2025.

Nadibaidze, Anna; Bode, Ingvild; Zhang, Qiaochu (2024): AI in military decision support systems. A review of developments and debates. Odense: Center for War Studies. Available online at https://www.sdu.dk/en/forskning/forskningsenheder/samf/cws/cws-activities/2024/ai-gammel, last accessed on 24.11.2025.

O'Donnell, James (2024): We saw a demo of the new AI system powering Anduril's vision for war. In: MIT Technology Review. Available online at https://www.technologyreview.com/2024/12/10/1108354/we-saw-a-demo-of-the-new-ai-system-powering-andurils-vision-for-war/, last accessed on 17.10.2025.

Reuters (2025): US defense department awards contracts to Google, Musk's xAI. In: Reuters, 14.07.2025. Available online at https://www.reuters.com/business/autos-transportation/us-department-defense-awards-contracts-google-xai-2025-07-14/, last accessed on 17.10.2025.

Rotolo, Daniele; Hicks, Diana; Martin, Ben (2015): What is an emerging technology? In: Research Policy 44 (10), S. 1827–1843. https://doi.org/10.1016/j.respol.2015.06.006

Rubstov, Alexey (2025): AI supply chain shocks. Insights from DeepSeek R1. Toronto: Global Risk Institute. Available online at https://globalriskinstitute.org/publication/ai-supply-chain-shocks-insights-from-deepseek-r1/, last accessed on 24.11.2025.

Rudra, Sourav (2025): This open source software was used in Ukraine's drone attack on Russia. Is this a turning point for open source software in warfare? In:

https://doi.org/10.14512/tatup.7248

Its FOSS, 04.06.2025. Available online at https://news.itsfoss.com/open-source-drone-attack/, last accessed on 17.10.2025.

Sauer, Frank (2020): Stepping back from the brink. Why multilateral regulation of autonomy in weapons systems is difficult, yet imperative and feasible. In: International Review of the Red Cross 102 (913), pp. 235–259. https://doi.org/10.1017/S1816383120000466

Schörnig, Niklas; Suckau, Liska; Korkusuz, Abdullah; Reinhold, Thomas (2024): Emerging disruptive technologies. Neue Militärtechnologien in nationalen Sicherheitsstrategien – eine vergleichende Analyse. In: CNTR Monitor. 2024. Perspektiven auf Dual Use. Frankfurt a. M.: Peace Research Institute, pp. 58–77. https://doi.org/10.48809/cntr2024

Slusher, Matthew (2025): Lessons from the Ukraine conflict. Modern warfare in the age of autonomy, information, and resilience. Washington, DC: CSIS. Available online at https://www.csis.org/analysis/lessons-ukraine-conflict-modern-warfare-age-autonomy-information-and-resilience, last accessed on 24.11.2025.

Sprenger, Sebastian (2025): Saab, Helsing let Gripen fighter fly with AI in charge. In: Defense News, 11.06.2025. Available online at https://www.defensenews.com/global/europe/2025/06/11/saab-helsing-let-gripen-fighter-fly-with-ai-in-charge/, last accessed on 17.10.2025.

Stepanenko, Kateryna (2025): The battlefield AI revolution is not here yet. The status of current Russian and Ukrainian AI drone efforts. Washington, DC: Institute for the Study of War. Available online at https://understandingwar.org/research/russia-ukraine/the-battlefield-ai-revolution-is-not-here-yet-the-status-of-current-russian-and-ukrainian-ai-drone-efforts/, last accessed on 24.11.2025.

Suckau, Liska (2024): The limits of autonomy. Critically assessing factors limiting full autonomy of military uncrewed ground vehicles. Frankfurt a. M.: Peace Research Institute Frankfurt. https://doi.org/10.48809/prifspot2406

Sullivan, Helen (2025): A journey through the hyper-political world of microchips. In: The Guardian, 28.02.2025. Available online at https://www.theguardian.com/technology/2025/feb/28/inside-the-mind-bending-tin-blasting-and-hyper-political-world-of-microchips, last accessed on 10.11.2025.

Teer, Joris; Seaman, John; Caruso, Alessia (2024): EUISS intra-EU workshop outcomes. Starting with the end in mind. De-risked gallium, germanium, and rare earth value chains by 2030. Paris, France, 09.12.2024. Available online at https://www.iss.europa.eu/sites/default/files/2025-03/EUISS%20workshop%20outcomes%3B%20De-risked%20Ga%20Ge%20and%20REE%20value%20chains%20-%20FINAL.pdf, last accessed on 24.11.2025.

Watts, Tom; Bode, Ingvild (2023): Loitering munitions and unpredictability. Autonomy in weapon systems and challenges to human control. Odense: Center for War Studies. Available online at https://www.sdu.dk/en/forskning/forskningsenheder/samf/cws/cws-activities/2023/loitering-munitions-unpredictability, last accessed on 24.11.2025.

Wu, Emily (2024): 'Silicon Shield'. Looking beyond semiconductors. Washington, DC: United States Institute of Peace. Available online at https://www.usip.org/publications/2024/01/silicon-shield-looking-beyond-semiconductors, last accessed on 24.11.2025.

Zeff, Maxwell (2025): The Pentagon says AI is speeding up its 'kill chain'. In: TechCrunch 09.01.2025. Available online at https://techcrunch.com/2025/01/19/the-pentagon-says-ai-is-speeding-up-its-kill-chain/, last accessed on 17.10.2025.

DR. THOMAS REINHOLD
is a researcher at the Research Department International Security and the Cluster for Natural and Technical Science Arms Control Research (CNTR) at PRIF, the Peace Research Institute Frankfurt. He conducts research on the militarization of cyberspace, AI and possibilities for arms control and disarmament of these technologies.

TATuP Zeitschrift für Technikfolgenabschätzung in Theorie und Praxis
Journal for Technology Assessment in Theory and Practice

oekom science

RESEARCH ARTICLE

Future warfare and robust healthcare: Entangling technology assessment and nursing science

Miriam Läpple*,[1], Hanna Wüller[2]

Abstract · Nursing plays a decisive role in coping with crises situations. Nursing concepts are therefore particularly relevant in times of war and for warfare. In this article, we argue for an entanglement of technology assessment and nursing and show how they can enrich each other. Technology assessment can learn from nursing by applying principles such as high proficiency, efficient organizational structures, and decentralization to develop robust healthcare technology. Conversely, nursing can learn from technology assessment by adopting methods of influence and policy advice and adapting them to its own needs. Through this entanglement, the two disciplines can jointly lay the foundations for a more robust healthcare system in Germany.

Zukünftige Kriegsführung und robuste Gesundheitsversorgung: Verflechtung von Technikfolgenabschätzung und Pflegewissenschaft

Zusammenfassung · *Bei der Bewältigung von Krisensituationen spielt die Gesundheits- und Krankenpflege eine entscheidende Rolle. Pflegekonzepte sind deshalb in Kriegszeiten und für die Kriegsführung besonders relevant. In diesem Artikel plädieren wir für eine Verflechtung von Technikfolgenabschätzung und Krankenpflege und zeigen auf, wie sie sich gegenseitig bereichern können. Die Technikfolgenabschätzung kann von der Pflege lernen, indem sie Prinzipien wie hohe Fachkompetenz, effiziente Organisationsstrukturen und Dezentralität zur Entwicklung robuster Gesundheitstechnologien anwendet. Umgekehrt kann die Pflege von der Technikfolgenabschätzung lernen, indem sie Methoden der Einflussnahme und Politikberatung übernimmt und an ihre eigenen Bedürfnisse anpasst. Durch diese Verflechtung können beide Disziplinen gemeinsam die Grundlagen für eine robustere und effektivere Gesundheitsversorgung in Deutschland schaffen.*

Keywords · *vulnerability, agential realism, nursing, healthcare, robustness*

This article is part of the Special topic "Technology assessment and future warfare: The Good, the Bad, and the Ugly," *edited by K. Weber, M. Bresinsky. https://doi.org/10.14512/tatup.7286*

Introduction

Nursing deals with crises on a disciplinary basis to ensure the provision of healthcare (Gebbie et al. 2022) and needs to consider humans, non-humans, situations, and environments in its concepts more than ever. At the same time, technology assessment (TA) considers policy, politics and societal values.

To achieve robustness[1] in German healthcare under different types of crises, we invite our readers to consider combining TA and nursing science to entangle disciplines and improve professional concepts and practice. We reflect on the following questions: How can nursing science benefit from concepts of TA, and vice versa? We use types of warfare, such as physical and cyberwarfare, as examples; however, our thoughts strive for universal applicability in any crisis. To answer these questions, we use the concepts of agential realist vulnerability, primary nursing, and TA concepts, such as scenario building, investigation of social and disciplinary values, and formats for expert and citizen dialogue and policy advice. First, we explore the relationship between nursing and warfare and then present nursing concepts that

* *Corresponding author: mlaepple@uni-koblenz.de*
[1] *Institut für Pflegewissenschaft, University of Koblenz, Koblenz, DE*
[2] *Faculty of Management, Culture and Technology, Osnabrück University of Applied Sciences, Osnabrück, DE*

https://doi.org/10.14512/tatup.7252
Received: 08. 06. 2025; revised version accepted: 20. 10. 2025; published online: 23. 03. 2026 (peer review)

1 Lecocq (2024) proposed the concept of robustness – originating from biology and evolutionary principles – in healthcare as a mixture of redundancy, heterogeneity, and apparent waste, among others, to cope with fluctuations, unexpected situations, and environmental changes. Lecocq argues that healthcare institutions should orient themselves on these principles to adapt to changing conditions rather than focusing on optimization and efficiency.

can be entangled with TA. Finally, we propose concrete examples of this entanglement to promote robustness in healthcare.

The relationship of healthcare, nursing, and warfare

Healthcare is essential for promoting, maintaining, and restoring health, and it plays a crucial role in quality of life. It is a key target within the United Nations' Sustainable Development Goals for global development until 2030 (UN 2023; WHO and UNICEF 2022). In the European Union, healthcare is subject to organizational and technical requirements. This is because it is defined as a critical sector (EU 2022). It is essential for maintaining national security and functioning, economic stability, and public goods.[2] In Germany, the Federal Office of Civil Protection and Disaster Assistance has promoted strategies for Critical Sector Protection to prevent risks (BBK 2008, 2020). However, it is not just about avoiding risks; it is also about managing and dealing flexibly with challenges in both daily life and crises.

Nursing is a vital part of healthcare. It addresses health promotion, prevention, cure, rehabilitation, and palliation. Nursing focuses on environmental and situational conditions that influence health and illness. Its goal is to provide access to healthcare (White et al. 2025). In Germany, the Social Code Books (Sozialgesetzbuch, SGB) V and XI clearly state that nursing is centered on three key areas: life stages of illness, rehabilitation, and palliation at the end of life. There is a strong emphasis on cure and long-term care.[3] In contrast, international contexts recognize the broader role of nurses in preventive and health-promotional measures. Nurses are generally in close contact with patients, their families, and other healthcare professionals. This puts them in a unique position to manage care from an overarching perspective.

Nursing has always been tasked with military readiness, and war has provided nursing with the opportunity to demonstrate its contributions to healthcare to the wider public. War has led to exceptional situations that require informal decision-making and action on battlefields (Tschudin and Schmitz 2003). Florence Nightingale and Mary Seacole are prime examples of nurses who established independent support structures in the Crimean War in 1853 (McDonald 2012). Nightingale's work in war allowed her to observe, document, and analyze the situational and environmental conditions and consequences of war-related logistics on health outcomes (Fee and Garofalo 2010).

Warfare has evolved over time, and nurses must adapt their tasks accordingly. For this paper, we use a model that describes the transformation of strategies, tactical operations, different aims, and types of arms as generations of warfare. These generations do not replace each other; they overlap (Tsetos 2023): The first to third generations aim to incapacitate soldiers and destroy war equipment physically using various firearms, soldier formations, and other forms of weaponry. Nurses are among the first responders in combat zones, providing medical care and transporting the injured to military hospitals (Fink and Milbrath 2023; D'Antonio 2002). The use of bombs also affects civilians in the interior of the country, who are cared for by nurses. The fourth generation focuses on indirect warfare. It involves influencing democratic states by acting aggressively in cyberspace. This includes election interference and hacking of governmental institutions. This directly impacts civil life, creates uncertainty, and imposes considerable public and psychological pressure on state-level decision-makers. The consequences of these actions could lead to riots and widespread unrest. The fifth generation, also known as non-kinetic warfare, involves conflicts taking place on conventional battlefields and utilizing autonomous systems. It is characterized by the use of psychological warfare tactics, such as social engineering, economic instability, espionage, systematic disinformation, deepfakes, and cybercrime. Notably, these actions are often perpetrated without direct attribution to a specific actor, further complicating the situation. Today, warfare is on the cusp of the next generation, with the expansion of hybrid, unmanned, and AI-dominated weapons and information systems. Experts advocate for expanding skills and tactics for both analog and digital operational readiness (Sauer 2022). The challenges that arise for public life from generation 4 onward are addressed in this paper. It reflects on the possibilities of an entangled understanding of TA and nursing science. Nurses are valuable actors in bridging the gap between technological advancements and maintaining structures in war-affected healthcare. In the following sections, we introduce nursing concepts, such as agential realist vulnerability and primary nursing.

Affecting vulnerability: agential realist perspectives

The concept of vulnerability is useful for assessing the impact of technology on nursing. We take into account both human and non-human actors and utilize the concept of agential realism (Barad 2007), which dissolves dualisms and thereby eliminates the separation between human and non-human entities. This analytical tool allows for the examination of complex phenomena in nursing. Agential realism provides crucial perspectives that enrich the concept of vulnerability and are essential for developing robust healthcare systems.

Agential realism: including technology

Agential realism was developed through the entanglement of various theoretical frameworks. Entanglement is the process of combining theories to enhance and refine them. In the case of

2 BSI-Kritis Ordinance (BSI-KritisV), as amended on 22.04.2016 (Federal Law Gazette I p. 958), last amended by Art. 1 Ordinance of 29.11.2023 (Federal Law Gazette I No. 339).

3 Social Code Book V (SGB V), as amended on 20.12.1988 (Federal Law Gazette I p. 2477), last amended by Art. 1 of Act of 25.02.2025 (Federal Law Gazette I No. 64); SGB XI, as amended on 26.05.1994 (Federal Law Gazette I p. 1014), last amended by Art. 4 of Act of 30.05.2024 (Federal Law Gazette I No. 173).

 https://doi.org/10.14512/tatup.7252

agential realism, Barad (2007) drew upon insights from Nils Bohr's quantum mechanics, which posits that the results of observations are dependent on the apparatus used. Additionally, Foucault's theory, which highlights the enabling and disabling effects of power and discourse, was incorporated. Butler's understanding of the discursive formation of bodies further enhanced these concepts. This integration of theories gave rise to a framework that acknowledges the significance of the apparatus, the influence of discourse on the formation of bodies, and the complex interplay between these factors.

Technology is a constant factor in our environment, so vulnerability needs to be considered with technology as a non-human actor as well.

The term 'intra-action' is the core of agential realism. In contrast to interaction, it states that actors cannot be described apart from a phenomenon but are created intra-actively within it and its properties. The boundaries of actors are understood to be fluid, and the process of gaining knowledge involves avoiding dualisms, such as the dichotomy between human and non-human. The linguistic representation of the phenomenon is challenging because it makes it difficult to communicate about actors without reinforcing their prior definitions: A person becomes a patient by lying in a hospital bed and wearing a surgical gown. At this point, the bed, the person, and the nurse become an interconnected care-dependency phenomenon (Wüller 2023). The bed's functionalities and the properties of the patient and nurse become highly relevant and form a joint phenomenon in a specific situation.

Agential realist vulnerability in nursing science

Vulnerability is a multidisciplinary concept with several meanings depending on its context of use (Fuller and Pincetl 2015). In healthcare, the concept differs as well, as virology, and statistics use the term in relation to relative risks concerning infectious diseases. This approach provides a solid epidemiological foundation for public health, with the clear objective of identifying and safeguarding vulnerable individuals from these threats: During the pandemic, this dominant perspective provided a risk-based justification for prioritizing services (BMG et al. 2021). This is a practical and comprehensible approach, and healthcare professionals often align themselves with these epidemiological-driven assumptions (Läpple 2024).

Anthropology offers another perspective, considering humankind as psycho-physical unity: bodily beings related to and dependent on social networks and interaction. Human vulnerability is not just a weakness; it's also the key to being open to the environment and the prerequisite for thriving and developing (Huth and Thonhauser 2020). However, vulnerability can be heightened or lowered in different situations or life stages (Sellman 2009). In the following, we add agential realism to include matter-related, situational, and environmental aspects: We demonstrate that humankind is vulnerable to its environment and uncertain situations that are difficult to control. Technology is a constant factor in our environment, so vulnerability needs to be considered with technology as a non-human actor as well. While each actor remains vulnerable to a certain degree, the distribution of vulnerability can change the situation, professionalism, traditional roles, privileges, and reasons for actions, among others. This is a fundamental difference to the epidemiological perspective where an actor whether is vulnerable or not. The concept of agential realist vulnerability aligns with the generations of warfare, as there is no unilateral strategy of war anymore, but the battlefield expands into civilian spaces: psychologically in producing uncertainty, and virtually by hacking critical sectors and destabilizing healthcare supply (Sauer 2022; Tsetos 2023). Agential realist vulnerability is the ability to be open to unexpected changes while maintaining flexibility in dealing with uncertain situations.

Vulnerability in healthcare is a concern for patients, healthcare professionals, and technology. Its dynamic, situational, and environmental character makes it challenging to predict its distribution and its impact on healthcare, especially in the event of an unexpected physical or cyberattack on healthcare structures. Next, we will show how entanglement of agential realist vulnerability and TA can take place.

Technology assessment meets nursing: constructing robust healthcare

The entanglement of nursing and TA alters both disciplines. This is due to the acknowledgement of technology's shifting vulnerabilities and those of everyone[4], which are particularly evident during crises. In this chapter, we first describe the contributions of nursing to TA and then outline the contributions of TA to nursing. Nursing contributes knowledge about people's needs and lifeworld, while TA provides concepts and methods of scenario building, investigation of social and disciplinary values, expert and citizen dialogue formats, and policy advice to the entanglement.

First, nursing brings advanced professional concepts to TA, such as agential realist primary nursing. Primary nursing is an organizational model in which nurses are constantly assigned to

4 In agential realism, there is no separation of human and non-human actors and the mention of both actors at this point is merely for clarification purposes.

the same patients (Manthey et al. 1970).[5] This approach adds significant value because primary nurses have a high level of education, decentralized knowledge, and a considerable degree of decision-making authority. They work in interdisciplinary teams and are responsible for care management. Agential realist primary nurses understand all factors influencing a patient's healthcare. In hospitals, they're well-versed in technical issues, such as loose network socket contacts, pending software updates, and Wi-Fi fluctuations in the building. In the community, they know the environments of people being cared for, their life conditions, and their needs. They anticipate possible problems and actively work with scenarios, switching to different modes of nursing care when situationally required, e.g. in the event of a physical or a cyberattack that impacts people's daily life. Primary nursing is applicable to any crisis, because it takes into account environmental, technological, and situational factors. Its decentralized nature distributes risks, uncertainty, and vulnerability, ensuring that decentralized knowledge remains accessible even if the respective nurse dies in a crisis. This must be taken into account in future scenario development.

Second, TA brings to nursing its concepts and methods of participative technology development, scenario building, investigation of social and disciplinary values, expert and citizen dialogue formats, and policy advice. TA can promote nursing as a relevant discipline for healthcare in Germany on a macro level. TA concepts, such as etatism and comprehensiveness, can enhance political awareness when nursing is integrated into policy advice. On a meso level, TA addresses issues of cooperation with other disciplines, such as tactical medicine or the Federal Agency for Technical Relief, which primarily operate in manifest crises. In contrast, nursing approaches uncertainty and vulnerability in daily life and practice, testing procedures and decentralization to promote robustness. TA's dialogue strategies are key to facilitating exchanges between all disciplines dealing with crises about their interfaces, responsibilities, and boundaries. This helps develop decentralized and responsible modes of action, such as in the event of a physical attack. Technologies are developing at a micro level that are convincing due to their applicability, feasibility, and added value in healthcare. This is happening alongside the concept of "Leitbild assessment" (Grunwald 2009).

Through their entanglement, we find that TA and nursing are altered by improved robust technology development, providing technical, procedural, professional, and strategic knowledge and structures, such as nursing authority to decide and report, and professional autonomy. As a result, nursing as a discipline is undergoing a transformation. It is achieving and valuing technological knowledge, gaining authority, and advocating for its contribution to robust healthcare. TA concepts also change interactively as the boundaries of disciplines in interaction are established dynamically within the phenomenon. Roles, authority, discourses, and structures must be questioned and coordinated synchronously. Their usual persistence cannot be assumed.

TA concepts, such as etatism and comprehensiveness, can enhance political awareness when nursing is integrated into policy advice.

The use of technology in nursing is often suboptimal for two primary reasons. First, it does not address the needs of nursing professionals or those of patients (Endter 2018). Entangled TA alters and reflects critically to which extent nursing as an underestimated and still powerless discipline in German healthcare is actually involved in all stages of technology development. Power-related aspects of agential realism invoke this as another point for altering TA approaches: We must ensure that developed technologies are deemed useful and necessary by nurses who use them. Nurses benefit from their knowledge of environmental, structural, and situational factors. The nursing concept of agential realist vulnerability addresses this knowledge. It comprises technological, situational, personal, and environmental factors in healthcare. Technology must function both digitally and analogically. It must address tasks such as managing raw materials, drugs, or waste. It must ensure communication in crises in a discreet manner. It must tag people needing special treatment in an ethical way. Technology must guarantee that the diversity of human needs remains a priority, even during crises, including social and educational needs.

In short, an entanglement of TA and nursing science provides following practical value:

- Germany is prepared for crises with robust healthcare: Crises and modes of warfare are irrelevant. TA scenarios account for intra-active effects and vulnerabilities among the involved actors.
- Teams are established that integrate knowledge of all involved parties (e.g., soldiers, nurses, hospital management, developers, mayors, engineers, . . .). They are powerful agents designed to create robust healthcare, whether for physical or digital attacks.
- Technology for robust healthcare, such as electronic patient records and patient bells, is developed for analog and digital use. It is developed in compliance with ethics and safety standards (Endter 2018; Weber 2016). Nurses are trained and responsible for playing a substantial role in technology development.

5 Primary nursing originated in US nursing science and is currently rarely used in German nursing. We propose the concept from a professional perspective, as it contributes to making German nursing crisis-proof.

Conclusions

We have demonstrated the value of combining TA and nursing. Nursing's concepts and methods of TA serve as a vehicle to promote the potential of nursing in policy advice and in dialogue methods. Nursing provides the professional content and competencies necessary to manage care pathways. Both disciplines are entangled and transformed due to agential realist premises. These include intra-action, non-dualist actors, and phenomena with flexible boundaries. Entanglement's mission is to build robust healthcare systems in times of crisis, whether it's a physical attack, a digital attack, a pandemic, or a natural disaster. This entanglement allows us to address and develop flexible scenarios, decentralized knowledge, high proficiency, dynamic boundaries, and adaptive responses to the requirements and conditions of crises.

This entanglement requires investment in the German healthcare system. Nursing must be empowered and commissioned. The relevance of primary nursing as a decentralized, crisis-resilient, and setting-independent organizational model must be developed to address agent-realistic vulnerability in crises. This development is crucial for creating a robust healthcare system that can effectively respond to various types of crises. It requires a commitment to investing in the necessary infrastructure, education, and training.

Funding • This article received no funding.

Competing interests • The authors declare no competing interests.

Ethical oversight • The authors confirm that all procedures were performed in compliance with relevant laws and institutional guidelines.

References

Barad, Karen (2007): Meeting the universe halfway. Quantum physics and the entanglement of matter and meaning. Durham, NC: Duke University Press. https://doi.org/10.2307/j.ctv12101zq

BBK – Bundesamt für Bevölkerungsschutz und Katastrophenhilfe (ed.) (2008): Schutz Kritischer Infrastruktur – Risikomanagement im Krankenhaus. Leitfaden zur Identifikation und Reduzierung von Ausfallrisiken in Kritischen Infrastrukturen des Gesundheitswesens. Available online at https://www.bbk.bund.de/SharedDocs/Downloads/DE/Mediathek/Publikationen/PiB/PiB-02-risikomankrankh.pdf?__blob=publicationFile&v=7, last accessed on 28.10.2025.

BBK (ed.) (2020): 10 Jahre „KRITIS-Strategie". Einblicke in die Umsetzung der Nationalen Strategie zum Schutz Kritischer Infrastrukturen. Bonn: Bundesamt für Bevölkerungsschutz und Katastrophenhilfe.

BMG – Bundesministerium für Gesundheit; Robert Koch-Institut; Paul-Ehrlich-Institut; Bundeszentrale für gesundheitliche Aufklärung (eds.) (2021): Nationale Impfstrategie COVID-19. Strategie zur weiteren Durchführung und Evaluierung der Impfung gegen SARS-CoV-2 in Deutschland – aktualisiert. Available online at https://www.bundesgesundheitsministerium.de/fileadmin/Dateien/3_Downloads/C/Coronavirus/Impfstoff/Nationale_Impfstrategie_Juni_2021.pdf, last accessed on 03.06.2025.

D'Antonio, Patricia (2002): Nurses in war. In: The Lancet 360 (1), pp. 7–8. https://doi.org/10.1016/S0140-6736(02)11798-3

Endter, Cordula (2018): How older people matter. Nutzer- und Nutzerinnenbeteiligung in AAL-Projekten. In: Harald Künemund and Uwe Fachinger (eds.): Alter und Technik. Sozialwissenschaftliche Befunde und Perspektiven. Wiesbaden: Springer VS, pp. 207–225. https://doi.org/10.1007/978-3-658-21054-0_11

EU – European Union (2022): Directive (EU) 2022/2555 of the European Parliament and of the council of 14 December 2022 on measures for a high common level of cybersecurity across the union, amending regulation (EU) No 910/2014 and directive (EU) 2018/1972, and repealing directive (EU) 2016/1148. Available online at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02022L2555-20221227, last accessed on 16.07.2025.

Fee, Elizabeth; Garofalo, Mary (2010): Florence Nightingale and the Crimean War. In: American Journal of Public Health 100 (9), p. 1591. https://doi.org/10.2105/AJPH.2009.188607

Fink, Anne; Milbrath, Gwyneth (2023): A concept analysis of nurses in conflicts after World War II. In: Journal of Advanced Nursing 79 (1), pp. 31–47. https://doi.org/10.1111/jan.15454

Fuller, Ashley; Pincetl, Stephanie (2015): Vulnerability studies. A bibliometric review. In: The Professional Geographer 67 (3), pp. 319–329. https://doi.org/10.1080/00330124.2014.970835

Gebbie, Kristine; Hutton, Alison; Steward, David (2022): Core competencies in disaster nursing. Competencies for nurses involved in emergency medical teams (Level III). Geneva: International Council of Nurses.

Grunwald, Armin (2009): Technology assessment. Concepts and methods. In: Dov Gabbay, Anthonie Meijers, Paul Thagard and John Woods (eds.): Philosophy of Technology and Engineering Sciences. Handbook of the Philosophy of Science. Amsterdam: Elsevier, pp. 1103–1146. https://doi.org/10.1016/b978-0-444-51667-1.50044-6

Huth, Martin; Thonhauser, Gerhard (2020): Introduction. In: Philosophy Today 64 (3), pp. 537–555. https://doi.org/10.5840/philtoday2020643346

Läpple, Miriam (2024): Vulnerabilität in der Pflege und Pflegewissenschaft. Ein Narrative Review über den deutschsprachigen und internationalen Erkenntnisstand. In: pflegekongress24. Abstractband Poster. Wien: Medical Update, Marketing & Media, p. 37. Available online at https://www.pflegenetz.at/wp-content/uploads/2025/01/abstractband-poster-pk24.pdf, last accessed on 19.02.2026.

Lecocq, Dan (2024): Drawing from the insights of biology, sustainable healthcare systems should prioritise robustness over optimisation. In: Nursing philosophy 25 (4), p. e12510. https://doi.org/10.1111/nup.12510

Manthey, Marie; Ciske, Karen; Robertson, Patricia; Harris, Isabel (1970): Primary nursing. A return to the concept of "my nurse" and "my patient". In: Nursing Forum 9 (1), pp. 65–84. https://doi.org/10.1111/j.1744-6198.1970.tb00442.x

McDonald, Lynn (2012): Florence Nightingale and Mary Seacole. Nursing's bitter rivalry. In: History Today 62 (9), pp. 10–16.

Sauer, Frank (2022): Unbemannte Systeme. Rüstung, Kontrolle und Rüstungskontrolle. In: Metis Institut für Strategie und Vorausschau (ed.): Metis Studie, 28. Neubiberg: University of the Bundeswehr Munich.

Sellman, Derek (2009): Vulnerability and nursing. A reply to Havi Carel. In: Nursing Philosophy 10 (3), pp. 220–222. https://doi.org/10.1111/j.1466-769x.2009.00409.x

Tschudin, Verena; Schmitz, Christine (2003): The impact of conflict and war on international nursing and ethics. In: Nursing Ethics 10 (4), pp. 354–367. https://doi.org/10.1191/0969733003ne618oa

Tsetos, Konstantin (2023): Trends und Entwicklungen hybrider Bedrohungen. In: Metis Institut für Strategie und Vorausschau (ed.): Metis Studie, 35. Neubiberg: University of the Bundeswehr Munich.

UN – United Nations (ed.) (2023): What is sustainable development? Available online at https://www.un.org/sustainabledevelopment/blog/2023/08/what-is-sustainable-development/, last accessed on 15.01.2026.

Weber, Karsten (2016): MEESTAR^2. Ein erweitertes Modell zur ethischen Evaluierung soziotechnischer Arrangements. In: Robert Weidner (ed.): Zweite Transdisziplinäre Konferenz. Technische Unterstützungssysteme, die die Menschen wirklich wollen. Hamburg: Helmut-Schmidt-Universität, pp. 317–326.

White, Jill; Gunn, Michelle; Chiarella, Mary; Catton, Howard; Steward, David (2025): Renewing the definitions of 'nursing' and 'a nurse'. Final project report. Geneva: International Council of Nurses.

WHO – World Health Organization; UNICEF – United Nations Children's Fund (2022): Primary health care measurement framework and indicators. Monitoring health systems through a primary health care lens. Geneva: World Health Organization.

Wüller, Hanna (2023): Pflege und Technik. Empirische Einblicke in Care-Arbeit aus der Perspektive des Agentiellen Realismus. Bielefeld: transcript. https://doi.org/10.1515/9783839467114

MIRIAM LÄPPLE

is a registered nurse since 2010 and holds a PhD since 2022. After various roles in nursing care, she currently is a postdoctoral researcher at the Institut für Pflegewissenschaft at the University of Koblenz. Her research interests include vulnerability, technology, health promotion, and nursing in the community.

HANNA WÜLLER

is a deputy professor of nursing science at University of Applied Sciences Osnabrück. With a background in business information science and public health, she is looking at the world from an interdisciplinary perspective. Her research interests include nursing, technology, new materialisms, and reconstructive research methods.

TATuP Zeitschrift für Technikfolgenabschätzung in Theorie und Praxis
Journal for Technology Assessment in Theory and Practice

oekom science

RESEARCH ARTICLE

Rethinking participatory technology assessment in security governance

Dana Mahr*,1

Abstract · This article explores participatory technology assessment (pTA) in security contexts and asks whether it has a purely symbolic function or whether it can enable real democratic influence. Googles' involvement in the U.S. military's Project Maven serves as an example. At the time, Google employees publicly protested against their company's involvement in the military use of its AI, leading Google to drop its contract with the Pentagon. However, a literature review has shown that secrecy and power asymmetries are typical characteristics of security innovations, so formal pTA rarely goes beyond symbolic politics. Nonetheless, conflicts such as these can open up opportunities for public scrutiny and democratic influence.

Neue Ansätze zur partizipativen Technikfolgenabschätzung in der Sicherheitsgovernance

Zusammenfassung · *Dieser Beitrag geht der Frage nach, ob partizipative Technikfolgenabschätzung (pTA) in der Sicherheitsgovernance eine rein symbolische Funktion hat oder ob sie echte demokratische Einflussnahme ermöglicht. Die Beteiligung Googles am U.S.-Militärprojekt Maven dient als Beispiel. Google-Mitarbeiterinnen und -Mitarbeiter protestierten damals öffentlich gegen die Beteiligung ihres Unternehmens an der militärischen Nutzung seiner KI, woraufhin Google seinen Vertrag mit dem Pentagon nicht verlängerte. Eine Literaturanalyse hat jedoch gezeigt, dass Geheimhaltung und Machtasymmetrien typische Merkmale von sicherheitsrelevanten Innovationen sind und formale pTA somit selten über Symbolpolitik hinausgeht. Dennoch können Konfliktsituationen wie diese neue Möglichkeiten der öffentlichen Kontrolle und demokratischen Einflussnahme eröffnen.*

* *Corresponding author: dana.mahr@kit.edu*

[1] *Institute for Technology Assessment and Systems Analysis, Karlsruhe Institute of Technology, Karlsruhe, DE*

https://doi.org/10.14512/tatup.7231
Received: 22. 05. 2025; revised version accepted: 29. 10. 2025; published online: 23. 03. 2026 (peer review)

Keywords · *technology assessment, military research, public participation, arms control, artificial intelligence*

This article is part of the Special topic "Technology assessment and future warfare: The Good, the Bad, and the Ugly," *edited by K. Weber, M. Bresinsky. https://doi.org/10.14512/tatup.7286*

Introduction

Participatory technology assessment (pTA) refers to processes in which citizens and stakeholders are involved in decisions about new technologies (Hennen 2012). According to democratic principles, risk and ethical issues should not be determined solely by expert committees; the public affected should also be heard. In areas of security policy (i.e., technologies that affect the military, intelligence services, or issues of war and peace) these democratic demands face particular hurdles: secrecy, a discourse of urgency (emergency and threat rhetoric), and powerful, often hierarchical actors stand in the way of broad participation. This often means that participation processes in this sector remain rather formal or symbolic acts, without enabling actual co-creation (Heide and Villeneuve 2021).

A prominent example of this tension is the Pentagon's 'Project Maven' (2017–2019), which developed AI technology for object recognition in drone videos. Google was involved in the project as an industry partner at times, but this only became known after the fact. In April 2018, more than 3,100 Google employees protested in an open letter against their company's role in Maven and demanded that Google should not participate "in the business of war" (Google Employees 2018). The letter, with its core message 'Google should not be in the business of war,' made headlines around the world. This sparked a broad debate that revealed contradictions between the company's publicly proclaimed values and its involvement in military applications. Under pressure from internal protests and negative publicity, Google announced in June 2018 that it would allow the Maven contract with the Department of Defense to expire. This case illustrates, on the one hand, the desire for democratic influence on military technology developments, but on the other

hand, the narrow limits of such influence under security policy conditions: Despite Google's withdrawal, the actual project development continued unabated, now with other companies in the background.

Against this backdrop, the research question arises as to what participatory processes look like and how they work in areas of tight secrecy. Specifically, the article asks: Does pTA in the defense and security sector remain mere symbolic politics? Or are there ways in which participation can lead to real change despite power asymmetries and secrecy? How does this finding contribute to the debate on democratic control of security technologies? The aim of this article is to explore this tension and contribute to technology assessment (TA) and science and technology studies (STS) by examining participatory approaches in the hitherto neglected field of security governance.

Does participatory technology assessment in the defense and security sector remain mere symbolic politics?

Literature review

Early pTA scholarship argued that involving citizens in technology decisions (via citizens' juries, consensus conferences, etc.) enhances legitimacy (Hennen et al. 2023; Wesselink et al. 2011). In practice, however, critics observed that such exercises often reproduce existing hierarchies rather than disrupting them (Felt and Fochler 2008). This prompted STS scholars to reject the notion of a single 'public.' Instead, they emphasize multiple, context-specific publics (Warner 2002; Marres 2007). For example, Pesch et al. (2020) advocate forming dedicated 'local publics' so that acceptability is judged by diverse community stakeholders (including local communities) rather than an abstract general public, reflecting the co-production of knowledge and values (Witjes 2017). In short, contemporary literature suggests that meaningful pTA must engage various publics rather than treat participation as a one-size-fits-all or token gesture.

Security conditions create further challenges. Democratic theory holds that participation only matters when processes are transparent, inclusive, and answerable to citizens (Habermas 2001; Dryzek 2002). But secrecy in defense policymaking directly conflicts with these ideals. Analysts warn that secret policymaking produces a 'knowledge deficit' and prevents citizens from authorizing or contesting hidden actions (Mokrosinska 2023), while withholding information in military affairs erodes citizen consent (Perthes 2011). Appeals to 'necessary secrecy' may even cloak unethical practices (Born and Leigh 2007). Under such conditions, participatory exercises risk being purely symbolic. When urgency and confidentiality dominate, public forums tend to rubber-stamp pre-set outcomes (Taylor et al. 2017). In military contexts these pressures intensify: Secrecy is woven into operations (Mickan 2013) even as life-and-death technologies arguably demand popular scrutiny. Overall, scholars conclude that confidentiality requirements routinely undermine accountability, often relegating participation to a thin veneer that deepens public exclusion (Guerrero 2018).

Research on emerging military technologies shows that narrative framing also plays a performative role. Malmio (2023) finds that debates on AI (e.g., Project Maven) are framed by competing 'enabling' narratives (AI as life-saving precision tool) versus 'constraining' narratives (emphasizing human accountability), and that these frames actively shape technological trajectories by defining which ethical choices seem possible. More broadly, foresight studies note a consensus among experts on the need for civilian engagement in security innovation, but lament a lack of concrete participation models for defense (Vicente-Oliva 2025). As Hennen et al. (2023) and Ladikas et al. (2023) argue, transnational security challenges strain national TA designs, calling for new, cross-border engagement frameworks beyond the nation-state.

Nonetheless, informal or insurgent forms of influence can emerge. Whistleblowers, media exposés, or employee activism sometimes thrust hidden military R&D into public view. Lindelauf and Meerveld (2025) propose 'hybrid' transparency arrangements (for example, keeping military AI algorithms closed to the general market but open to audit by vetted, trusted partners) to build trust without fully sacrificing confidentiality. The Project Maven case exemplifies the limits of such bottom-up contestation: Google employees' protests forced the company to withdraw (imposing an internal pause and ethical commitment), but the Pentagon's AI program continued largely as planned (Xue and Guo 2024). Thus, while these episodes can expose value conflicts and impose constraints on some actors, entrenched secrecy and power asymmetries often mean that underlying innovation trajectories remain unaffected.

Methodology

This paper follows a qualitative case study design using Project Maven as an example. This case study was selected because Project Maven is a prominent current example of the intertwining of high technology and the security apparatus, and it can be partially reconstructed through public documents and debates. The case thus provides empirical insights into otherwise difficult-to-access processes at the interface between the technology

industry and the military. At the same time, Maven paradigmatically illustrates the thesis of the tension between (symbolic) participation and democratic conflict potential.

The analysis is divided into two steps: First, a comprehensive literature review was conducted, bringing together theoretical and conceptual foundations from the fields of TA, security research, STS, and democracy theory. Second, primary and secondary sources on the Project Maven case were evaluated. To this end, the available sources were systematically recorded: official government documents (e.g., reports from the U.S. Department of Defense and analyses from the Congressional Research Service), parliamentary hearings and debate contributions, press articles (international and US-internal, 2017–2024), reports from non-governmental organizations and think tanks, and public statements by the companies and actors involved (e.g., blog posts by Google executives, the published corporate mission statement on AI ethics, open letters from employees). The identified documents were examined using qualitative content analysis. Key events and decisions in the course of Maven were chronologically reconstructed, identifying key actors (Pentagon, Google management, Google employees, media, politicians) and their contributions to the discourse. Particular attention was paid to informal forms of participation (such as employee protests) and the institutional framework (e.g., the role of internal company forums vs. the lack of government participation formats). The case analysis is theory-driven: It embeds the empirical findings in discussions about participation and democracy in order to make empirical and normative classifications.

Research in security policy contexts poses specific methodological challenges. Much of it takes place in areas that are closed to the public; relevant documents are often subject to high levels of secrecy. The present study therefore relies on publicly available information. This entails limitations: The presentation is based on what has come to light (e.g., through media reports). It is naturally impossible to obtain a complete picture of internal decision-making processes at the Department of Defense or Google. In addition, the statements made by the actors must be viewed in the context of their possible self-interests (e.g., corporate statements may be strategically motivated). To counteract distortions, source triangulation was attempted: Wherever possible, information is corroborated by several independent sources (e.g., press reports are compared with official statements and subsequent analyses). Nevertheless, the results must be interpreted with the caveat that they primarily reflect publicly documented dynamics. These limitations are disclosed in the discussion in order to make the scope of the conclusions transparent.

Case study: Project Maven

Background of the project

Project Maven, formally known as the Algorithmic Warfare Cross-Functional Team, was launched in April 2017 by the U.S. Department of Defense. The goal was to accelerate the use of artificial intelligence in the military, in particular through the development of computer vision algorithms for object recognition in video recordings from drones (U.S. DoD 2017; Pellerin 2017; Jones 2018). The Pentagon was responding to a perceived gap: While AI (especially machine learning for image recognition) was making rapid progress in the civilian sector, military agencies were lagging behind. Instead of building AI capabilities exclusively in-house, the Department of Defense pursued a public-private partnership strategy and sought specific collaboration with the tech industry. By the end of 2017, Google had already joined Project Maven as its most important corporate partner (Malmio 2023). Google contributed its expertise in the development of machine learning models, cloud infrastructure, and mass data processing. Initially, this was done confidentially: The cooperation between Google and the Pentagon was not made public, presumably to avoid internal and external criticism in advance. Within Google itself, however, at least a circle of employees was aware that software was being adapted for military purposes. In early 2018, the first information about Maven reached the media, immediately triggering an ethical controversy (Crofts and van Rijswijk 2020). The public suddenly questioned whether a company whose products are used by billions of people should be involved in AI for the military.

The debate remained elitist and technocratic rather than democratic and participatory.

Protest by Google employees

The revelation of Google's contribution to Project Maven acted as a catalyst for internal protest within the company. In the spring of 2018, an unprecedented wave of employee activism formed at Google (Scheiber and Conger 2020). Over 3,100 employees signed an open letter to the company's management with the unambiguous demand: "Google should not be in the business of war" (Google Employees 2018). This letter, which was made public in April 2018, expressed a deep concern shared by many employees: Namely, that the AI tools they had developed could ultimately be used in drone missions to automate lethal decisions (Google Employees 2018). The signatories argued that their work should not be repurposed for military use without transparent debate and without their consent.

There were several remarkable aspects to the protest. First, it was one of the most visible cases of ethical dissent from within the tech industry. Google employees publicly took a stand

https://doi.org/10.14512/tatup.7231

against a lucrative defense project of their own employer – a move that was unprecedented on this scale. Scholars interpreted this event as an early example of 'bottom-up governance': It was not regulatory agencies or NGOs, but the company's own employees who pushed a technology company to rethink its role in military innovation (Crofts and van Rijswijk 2020). Second, the protest exposed the contradictions in Google's corporate culture. For years, Google had cultivated a certain moral identity with the slogan 'Don't be evil'; in 2018, however, this motto was quietly replaced by the more innocuous 'Do the right thing' (Google n.d.; Horwitz 2022). For the protesting employees, the collaboration with the Pentagon represented a clear betrayal of values – both the old and the new company credo. This was a clash between the pursuit of profit, public image, and ethical responsibility. The controversy thus exemplified how a private company can become a venue for social negotiation when government decision-making processes remain closed: The workforce sparked a debate that should have taken place on the socio-political stage, for example in parliaments.

Without technical transparency, meaningful debate is impossible.

Reactions from the company

In the face of growing criticism, Google's management felt compelled to act quickly. The management team, led by CEO Sundar Pichai and the head of the cloud division, Diane Greene, initially sought dialogue with the employees. Internal town hall meetings and discussion groups were organized, during which management promised to rethink its own guidelines for military contracts. In fact, two far-reaching announcements followed at the end of May/beginning of June 2018: First, Diane Greene informed employees that Google would not renew the current Maven contract when it expired in 2019 (Statt 2018). Second, on June 7, 2018, Google published a set of AI principles that would henceforth serve as ethical guidelines for Google's development of artificial intelligence (Pichai 2018). These principles explicitly prohibited the development of AI for weapons systems, but left open the possibility of continuing to operate in other areas of defense, such as cybersecurity and logistics (Shane and Wakabayashi 2018).

On the one hand, the announcement of these AI principles was a direct concession to employee protests: Google attempted to address ethical concerns and regain lost trust. On the other hand, it clearly served to enhance the company's external reputation: The aim was to signal that Google was handling AI responsibly. Nevertheless, criticism from various quarters was inevitable. Scientists and observers noted that voluntary commitments such as these 'ethical principles' are often non-binding in corporate practice and lack enforcement (Malmio 2023). Without external control mechanisms, such guidelines could easily be circumvented or adapted if commercial or political interests suggested it. Furthermore, it became clear that although Google's direct withdrawal from Maven represented a symbolic victory for the protesters, the Pentagon project itself continued unabated. In other words, the company's decision primarily affected its public image – military-technological development as such remained unaffected (Hogue 2021). This already suggests that symbolic successes are possible, but do little to change structural path dependencies.

Publicity and progress of the project

What is striking about the Project Maven conflict is the lack of institutionalized public deliberation beyond Google. Neither the Department of Defense nor the U.S. Congress initiated any public technology impact assessments or citizen dialogues on the ethical and social implications of the use of AI in the military during that period (Hogue 2021). The debate took place primarily in internal company forums, in expert circles (e.g., posts in technology and legal blogs), and in specialized media. Thus, to put it bluntly, the debate remained elitist and technocratic rather than democratic and participatory. Although mainstream media reported on the internal conflict at Google and there were comments from NGOs, there was no broad public participation or parliamentary hearing on Maven (U.S. Department of Defense 2017). This underscores the problematic fact that security policy technology decisions are often made without broad public feedback – unless internal whistleblowers or protests happen to make them public.

After Google's withdrawal, it soon became clear who would continue Maven's development. In 2019, media reports indicated that Palantir Technologies had assumed key parts of the project. According to Business Insider, the company internally launched the code-named project 'Tron' to deliver AI models for drone video analysis, thereby continuing Google's earlier work (Peterson 2019). The report noted that Palantir had taken over Project Maven after Google ended its Pentagon contract in March 2019 following employee protests. Palantir (long linked to the security sector) thus seamlessly replaced Google.

The seamless continuity of the project under different leadership highlights a core element of security-driven innovation: Even if a single company withdraws due to public pressure, the technological path remains intact as long as the need within the security apparatus persists. In the case of Maven, this is exactly what happened. The fundamental military demand for AI-supported analysis of surveillance data remained unbroken – and Palantir was found to be a willing replacement. In fact, the Department of Defense expanded its cooperation with Palantir in the following years. In May 2024, Reuters reported that the Pentagon had awarded Palantir a $480 million contract for an advanced Maven Smart System (Reuters 2024). The specialist portal C4ISRNet also reported that a five-year contract would

enable the wider use of this system (Albon 2024). It is clear that structural drivers (in this case, the strategic imperative to improve the evaluation of intelligence material through AI) ensure that a project like Maven continues, regardless of interim reputation crises or personnel changes on the provider side.

Overall, the Maven case demonstrates the limits of corporate-driven protests: While the action taken by Google employees was able to influence the behavior of a single company, it did not change the long-term course of government arms policy. This continues to be determined by geopolitical priorities (e.g., the technological race with rivals such as China) and the interests of security agencies. Thus, innovation remained in the world, only the constellation of actors shifted slightly. This presents a dilemma for democratic control: Even if interventions are successful in individual cases, they must be institutionally anchored in order to have more than a symbolic effect – otherwise, the development of military technology will take place under different circumstances.

Discussion

The Project Maven case highlights institutional, epistemic, and power-political barriers that restrict genuine participation in security innovation. Institutionally, there is a deep asymmetry between the security apparatus and the democratic public sphere. Military and intelligence agencies operate within a closed 'security zone,' shielded by secrecy rules, clearances, and black budgets that place decisions beyond public control. As Mickan (2013) notes, secrecy is a constitutive element of the military, yet this tension must not come at the expense of informed citizens. In Maven, no formal participation took place – basic information such as data use or algorithmic design remained classified. The only 'participants' were Google employees, whose protest mattered mainly because Google's public brand and dependence on skilled labor gave them leverage. By contrast, traditional defense contractors face no comparable pressure; their activities usually remain invisible and only surface through leaks or media scrutiny.

Epistemically, knowledge asymmetries further block participation. Maven's AI systems functioned as a black box: Neither internal actors nor the public knew how models operated or what data they used. Without technical transparency, meaningful debate is impossible. Even Google staff demanding insight into the project met resistance, while external observers had no access to relevant facts. As Lindelauf and Meerveld (2025) argue, limited openness toward trusted partners could strengthen accountability, but under current secrecy regimes participation remains largely superficial. The epistemic gap between experts with clearance and lay publics thus widens, reinforcing perceptions of incompetence on the latter's side.

Power-political barriers arise when urgency and threat narratives justify exceptional measures. In the Maven debate, references to a technological race with China served to sideline democratic procedures – a typical case of securitization. Born and Leigh (2007) warn that such appeals to 'necessary secrecy' can mask dubious practices. The decision to partner with Google was driven by efficiency, not public deliberation. Civil society's influence was indirect: Only when reputational risk threatened Google did management react. As Vicente-Oliva (2025) notes, experts call for more citizen involvement in defense foresight, yet no concrete models exist. Maven confirms that participatory impulses remain extra-institutional and symbolically charged.

To address these tensions, several reforms have been proposed. Advisory boards with security clearance could review classified projects while representing diverse perspectives, though confidentiality risks curbing critique. Confidential parliamentary hearings might allow selected experts and NGOs to advise defense committees behind closed doors, using existing democratic channels but offering limited public transparency. Simulated citizen forums could model deliberation through hypothetical scenarios, though their policy impact would remain uncertain. Each approach faces resistance from security institutions reluctant to share authority. Yet incremental steps (such as independent ombudsmen or periodic public reports on defense AI) could create 'embedded transparency' without endangering operational secrecy.

Overall, the Maven protests exposed systemic tensions rather than resolving them. Participation under secrecy remains ad hoc and largely symbolic: It can illuminate value conflicts but rarely transforms underlying power structures or decision-making in security policy.

Conclusion

PTA in security governance often remains largely symbolic because secrecy, urgency narratives, and hierarchical power structures render transparency and inclusion difficult. However, the Project Maven case illustrates that critical contestation can still emerge. Protests of these effects are contingent and fragile – Maven's AI project continued under other contractors, showing that symbolic resistance rarely changes structural power asymmetries. In sum, pTA in the security sector remains constrained but not futile: Even symbolic participation can become politically productive when moments of contestation are harnessed to uphold democratic oversight and accountability.

Funding • This article received no funding.

Competing interests • The author declares no competing interests.

Ethical oversight • The author confirms that all procedures were performed in compliance with relevant laws and institutional guidelines.

Acknowledgements • I would like to thank Nora Weinberger, whose sharp questions, generous feedback, and intellectual sparring were essential to this paper. Her critical reflections helped me see the text more clearly. This article carries her traces.

https://doi.org/10.14512/tatup.7231

References

Albon, Courtney (2024): Palantir wins contract to expand access to Project Maven AI tools. In: C4ISRNET, 30.05.2024. Available online at https://www.c4isrnet.com/artificial-intelligence/2024/05/30/palantir-wins-contract-to-expand-access-to-project-maven-ai-tools/, last accessed on 04.11.2025.

Born, Hans; Leigh, Ian (2007): Democratic accountability of intelligence services. Geneva: Geneva Centre for the Democratic Control of Armed Forces.

Crofts, Penny; van Rijswijk, Honni (2020): Negotiating 'evil'. Google, Project Maven and the corporate form. In: Law, Technology and Humans 2 (1), pp. 75–90. https://doi.org/10.5204/lthj.v2i1.1313

Dryzek, John (2002): Deliberative democracy and beyond. Liberals, critics, contestations. Oxford: Oxford University Press. https://doi.org/10.1093/019925043X.001.0001

Felt, Ulrike; Fochler, Maximilian (2008): The bottom-up meanings of the concept of public participation in science and technology. In: Science and Public Policy 35 (7), pp. 489–499. https://doi.org/10.3152/030234208X329086

Google (n.d.): Our approach to information. How search works. Available online at https://www.google.com/intl/en_us/search/howsearchworks/our-approach/, last accessed on 04.11.2025.

Google Employees (2018): Open letter to Sundar Pichai. Available online at https://static01.nyt.com/files/2018/technology/googleletter.pdf, last accessed on 04.11.2025.

Guerrero, Alexander (2018): Defense and ignorance. War, secrecy, and the possibility of popular sovereignty. Oxford: Oxford University Press. https://doi.org/10.1093/oso/9780190922542.003.0016

Habermas, Jürgen; Rehg, William (2001): Between facts and norms. Contributions to a discourse theory of law and democracy. Cambridge, MA: MIT Press.

Heide, Marlen; Villeneuve, Jean-Patrick (2021): Framing national security secrecy. A conceptual review. In: International Journal: Canada's Journal of Global Policy Analysis 76 (2), pp. 238–256. https://doi.org/10.1177/00207020211016475

Hennen, Leonhard (2012): Why do we still need participatory technology assessment? In: Poiesis & Praxis 9 (1–2), pp. 27–41. https://doi.org/10.1007/s10202-012-0122-5

Hennen, Leonhard; Peissl, Walter; Hahn, Julia; Ladikas, Miltos; van Est, Rinie; Lindner, Ralf (2023): Introduction. Technology assessment beyond national boundaries. In: Leonhard Hennen, Julia Hahn, Miltos Ladikas, Ralf Lindner, Walter Peissl and Rinie van Est (eds.): Technology assessment in a globalized world. Cham: Springer, pp. 1–14. https://doi.org/10.1007/978-3-031-10617-0_1

Hogue, Simon (2021): Project Maven, big data, and ubiquitous knowledge. The impossible promises and hidden politics of algorithmic security vision. In: Aleš Završnik and Vasja Badalič (eds.): Automating crime prevention, surveillance, and military operations. Cham: Springer, pp. 203–221. https://doi.org/10.1007/978-3-030-73276-9_10

Horwitz, Josh (2022): Google is losing 'Don't be evil' in its code of conduct, and what's left is corporate jargon. In: Quartz, 20.07.2022. Available online at https://qz.com/1282892/google-is-losing-dont-be-evil-in-its-code-of-conduct-and-whats-left-is-corporate-jargon, last accessed on 31.10.2025.

Jones, Felicity (2018): Project Maven. Machine learning in the military target selection process. In: Technology and Operations Management, 13.11.2018. Available online at https://d3.harvard.edu/platform-rctom/submission/project-maven-machine-learning-in-the-military-target-selection-process/, last accessed on 04.11.2025.

Ladikas, Miltos; Hahn, Julia; Hennen, Leonhard; van Est, Rinie; Peissl, Walter; Lindner, Ralf (2023): The shape of global technology assessment. In: Leonhard Hennen, Julia Hahn, Miltos Ladikas, Ralf Lindner, Walter Peissl and Rinie van Est (eds.): Technology assessment in a globalized world. Cham: Springer, pp. 225–235. https://doi.org/10.1007/978-3-031-10617-0_11

Lindelauf, Roy; Meerveld, Herwin (2025): Building trust in military AI starts with opening the black box. In: War on the Rocks, 12.08.2025. Available online at https://warontherocks.com/2025/08/building-trust-in-military-ai-starts-with-opening-the-black-box/, last accessed on 31.10.2025.

Malmio, Irja (2023): Ethics as an enabler and a constraint. Narratives on technology development and artificial intelligence in military affairs through the case of Project Maven. In: Technology in Society 72, p. 102193. https://doi.org/10.1016/j.techsoc.2022.102193

Marres, Noortje (2007): The issues deserve more credit. Pragmatist contributions to the study of public involvement in controversy. In: Social Studies of Science 37 (5), pp. 759–780. https://doi.org/10.1177/0306312706077367

Mickan, Thomas (2013): Kommentar. Geheimhaltung, Demokratie und Militär. In: IMI-Standpunkt 34, 18.07.2013. Available online at https://www.imi-online.de/2013/07/18/kommentar-geheimhaltung-demokratie-und-militar, last accessed on 31.10.2025.

Mokrosinska, Dorota (2023): Necessary but illegitimate. On democracy's secrets. In: The Review of Politics 85 (1), pp. 73–97. https://doi.org/10.1017/S0034670522000936

Pellerin, Cheryl (2017): Project Maven industry day pursues artificial intelligence for DoD challenges. In: U.S. Department of Defense News, 27.10.2017. Available online at https://www.war.gov/News/News-Stories/Article/Article/1356172/project-maven-industry-day-pursues-artificial-intelligence-for-dod-challenges/, last accessed on 31.10.2025.

Perthes, Volker (2011): Wikileaks und warum Diskretion in der Außen- und Sicherheitspolitik wichtig ist. In: Eva Gilmer and Heinrich Geiselberger (eds.): Wikileaks und die Folgen. Netz – Medien – Politik. Frankfurt a. M.: Suhrkamp, pp. 164–174.

Pesch, Udo; Huijts, Nicole; Bombaerts, Gunter; Doorn, Neelke; Hunka, Agnieszka (2020): Creating 'local publics'. Responsibility and involvement in decision-making on technologies with local impacts. In: Science and Engineering Ethics 26 (4), pp. 2215–2234. https://doi.org/10.1007/s11948-020-00199-0

Peterson, Becky (2019): Palantir grabbed Project Maven defense contract after Google left the program. Sources. In: Business Insider, 10.12.2019. Available online at https://www.businessinsider.com/palantir-took-over-from-google-on-project-maven-2019-12, last accessed on 04.11.2025.

Pichai, Sundar (2018): AI at Google. Our principles. In: The Keyword (Google Blog), 07.06.2018. Available online at https://blog.google/technology/ai/ai-principles/, last accessed on 31.10.2025.

Reuters (2024): Pentagon awards $480 million deal to Palantir for 'Maven' prototype. In: Reuters, 30.05.2024. Available online at https://www.reuters.com/technology/palantir-wins-480-million-us-army-deal-maven-prototype-2024-05-29/, last accessed on 31.10.2025.

Scheiber, Noam; Conger, Kate (2020): The great Google revolt. In: The New York Times, 18.02.2020. Available online at https://www.nytimes.com/interactive/2020/02/18/magazine/google-revolt.html, last accessed on 31.10.2025.

Shane, Scott; Wakabayashi, Daisuke (2018): 'The business of war'. Google employees protest work for the Pentagon. In: The New York Times, 04.04.2018. Available online at https://www.nytimes.com/2018/04/04/technology/google-letter-ceo-pentagon-project.html, last accessed on 04.11.2025.

Statt, Nick (2018): Google reportedly leaving Project Maven military AI program after 2019. In: The Verge, 01.06.2018. Available online at https://www.theverge.com/2018/6/1/17418406/google-maven-drone-imagery-ai-contract-expire, last accessed on 04.11.2025.

Taylor, Bryan; Bean, Hamilton; O'Gorman, Ned; Rice, Rebecca (2017): A fearful engine of power. Conceptualizing the communication–security relationship. In: Annals of the International Communication Association 41 (2), pp. 111–135. https://doi.org/10.1080/23808985.2017.1312482

U.S. DoD – United States Department of Defense (2017): Establishment of an algorithmic warfare cross-functional team (Project Maven). Washington, DC: United States Department of Defense. Available online at https://www.govexec.com/media/gbc/docs/pdfs_edit/establishment_of_the_awcft_project_maven.pdf, last accessed on 04.11.2025.

Vicente-Oliva, Silvia (2025): Participation of civil society in security and defense foresight exercises. In: Futures & Foresight Science 7 (1), p. e206. https://doi.org/10.1002/ffo2.206

Warner, Michael (2002): Publics and counterpublics. In: Public Culture 14 (1), pp. 49–90. https://doi.org/10.1215/08992363-14-1-49

Wesselink, Anna; Paavola, Jouni; Fritsch, Oliver; Renn, Ortwin (2011): Rationales for public participation in environmental policy and governance. Practitioners' perspectives. In: Environment and Planning A: Economy and Space 43 (11), pp. 2688–2704. https://doi.org/10.1068/a44161

Witjes, Nina (2017): The co-production of science, technology and global politics. Exploring emergent fields of knowledge and policy. Munich: Technische Universität München. Available online at https://mediatum.ub.tum.de/doc/1350479/document.pdf, last accessed on 04.11.2025.

Xue, Jonathan; Guo, Lifu (2024): AI Cold War with China? The advantage of public conversations about ethics. In: GRACE: Global Review of AI Community Ethics 2 (1), p. 1–18. https://doi.org/10.60690/vdnrw404

DR. DANA MAHR
is a researcher at the Institute for Technology Assessment and Systems Analysis (ITAS) at the Karlsruhe Institute of Technology (KIT). She earned her PhD from Bielefeld University in 2013 and previously held research positions at the Université de Genève and the Universität zu Lübeck.