



NATO NUCLEAR DETERRENCE: ITS ADAPTATION AND CHANGING REQUIREMENTS

Annotated Bibliography

Center for Global Security Research
LAWRENCE LIVERMORE NATIONAL LABORATORY

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Since 2014, NATO has embarked on the biggest reinforcement of collective deterrence and defense after the end of the Cold War. This has involved efforts to strengthen nuclear deterrence in response to Russia's coercive nuclear signaling, growing nuclear capabilities, and integrated role of nuclear weapons in Russia's multi-domain approach to conflict. The urgency for the Alliance to continue its nuclear adaptation process was further bolstered by renewed Russia's aggression against Ukraine in February 2022 backed by explicit and implicit nuclear threats. This annotated bibliography collects selected literature that discuss NATO nuclear basics, takes stock of NATO's nuclear adaptation progress over the last eight years, and explores future requirements for NATO's nuclear deterrence policy and posture. The literature list is not exhaustive and is intended to provide the basis for better understanding and further exploration of these topics.

Key Topics:

1. Historical Background: Cold War, 1990s, and early 2000s
2. Russia's Nuclear Doctrine and Capabilities
3. The Global Nuclear Context
4. U.S. Nuclear Fundamentals
5. NATO Nuclear Basics
6. NATO's Nuclear Evolution Since 2014
7. European Nuclear Balance: Net Assessment
8. Towards Integrated and Coherent NATO's Deterrence Posture
9. Escalation, De-escalation and War Termination
10. Impact of Emerging Technologies
11. Future of Nuclear Arms Control and Risk Reduction Measures

1. Historical Background: Cold War, 1990s, and early 2000s

Freedman, Lawrence, and Jeffrey Michaels. *The Evolution of Nuclear Strategy*. 4th Edition. London, UK: Palgrave MacMillan, 2019.

The fourth edition of this seminal book provides a comprehensive overview of the evolution of nuclear strategy since the beginning of the nuclear age. It thoroughly discusses the key developments in NATO approach to nuclear weapons during the Cold War and beyond.

Alberque, William. "The NPT and the Origins of NATO's Nuclear Sharing Arrangements." *Proliferation Papers*, No. 57, February 2017.

https://www.ifri.org/sites/default/files/atoms/files/alberque_npt_origins_nato_nuclear_2017.pdf.

Drawing on a historical record, Alberque shows that the text of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) was crafted by the United States and the Soviet Union in the way that made NATO's nuclear sharing arrangements compatible with the Treaty obligations. This contradicts Russia's accusations that the United States and NATO Allies are violating the NPT.

Delpech, Thérèse. *Nuclear Deterrence in the 21st Century: Lessons from the Cold War for a New Era of Strategic Piracy*. Santa Monica, CA: RAND Corporation, 2012.

<https://www.rand.org/pubs/monographs/MG1103.html>.

Delpech calls for a renewed intellectual effort on nuclear deterrence. She examines whether and how the Cold War nuclear concepts – such as stability, second strike, parity and credibility– remain relevant in the 21st century and what lessons can be drawn from the key Cold War nuclear crises.

On the evolution of NATO's nuclear strategy, policy and posture, see also:

"The history of NATO TNF policy: The role of studies, analysis and exercises conference proceedings. Volume 1, Introduction and summary". Ed. By R.L. Rinne. Sandia National Laboratories, Livermore, CA , 1994. <https://www.osti.gov/servlets/purl/10132869>.

Larsen, Jeffrey A. "The Future of U.S. Non-Strategic Nuclear Weapons and Implications for NATO Drifting Toward the Foreseeable Future." Brussels, Belgium: NATO Public Diplomacy Division, 2006. <https://www.nato.int/acad/fellow/05-06/larsen.pdf>.

U.S. Department of Defense. "Report of the Secretary of Defense Task Force on DOD Nuclear Weapons Management. Phase II: Review of the DoD Nuclear Mission," September 2008. <https://apps.dtic.mil/sti/pdfs/ADA492647.pdf>.

On the history of key non-proliferation and arms control agreements that have shaped NATO's nuclear posture, see:

Glitman, Maynard W. *The Last Battle of the Cold War. An Inside Account of Negotiating the Intermediate Range Nuclear Forces Treaty*. London, UK: Palgrave MacMillan, 2006.

Koch, Susan J. "The Presidential Nuclear Initiatives of 1991-1992." Washington D.C: Center for the Study of Weapons of Mass Destruction, National Defense University, 2012. https://ndupress.ndu.edu/Portals/68/Documents/casestudies/CSWMD_CaseStudy-5.pdf.

On lessons from the Cold War, see also:

Ruiz Palmer, Diego. "A Strategic Odyssey: Constancy of Purpose and Strategy-Making in NATO, 1949-2019." *NDC Research Paper* no. 3. Rome, Italy: NATO Defense College, 2019. <https://www.ndc.nato.int/news/news.php?icode=1330>.

Yost, David S. "Strategic Stability in the Cold War: Lessons for Continuing Challenges." *Proliferation Papers*, no. 36, 2011. <https://www.ifri.org/sites/default/files/atoms/files/pp36yost.pdf>.

2. Russia's Nuclear Doctrine and Capabilities

Johnson, Dave. "Russia's Conventional Precision Strike Capabilities, Regional Crises, and Nuclear Thresholds." *Livermore Papers on Global Security*, No. 3. Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, February 2018. <https://cgsr.llnl.gov/content/assets/docs/Precision-Strike-Capabilities-report-v3-7.pdf>.

This Livermore Paper on Global Security explores nuclear thresholds in Russian military doctrine with an eye to understanding how Russian thinking integrates the operational effects of conventional strikes with nuclear deterrence and coercion. The paper contributes to a debate about the place of escalate-to-deescalate strategies in Russian military thought and the prospects for Russian nuclear employment in a regional confrontation with NATO.

Kofman, Michael, Anya Fink, and Jeffrey Edmonds,. "Russian Strategy for Escalation Management: Evolution of Key Concepts." Alexandria, VA: Center for Naval Analysis, April 2020. https://www.cna.org/CNA_files/PDF/DRM-2019-U-022455-1Rev.pdf.

Based on an extensive review of authoritative Russian military-analytical literature published since 1991, this CNA report assesses the evolution of escalation management and intra-war deterrence in Russian military strategy. The authors observe Russian focus on applying forms of calibrated damage as a vehicle to manage escalation. Deterrent damage is meant to be dosed and applied in an iterative manner, with associated targeting and damage levels. Despite acquiring nonnuclear means of deterrence, Russia comprehensive approach to "strategic deterrence" continues to rely on nuclear weapons to deter and prosecute regional and large-scale conflicts.

Kristin Ven Bruusgaard. "Russian Nuclear Strategy and Conventional Inferiority." *Journal of Strategic Studies* 44, no. 1, 2021.

<https://www.tandfonline.com/doi/full/10.1080/01402390.2020.1818070>.

The author argues that Russian strategy is a product of perceptions of Russia's conventional inferiority vis-à-vis the United States. Noting that Russian conventional inferiority in the 1990s led to greater emphasis on nuclear deterrence, she argues that the growing strength of Russian conventional forces in the early 2000s allowed it to raise its threshold for nuclear use. The article concludes that the conventional-nuclear relationship is not necessarily static or deterministic, but rather, as Russia's modernization of its conventional forces illustrates, that the relationship can shift over time.

On Russia's strategy for escalation management, see also:

Johnson, Dave. "Russia's Deceptive Nuclear Policy." *Survival* 63, no. 3, 2021.

<https://www.tandfonline.com/doi/abs/10.1080/00396338.2021.1930410?journalCode=tsur20>.

Zysk, Katarzyna. "Escalation and Nuclear Weapons in Russia's Military Strategy." *The RUSI Journal*, Vol. 163, Issue 2, 2018. <https://doi.org/10.1080/03071847.2018.1469267>.

On the role of nuclear weapons in Russia's "Theory of Victory," see:

Brad Roberts. "On Theories of Victory: Red and Blue." *Livermore Papers on Global Security* No. 7. Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, 2020). <https://cgsr.llnl.gov/content/assets/docs/CGSR-LivermorePaper7.pdf>.

Roberts, Brad. Chapter 4: "The Second New Problem: Relations with Putin's Russia," in: *The Case for U.S. Nuclear Weapons in the 21st Century*. Stanford University Press, Stanford, CA, 2015.

Covington, Stephen R. "The Culture of Strategic Thought Behind Russia's Modern Approaches to Warfare." Cambridge, Massachusetts: Belfer Center for Science and International Affairs, October 2016. <https://www.belfercenter.org/publication/culture-strategic-thought-behind-russias-modern-approaches-warfare>.

On Russia's nuclear messaging accompanying aggression against Ukraine, see:

Durkalec, Jacek. "Nuclear-Backed "Little Green Men:" Nuclear Messaging in the Ukraine Crisis." *PISM Report*. Warsaw, Poland: Polish Institute of International Affairs, 2015. <http://www.pism.pl/publications/PISM-reports/Nuclear-Backed-Little-Green-Men-Nuclear-Messaging-in-the-Ukraine-Crisis>.

Arndt, Anna Clara, and Liviu Horovitz. "Nuclear rhetoric and escalation management in Russia's war against Ukraine: A Chronology." *Working Paper*. Berlin, Germany: German Institute for International and Security Affairs, September 2022. https://www.swp-berlin.org/publications/products/arbeitspapiere/Arndt-Horovitz_Working-Paper_Nuclear_rhetoric_and_escalation_management_in_Russia_s_war_against_Ukraine.pdf.

On Russia's nuclear capabilities, see:

Ashley, Robert P. "Russian and Chinese Nuclear Modernization Trends." Washington, DC: Defense Intelligence Agency, 2019. <https://www.dia.mil/News/Speeches-and-Testimonies/Article-View/Article/1859890/russian-and-chinese-nuclear-modernization-trends/>.

Boone, Roy, et al. "The Challenge of Russia's Non-Strategic Nuclear Weapons." University of Nebraska: National Strategic Research Institute, October 2021. <https://nsri.nebraska.edu/-/media/projects/nsri/docs/academic-publications/2021/october/the-challenge-of-russias-nsnw.pdf>.

Albertson, Michael. "Russia's Approach to Stockpile Modernization." In *Stockpile Stewardship in an Era of Renewed Competition*, edited by Brad Roberts. Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, 2022. https://cgsr.llnl.gov/content/assets/docs/CGSR_Occasional_Stockpile-Stewardship-Era-Renewed-Competition.pdf.

3. The Global Nuclear Context

Krepinevich, Andrew F., Jr. "The New Nuclear Age. How China's Growing Nuclear Arsenal Threatens Deterrence." *Foreign Affairs*, April 2022. <https://www.hudson.org/research/17755-the-new-nuclear-age>.

Krepinevich posits that China's nuclear expansion forces the United States to contend with the deterrence requirements of a tripolar nuclear world. This dynamic resembles the "three body problem" in physics, where the orbits of three large astronomical bodies are chaotic and impossible to reliably predict in advance. In this precarious new strategic context, the United States must consider the requirements of deterrence and strategic stability and their implications for the U.S. force posture. The author argues that in the context of tripolar nuclear rivalry, maintaining stability in crisis situations will likely be significantly more difficult than it is now.

Durkalec, Jacek, Charlotte Henderson, Lindsay Rand. "Extended Deterrence and the Two-War Problem. Workshop Summary." Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, April 2022. https://cgsr.llnl.gov/content/assets/docs/Workshop_Extended_Deterrence_and_Two_War_Problem_CGSR_Summary.pdf.

This CGSR workshop focused on understanding the impact on U.S. extended deterrence of the need to deter two near-peer nuclear-armed powers simultaneously. The participants observed that the risk of opportunistic aggression is growing as there is extensive evidence that the leaders of Russia and China (and also North Korea and Iran) are becoming less adverse to risk and more assertive in challenging the regional and global orders. To ensure that extended deterrence is fit for purpose in 2030, the United States and its allies should accelerate their efforts to adjust military, including nuclear, hardware and software for the purpose of deterrence campaigning.

Borja, Lauren, et al. "Multipolarity and U.S. Nuclear Strategy. Workshop Summary." Livermore, CA: Lawrence Livermore National Laboratory, Center for Global Security Research, 2021.
https://cgsr.llnl.gov/content/assets/docs/Workshop_Summary_Multipolarity_US_Nuclear_Strategy.pdf.

Participants of this CGSR workshop identified several scenarios in which closer Russia-China alignment could negatively impact U.S. extended deterrence and assurance of allies. This includes a scenario in which Beijing takes advantage of a Russia-orchestrated crisis in Ukraine; a scenario in which either Russia or China chooses to directly test the robustness of U.S. extended deterrence in one region; or, a scenario of a catalytic aggression. A two-peer problem also questions whether the United States has a sound strategy and sufficient forces to restore deterrence in scenarios in which a two-front regional war escalates to a nuclear war with two adversaries at the same time.

On interdependence between U.S. nuclear deterrence in Europe and in the Indo-Pacific, see:

Durkalec, Jacek, et al. "'Compete, Deter, and Win' in a Trans-Regional Perspective: On Meeting the New Challenges of Extended Deterrence. Workshop Summary." Livermore, CA: Lawrence Livermore National Laboratory, Center for Global Security Research, February 2019.
https://cgsr.llnl.gov/content/assets/docs/ED_Workshop_Summary_FEB2019_Final.pdf

Durkalec, Jacek. "U.S. Extended Deterrence in Europe and in the Asia-Pacific: Similarities, Differences, and Interdependencies, Workshop Summary." Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, 2018.
https://cgsr.llnl.gov/content/assets/docs/Summary_Report_ED_JAN2018final.pdf.

Roberts, Brad, et al. "Thinking Globally about U.S. Extended Deterrence New Regional Challengers and Challenges. Workshop Summary." Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, 2015.
https://cgsr.llnl.gov/content/assets/docs/Roberts_Extended_Deterrence_Key_Takeaways.pdf.

On accelerating nuclear challenges from China, see:

Zhao, Tong. "Implications For Russia's Nuclear Signaling During the Ukraine War for China's Nuclear Policy." The Asia-Pacific Leadership Network, October 2022. <https://cms.apln.network/wp-content/uploads/2022/10/PB-88-Tong-Zhao.pdf>.

Radzinsky, Brian. "The Strategic Implications of the Evolving US-China Nuclear Balance." The Washington Quarterly, vol. 44, no. 4, 2021. <https://www.tandfonline.com/doi/full/10.1080/0163660X.2021.2022856>.

Cunningham, Fiona S. and Taylor M. Fravel. "Dangerous Confidence? Chinese Views on Nuclear Escalation." *International Security*, Vol. 44, No. 2, 2019. https://www.mitpressjournals.org/doi/full/10.1162/isec_a_00359.

On increasing challenges from North Korea and Iran, see:

Lee, Manseok. "Deterring North Korea's Dynamic Nuclear Strategy." *War on the Rocks*, 22 February 2021. <https://warontherocks.com/2021/02/deterring-north-koreas-dynamic-nuclear-strategy/>.

Smith, Shane and Paul Bernstein. "North Korean Nuclear Command and Control: Alternatives and Implications." Washington, DC: DTRA Strategic Trends Research Initiative, 16 September 2022. https://wmdcenter.ndu.edu/Portals/97/Documents/Publications/NK-Nuclear-Command-and-Control_Report.pdf.

Brewer, Eric. "Iran on the Nuclear Brink." *Foreign Affairs*, 17 June 2022. <https://www.foreignaffairs.com/articles/iran/2022-06-17/iran-nuclear-brink>.

On U.S. Extended Deterrence in the Indo-Pacific:

Tsuruoka, Michito. "US Nuclear Weapons and US Alliances in North-East Asia." In *Alliances, Nuclear Weapons and Escalation: Managing Deterrence in the 21st Century*, edited by Stephan Frühling and Andrew O'Neil, 133-140. Canberra, Australia: ANU Press - The Australian National University, 2021. <https://press-files.anu.edu.au/downloads/press/n9294/pdf/ch12.pdf>.

Frühling, Stephan and Andrew O'Neil. "Alliances and Nuclear Risk: Strengthening US Extended Deterrence." *Survival*, vol 64, no. 1 (2022). <https://www.tandfonline.com/doi/abs/10.1080/00396338.2022.2032969>.

Ahn, Jennifer. "The Evolution of South Korea's Nuclear Weapons Policy Debate." *Council on Foreign Relations*, August 16, 2022, <https://www.cfr.org/blog/evolution-south-koreas-nuclear-weapons-policy-debate>.

4. U.S. Nuclear Fundamentals

Department of Defense. *2022 National Defense Strategy, Nuclear Posture Review, and Missile Defense Review*. October 2022. <https://media.defense.gov/2022/Oct/27/2003103845/-1/-1/1/2022-NATIONAL-DEFENSE-STRATEGY-NPR-MDR.PDF>.

These three U.S. strategic review documents set out Biden Administration's top-level defense priorities and explain how these priorities will be achieved through focus on integrated deterrence, campaigning, and building enduring advantages. The 2022 Nuclear Posture Review formulates the role of nuclear weapons in U.S. strategy, the U.S. tailored approach to nuclear deterrence, the agenda for strengthening regional deterrence, the U.S. approach to arms control and non-proliferation, as well as the way forward with the nuclear modernization and revitalizing nuclear enterprise.

U.S. Department of Defense. *The Nuclear Matters Handbook 2020 [Revised]*. <https://www.acq.osd.mil/ncbdp/nm/NMHB2020rev/index.html>.

This handbook provides comprehensive overview of the U.S. nuclear deterrent and a basic understanding of nuclear matters and related topics. Each chapter in the handbook features a unique aspect of the U.S. nuclear deterrent, including brief history of U.S. nuclear weapons, nuclear weapons employment policy and planning, nuclear command and control, and nuclear weapons effects.

U.S. Department of Defense. "Report on the Nuclear Employment Strategy of the United States— 2020." https://www.esd.whs.mil/Portals/54/Documents/FOID/Reading%20Room/NCB/21-F-0591_2020_Report_of_the_Nuclear_Employment_Strategy_of_the_United_States.pdf.

This report to the U.S. Congress explains changes in the U.S. nuclear employment strategy following the U.S. President's April 2019 nuclear weapons employment guidance. The document states that the United States cannot rely on adversaries to perceive threats of large-scale nuclear responses as credible in all situations, and therefore, it will continue to field a range of nuclear and non-nuclear capabilities that provide U.S. leadership with options that can be tailored to different requirements. If deterrence fails, the United States will strive to end any conflict "at the lowest level of damage possible and on the best achievable terms." for the United States, and its allies, and partners.

Key U.S. official documents, see also:

The Joint Chiefs of Staff. *Joint Publication 3-72. Nuclear Operations*. 11 June 2019. https://www.esd.whs.mil/Portals/54/Documents/FOID/Reading%20Room/Joint_Staff/19-F-1400_Joint_Publication_JP_03-72_Nuclear%20Operations_06-11-2019.pdf.

U.S. Department of Defense. "Nuclear Posture Review." February 2018.
<https://media.defense.gov/2018/Feb/02/2001872886/-1/-1/1/2018-NUCLEAR-POSTURE-REVIEW-FINAL-REPORT.PDF>

U.S. Department of Defense. Report on Nuclear Employment Strategy of the United States. 12 June 2013. <https://apps.dtic.mil/sti/pdfs/ADA590745.pdf>.

U.S. Department of Defense. "Nuclear Posture Review." April 2010.
[https://dod.defense.gov/Portals/1/features/defenseReviews/NPR/2010 Nuclear Posture Review Report.pdf](https://dod.defense.gov/Portals/1/features/defenseReviews/NPR/2010_Nuclear_Posture_Review_Report.pdf)

On U.S. nuclear capabilities and infrastructure, see:

Woolf, Amy. "U.S. Strategic Nuclear Forces: Background, Developments, and Issues." CRS Report, RL33640. Washington, DC: Congressional Research Service, 14 December 2021.
<https://crsreports.congress.gov/product/pdf/RL/RL33640/69>.

Harvey, John R. "Modernizing the U.S. Nuclear Arsenal: The Road to 2030 and Beyond." in: "Fit For Purpose? The U.S. Strategic Posture in 2030 and Beyond." CGSR Occasional Papers, Livermore, CA: Center for Global Security Research, October 2020: 16-27.
<https://cgsr.llnl.gov/content/assets/docs/The-US-Strategic-Posture-in-2030-and-Beyond.pdf>.

On the role of nuclear weapons in integrated deterrence, see:

Adm. Richard, Charles. "Speech at the 2022 Space and Missile Defense Symposium." 11 August 2022. <https://www.stratcom.mil/Media/Speeches/Article/3126694/2022-space-and-missile-defense-symposium/>.

Bernstein, Paul and Austin Long. "Multi-Domain Deterrence: Some Framing Considerations." In *Getting the Multi-Domain Challenge Right*. Ed. Brad Roberts. Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, December 2021. https://cgsr.llnl.gov/content/assets/docs/CGSR_Getting-the-Multi-Domain-Challenge-Right.pdf.

Radzinsky, Brian, et al. "Setting Priorities for Deterrence Integration. Workshop Report." Livermore, CA: Lawrence Livermore National Laboratory, August 2021.
https://cgsr.llnl.gov/content/assets/docs/Workshop_Summary_Integration2021.pdf

On U.S. nuclear operations, see:

Managing U.S. Nuclear Operations in the 21st Century. Ed. Charles L. Glaser, Austin Long and Brian Radzinsky. Washington, DC: Brookings Institution Press, 2022.

5. NATO Nuclear Basics

NATO. *NATO 2022 Strategic Concept*. June 2022.

https://www.nato.int/nato_static_fl2014/assets/pdf/2022/6/pdf/290622-strategic-concept.pdf.

NATO's 2022 Strategic Concept provides the blueprint for NATO in a more dangerous and competitive strategic environment. The document highlights that "the fundamental purpose of NATO's nuclear capability is to preserve peace, prevent coercion and deter aggression." It describes the major nuclear challenges for the Alliance, and the role of nuclear weapons in an "appropriate mix" of NATO capabilities.

NATO. *Deterrence and Defence Posture Review*. May 2012.

https://www.nato.int/cps/en/natohq/official_texts_87597.htm.

This 2012 document, together with the 2022 Strategic Concept and the guidance from Heads of State and Government at the 2014 Wales, 2016 Warsaw, 2018 Brussels and 2022 Madrid summits, continues to serve as a basis for current NATO nuclear policy.

Cox, Jessica. "Nuclear deterrence today." *NATO Review*. June 2020.

<https://www.nato.int/docu/review/articles/2020/06/08/nuclear-deterrence-today/index.html>.

This article, written by director of nuclear policy at NATO, explains the importance of NATO's nuclear weapons in addressing a renewed nuclear challenge from Russia. While expressing NATO's commitment to the goal of a world without nuclear weapons and to promoting arms control, nonproliferation and disarmament, the author highlights that the Alliance will continue to ensure the effectiveness of our deterrence and defense capabilities and posture, through ensuring that NATO nuclear deterrent remains safe, secure and effective.

On NATO's nuclear policy, see also:

NATO. "Fact Sheet: NATO's nuclear deterrence policy and forces." July 2022.

https://www.nato.int/cps/en/natohq/topics_50068.htm.

NATO. "Fact Sheet: NATO's Nuclear Sharing Arrangements." February 2022.

https://www.nato.int/nato_static_fl2014/assets/pdf/2022/2/pdf/220204-factsheet-nuclear-sharing-arrange.pdf.

On the future of nuclear deterrence after Russia's 2022 aggression against Ukraine:

Tertrais, Bruno. "What Future for Nuclear Deterrence?" Paris, France: The Fondation pour l'innovation politique, October 2022.

<https://www.fondapol.org/app/uploads/2022/10/fondapol-study-bruno-tertrais-what-future-for-nuclear-deterrence-10-2022-1.pdf>.

On contribution of UK's Nuclear Forces:

UK Defence Nuclear Organisation and Ministry of Defense. "Integrated Review of Security, Defence, Development and Foreign Policy 2021: nuclear deterrent." 27 April 2021. <https://www.gov.uk/guidance/integrated-review-of-security-defence-development-and-foreign-policy-2021-nuclear-deterrent>.

Mills, Claire. "Nuclear weapons at a glance: United Kingdom. Research Briefing." London, UK: House of Commons Library, July 2022. <https://researchbriefings.files.parliament.uk/documents/CBP-9077/CBP-9077.pdf>.

Davis, Ian. "The British Bomb and NATO. Six decades of contributing to NATO's strategic nuclear deterrent." Stockholm, Sweden: Stockholm International Peace Research Institute, 2015. https://www.sipri.org/sites/default/files/files/misc/NATO-Trident-Report-15_11.pdf.

On contribution of French Nuclear Forces:

Macron, Emmanuel. "Speech of the President of the Republic of France on the Defense and Deterrence Strategy." 7 February 2020. <https://www.elysee.fr/front/pdf/elysee-module-15162-en.pdf>.

Tertrais, Bruno. "French Nuclear Deterrence Policy, Forces, And Future: A Handbook." Paris, France: Fondation pour la Recherche Stratégique, February 2020. <https://www.frstrategie.org/sites/default/files/documents/publications/recherches-et-documents/2020/202004.pdf>.

6. NATO's Nuclear Evolution Since 2014

Mattelaer, Alexander. "Rethinking Nuclear Deterrence: A European Perspective." *CSDS Policy Brief*, no. 13/2022, May 2022. https://brussels-school.be/sites/default/files/CSDS%20Policy%20brief_2213.pdf.

Mattelaer argues that Russia's nuclear signalling in the 2022 war against Ukraine reminded NATO allies of the risks of nuclear coercion and escalation. Without NATO's nuclear capabilities, European states would become largely defenceless against such threats. Therefore, limiting NATO's defence policy discussions to hybrid threats, conventional deterrence, and arms control is inadequate; Europeans must refocus on nuclear deterrence and stop decoupling nuclear issues from other debates.

Durkalec, Jacek. "NATO Strategy to Counter Nuclear Intimidation." In Andrea Gilli (ed.), "Recalibrating NATO Nuclear Policy." *NDC Research Paper* no. 10. Rome: NATO Defense College, 2020. <https://www.ndc.nato.int/news/news.php?icode=1446>.

The author calls for NATO efforts to improve counter-nuclear intimidation strategy to negate Russia's coercive attempts in peacetime, crisis, and war. Such a strategy requires further improvements in NATO's public communications, military capabilities, and

preparedness to act. Concerning nuclear capabilities, NATO needs to do more to defuse any persisting doubts about the credibility of a collective nuclear mission based on U.S. nuclear gravity bombs and Allied dual-capable aircraft (DCA). To preserve the DCA's collective mission in the long-term, the Alliance should start assessing options for new capabilities and/or an extension of the scope of NATO nuclear consultations.

Roberts, Brad. "On 'Campaigning' for Nuclear Deterrence." In *Alliances, Nuclear Weapons and Escalation: Managing Deterrence in the 21st Century*, ed. Stephan Frühling and Andrew O'Neil. Canberra, Australia: ANU Press - The Australian National University, 2021. <https://press-files.anu.edu.au/downloads/press/n9294/pdf/ch17.pdf>.

Roberts details the challenges that policymakers and politicians face when engaging on nuclear deterrence issues and catalogues key lessons on how overcome these challenges. He argues that to effectively make the case for nuclear deterrence, it is useful to engage in campaigning that could borrow from approaches used by the advocates of disarmament. Such efforts, however, could be effective over the long-term only if allied governments are actively engaged in "upping their game" and bolstering their capacity for deterrence campaigning.

On assessments of NATO's progress since 2014, see:

Larsen, Jeffrey A. "NATO nuclear adaptation since 2014: the return of deterrence and renewed Alliance discomfort." *Journal of Transatlantic Studies* 17, 2019. <https://doi.org/10.1057/s42738-019-00016-y>.

Kulesa, Łukasz. "The Future of Deterrence: Effectiveness and Limitations of Conventional and Nuclear Postures – New Perspectives on Shared Security: NATO's Next 70 Years." Carnegie Europe, November 2019. <https://carnegieeurope.eu/2019/11/28/future-of-deterrence-effectiveness-and-limitations-of-conventional-and-nuclear-postures-pub-80440>.

Durkalec, Jacek. "The 2018 U.S. Nuclear Posture Review, NATO's Brussels Summit and Beyond." Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, June 2018. <https://cgsr.llnl.gov/content/assets/docs/NPR2018BOOKdigital.pdf>.

Karl-Heinz Kamp. "Nuclear Reorientation of NATO," NATO Defense College, *Commentary* no. 1/18, 2018. <http://www.ndc.nato.int/news/news.php?icode=1136>.

On different options to enhance NATO's nuclear deterrence policy and posture:

Binnendijk, Hans, David Gompert. "Decisive Response: A New Nuclear Strategy for NATO." *Survival*, vol. 61, no. 5, 2019. DOI: <https://www.tandfonline.com/doi/full/10.1080/00396338.2019.1662119>.

Kroenig, Matthew. "Toward a More Flexible NATO Nuclear Posture." *Issue Brief*. Washington DC: Atlantic Council, November 2016.

<https://www.atlanticcouncil.org/in-depth-research-reports/issue-brief/toward-a-more-flexible-nato-nuclear-posture/>.

Grand, Camille. "Nuclear deterrence and the Alliance in the 21st century." *NATO Review*, 2016. <http://www.nato.int/docu/review/2016/Also-in-2016/nuclear-deterrence-alliance-21st-century-nato/EN/index.htm>.

On NATO's nuclear burden sharing, see:

Bell, Robert G. *NATO Nuclear Burden-Sharing Post-Crimea: What Constitutes "Free-Riding"?* A Dissertation Submitted to The Faculty of The Fletcher School of Law and Diplomacy In Candidacy for the Degree of Doctor of Philosophy, June 2021.

<https://www.proquest.com/openview/83323aa5ada39eb2f98f62be0fa25585/1?cbl=18750&diss=y&pq-origsite=gscholar>.

On evolving public discourse on nuclear deterrence in Europe:

Europe's Evolving Deterrence Discourse, edited by Amelia Morgan and Anna Péczeli. Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, February 2021.

https://cgsr.llnl.gov/content/assets/docs/CGSR_euro_det_final.pdf.

On NATO's approach to the Treaty on the Prohibition of Nuclear Weapons:

Hill, Steven. "NATO and the Treaty on the Prohibition of Nuclear Weapons." London, UK: Chatham House, January 2021. <https://www.chathamhouse.org/sites/default/files/2021-01/2021-01-29-nato-tpnw-hill.pdf>.

7. Evolving Nuclear Balance: Net Assessment

Brad Roberts, *On Theories of Victory: Red and Blue*. Livermore Papers on Global Security No. 7. Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, 2020). <https://cgsr.llnl.gov/content/assets/docs/CGSR-LivermorePaper7.pdf>.

Roberts argues that while over the last three decades Russia and China have engaged in robust and sustained efforts aimed at development of new strategic thought, the U.S. ability to do so has atrophied. As a result, the United States and its allies have not developed their Blue theory of victory, that is coherent and robust set of ideas and principles on how to marshal their military and non-military tools to defend their interests if challenged militarily by a nuclear-armed adversary.

Chambers, William A. et al. "An Assessment of the U.S.-Russia Nonstrategic Nuclear Weapons Balance." Alexandria, VA: Institute for Defense Analysis, January 2021. <https://www.ida.org/>

</media/feature/publications/a/an/an-assessment-of-the-us-russia-nonstrategic-nuclear-weapons-balance/p-14248.pdf>.

The authors assess that the United States and NATO do not have established concepts of employment of non-strategic nuclear weapons to counter potential Russian theories of victory and Moscow's qualitative and quantitative advantage in non-strategic nuclear weapons. They posit several plausible mechanisms in which perception of imbalance in non-strategic nuclear weapons could impact Russian, U.S., and allied decision-making in a conflict. This includes Moscow's assessment that it has more options for tacit limitation of theater nuclear conflict that enable advantageous nuclear employment with manageable escalation risk.

Durkalec, Jacek et al. "Net Assessment and 21st Century Strategic Competition. Workshop Summary." Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, 2021. https://cgsr.llnl.gov/content/assets/docs/NetA_Workshop_Summary.pdf.

One of the key findings of this CGSR workshop is that the shifts of tripolar U.S.-Russia-China nuclear balance are troubling for the United States and its allies. Growing uncertainties at the strategic nuclear level are paired with negative changes at the regional nuclear level. This is taking place against the backdrop of the deteriorating regional non-nuclear balances that can increase allied interest in what more nuclear deterrence can contribute to their security.

On tripolar strategic balance between the United States, Russia and China:

Péczeli, Anna, et al. "Fit for Purpose? The U.S. Nuclear Posture in 2030 and Beyond. Workshop Summary." Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, June 2020. <https://cgsr.llnl.gov/content/assets/docs/US-Nuclear-Posture-2030-and-Beyond-Workshop-Summary.pdf>.

On Russia's net assessment of evolving strategic nuclear balance, see:

Fink, Anya Loukianova. "Russia's Assessment of the 2030 Strategic Balance." In *Fit for Purpose? The U.S. Strategic Posture in 2030 and Beyond*, edited by Brad Roberts. Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, 2020. <https://cgsr.llnl.gov/content/assets/docs/The-US-Strategic-Posture-in-2030-and-Beyond.pdf>.

On NATO and Russia's nuclear options in a conflict scenario:

Oberholtzer, Jenny. "Glass-jawed Europe: the vulnerability of NATO's conventional posture in nuclear conflict." In "Challenges to NATO's nuclear strategy," edited by Andrea Gilli, *NDC Research Paper* no.22, December 2021. <https://www.ndc.nato.int/news/news.php?icode=1642>.

On U.S. assessment about ability to win a war with Russia and China, see:

National Defense Strategy Commission. *Providing for the Common Defense: The Assessment and Recommendations of the National Defense Strategy Commission*, November 2018. <https://www.usip.org/sites/default/files/2019-07/providing-for-the-common-defense.pdf>.

8. Towards Integrated and Coherent NATO's Deterrence Posture

Menke, Harrison. "Aligning the nuclear and conventional elements of NATO's deterrence." In "Recalibrating NATO Nuclear Policy" ed. Andrea Gilli. *NDC Research Paper* no. 10, Rome: NATO Defense College, 2020. <https://www.ndc.nato.int/news/news.php?icode=1446>.

Menke recommends that to foreclose Russia's nuclear coercive options, NATO could seriously consider better aligning the conventional and nuclear elements of its own deterrence posture. This should encompass: leveraging deterrence forces for harmonizing nuclear deterrence and conventional operations; planning conventional campaigns for shape Russian strategic calculus; and understanding the impact of nuclear employment on conventional operations. The necessary adaptations should extend beyond declaratory statements and require real planning, training, exercising, and leadership attention to execute.

Anderson, Justin, and Lt Col James R. McCue. "Deterring, Countering, and Defeating Conventional- Nuclear Integration." *Strategic Studies Quarterly*, Spring 2021. https://www.airuniversity.af.edu/Portals/10/SSQ/documents/Volume-15_Issue-1/Anderson.pdf.

Anderson and McCue argue that countering and deterring conventional-nuclear integration (CNI) threats posed by potential adversaries requires an integrated, but not mirror-imaged, response of the United States and its allies. They propose a three-part framework for influencing adversaries' cost-benefit calculus. This include denying adversaries benefits from intermingling their conventional and nuclear forces and launching a standoff nuclear strike in theater; imposing costs in response to the threat or employment of nuclear weapons in theater; and encouraging adversary restraint by a combined diplomatc-military approach.

Bernstein, Paul I. "Toward an Integrated Strategic Deterrent." In "Fit For Purpose? The U.S. Strategic Posture in 2030 and Beyond." Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, October 2020. <https://cgsr.llnl.gov/content/assets/docs/The-US-Strategic-Posture-in-2030-and-Beyond.pdf>.

Bernstein explores the need for greater integration across the strategic forces toolkit as a means to strengthen deterrence and defense, the opportunities that exist to advance this goal, and obstacles that must be overcome to ensure progress. He argues that the strongest possible deterrence message to Russia is one that conveys clearly that NATO is willing and able to use the full spectrum of its capabilities to counter coercion and

aggression—and that these capabilities are mutually supportive rather than isolated from one another.

On conventional–nuclear coherence and integration, see also:

Peters, Robert, Justin Anderson, and Harrison Menke. “Deterrence in the 21st Century: Integrating Nuclear and Conventional Force.” *Strategic Studies Quarterly*, vol. 12, no. 4, 2018. https://www.airuniversity.af.edu/Portals/10/SSQ/documents/Volume-12_Issue-4/Menke.pdf.

Manzo, Vince A. and Aaron R. Miles. “The Logic of Integrating Conventional and Nuclear Planning.” *Arms Control Today*, November 2016. https://www.armscontrol.org/ACT/2016_11/Features/The-Logic-of-Integrating-Conventional-and-Nuclear-Planning.

MAJ Nolan, Terrence, and LTC Jason Wood. “The Army’s Place on the Nuclear Battlefield.” *Countering WMD Journal*, no. 24, 2022. https://www.nec.belvoir.army.mil/usanca/CWMDJournal/Issue_24_Countering_WMD_Journal_Final.pdf.

9. Escalation, De-escalation and War Termination

Radzinsky, Brian, et al. “De-Escalation and War Termination in Multi-Domain Regional Wars. Workshop Summary.” Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, May 2021. https://cgsr.llnl.gov/content/assets/docs/DEWT_Workshop_Summary.pdf.

The workshop reviewed the extant of thinking on de-escalation and war termination in modern regional wars involving nuclear-armed regional powers. The discussion highlighted that de-escalation and war termination strategy introduce complex and difficult issues that should be assessed and planned for in advance of a potential conflict with near-peer adversaries. Additionally, failure to understand both Blue and Red approaches could lead to large scale failures and potential devastating strategic consequences.

Warden, John K. “Limited Nuclear War: The 21st Century Challenge for the United States.” *Livermore Papers on Global Security*, No. 4. Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, July 2018. https://cgsr.llnl.gov/content/assets/docs/CGSR_LP4-FINAL.pdf.

Warden posits that in order to safeguard its national interests as well as its allies’, the United States will need to be nimble in drafting its future nuclear deterrence strategies, accounting for general trends and adversaries’ specific capabilities. Focusing on China, North Korea, and Russia, the author considers factors that may either discourage or incentivize their employment of nuclear weapons in the context of a regional conflict.

Morgan, Forrest E. "Dancing with the Bear: Managing Escalation in a Conflict with Russia," *Proliferation Papers*, no. 40, Winter 2012.

<https://www.ifri.org/sites/default/files/atoms/files/pp40morgan.pdf>.

Morgan argues that Cold War models of escalation management – Herman Kahn’s escalation dominance, Thomas Schelling’s brinkmanship, and conflict avoidance – are of limited value to the geopolitical environment of the 21st century. Explaining shortcomings of those concepts, Morgan proposes an approach to escalation control based on threshold management and describes how it might be applied to mitigate escalation risks in conflict with Russia.

On U.S. and NATO progress in developing their approach to counter-escalation and war termination, see also:

Péczei, Anna, et al. "The 2021 Defense Strategy Review and Modern Strategic Conflict. Workshop Report." Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, December 2020.

<https://cgsr.llnl.gov/content/assets/docs/The-2021-Defense-Strategy-Review-and-Modern-Strategic-Conflict.pdf>.

Durkalec, Jacek, et al. "Winning Conventional Regional Wars Against Nuclear-Armed Adversaries. 6th Annual Deterrence Workshop Summary." Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, November 2019. <https://cgsr.llnl.gov/content/assets/docs/Winning-Conventional-Regional-Wars-Summary.pdf>

Durkalec, Jacek, Paige Gasser, Oleksandr Shykov. "5th Annual LLNL Deterrence Workshop Multi-Domain Strategic Competition: Rewards and Risks. Workshop Summary." Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, November 2018.

https://cgsr.llnl.gov/content/assets/docs/Deterrence_Workshop_Summary_Final_2018.pdf.

On concepts of limited nuclear war and escalation management:

On Limited Nuclear War in the 21st Century, Ed. Jeffrey A. Larsen and Kerry M. Kartchner. Stanford University Press: Stanford, CA 2014.

Dangerous Thresholds: Managing Escalation in the 21st Century. Edited by by Forrest E. Morgan, Karl P. Mueller, Evan S. Medeiros, Kevin L. Pollpeter, and Roger Cliff. Santa Monica, California: RAND Corporation, 2008.

https://www.rand.org/content/dam/rand/pubs/monographs/2008/RAND_MG614.pdf.

10. Impact of Emerging Technologies

Miller, James N.Jr. and Richard Fontaine. "A New Era in U.S.-Russian Strategic Stability: How Changing Geopolitics and Emerging Technologies are Reshaping Pathways to Crisis and Conflict." Harvard Kennedy School Belfer Center for Science and International Affairs, Center for a New American Security, September 2017.

<https://s3.amazonaws.com/files.cnas.org/documents/CNASReport-ProjectPathways-Finalb.pdf?mtime=20170918101504>.

Miller and Fontaine examine how new technologies in cyber, space and counter-space, precision strike, and missile defense fields are reshaping the ways in which a U.S.-Russian crisis and conflict likely would unfold. Specifically, the authors argue that both sides are likely to have strong incentives to engage in significant attacks in cyber space and outer space in the early phases of a conflict what might incentivize inadvertent escalation. Furthermore, each side's development of modernized strategic offensive and defensive weapons may weaken each side's confidence in their strategic deterrents.

Cox, Jessica and Heather Williams. "The Unavoidable Technology: How Artificial Intelligence Can Strengthen Nuclear Stability." *The Washington Quarterly*, vol. 44, no. 1, 2021.

<https://www.tandfonline.com/doi/abs/10.1080/0163660X.2021.1893019>.

Cox and Williams observe that artificial intelligence can offer opportunities and risks, depending on its application. They assert that artificial intelligence can assist in deterrence and arms control, and that incorporating artificial intelligence into early warning and decision-making could invite time for de-escalation. The authors encourage the nuclear policy community to bolster and recruit talent with technical expertise and knowledge on artificial intelligence, cyber, and nuclear weapons.

Durkalec, Jacek, Anna Péczeli, Brian Radzinsky. "Nuclear decision-making, complexity and emerging and disruptive technologies: A comprehensive assessment." European Leadership Network, February 2022. <https://www.europeanleadershipnetwork.org/report/nuclear-decision-making-complexity-and-emerging-and-disruptive-technologies-a-comprehensive-assessment/>.

The authors highlight that the complex interactions of emerging and disruptive technologies (EDTs) could significantly impact nuclear decision-making, particular in an escalating regional conventional conflict. They find that in some scenarios, EDTs could affect the decision-making context and available choices in ways that could exacerbate nuclear escalation, while in other circumstances EDTs could encourage nuclear restraint. While the interactions of EDTs are likely to introduce additional complexity to a nuclear decision-making process, they are not the only source of complexity.

See also:

Gottemoeller, Rose. "The Standstill Conundrum: The Advent of Second-Strike Vulnerability and Options to Address It." *Texas National Security Review*, vol. 4, no. 4,

2021. <https://tnsr.org/2021/10/the-standstill-conundrum-the-advent-of-second-strike-vulnerability-and-options-to-address-it/>.

Roberts, Brad. “Emerging and Disruptive Technologies, Multi-domain Complexity, and Strategic Stability: A Review and Assessment of the Literature.” Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, 2021.

https://cgsr.llnl.gov/content/assets/docs/Deterrence_Integration_Annotated_Bibliography.pdf.

Durkalec, Jacek et al. “Annotated Bibliography: Multi-domain Complexity and Strategic Stability in Peacetime, Crisis, and War.” Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, 2021.

https://cgsr.llnl.gov/content/assets/docs/Deterrence_Integration_Annotated_Bibliography.pdf.

11. Future of Nuclear Arms Control and Risk Reduction Measures

Albertson, Michael. “Facing The Coming Arms Control Interregnum. Workshop Summary.” Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, August 2022. <https://cgsr.llnl.gov/content/assets/docs/Workshop-Summary-Arms-Control-Interregnum.pdf>.

One of the key conclusions of this CGSR workshop is that arms control needs to be re-focused and re-branded for its coming interregnum. The arms control strategy should concentrate on identifying concrete problems that can be solved by mutually agreed solutions, determining where and how to incentivize or push Russia and China to participate, and preparing to compete from a position of strength should competitors reject cooperation.

Williams, Heather. “What we got wrong about nuclear risk reduction.” *The Hill*, 23 May 2022. <https://thehill.com/opinion/national-security/3497843-what-we-got-wrong-about-nuclear-risk-reduction/>.

Williams highlights that new nuclear risk reduction tools are needed to counter Russian strategy of intentional escalation towards NATO, as current approaches rely on transparency and adherence to norms – two things Putin has no issue defying. She argues that reinforcing commitment to deterrence can serve to reduce risks by ensuring Russian leadership that any action taken against an Alliance member will result in a swift and devastating response.

Albertson, Michael. “Negotiating with Putin’s Russia: Lessons Learned from a Lost Decade of Bilateral Arms Control.” *Livermore Papers on Global Security* no. 9. Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, March 2021. <https://cgsr.llnl.gov/content/assets/docs/CGSR-LivermorePaper9.pdf>.

Albertson posits that Putin's – and thus is Russia's - arms control strategy has remained largely consistent over his presidential tenure. It has reflected Putin's focus on opportunism rather than any set plan, conflict and mistrust with the United States, and a predilection for tactical short-term gains at the expense of strategic bets on longer-term security solutions. The author provides practical recommendations on how the United States should prepare for any future arms control negotiations with Russia.

On new concepts for arms control in new strategic environment, see:

Albertson, Michael. "Closing the Gap: Aligning Arms Control Concepts with Emerging Challenges." *Livermore Papers on Global Security* no. 10.

Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, February 2022.

https://cgsr.llnl.gov/content/assets/docs/CGSR_Livermore_Paper_10_Closing_the_Gap.pdf.

Péczeli, Anna, Brad Roberts, Jonas Schneider, Adam Thomson, Oliver Thränert and Heather Williams. "Redesigning Nuclear Arms Control for New Realities." Zurich: Center for Security Studies, ETH Zürich, November 2021.

https://css.ethz.ch/en/publications/css-policy-perspectives/details.html?id=/r/e/d/e/redesigning_nuclear_arms_control_for_new.

Manzo, Vince. "Nuclear Arms Control Without a Treaty? Risks and Options After New START." *Deterrence and Arms Control Paper*, no. 1. Arlington, VA: Center for Naval Analysis, 2019. https://www.cna.org/CNA_files/PDF/IRM-2019-U-019494.pdf.

On European security implications of crisis in arms control:

Kulesa, Lukasz. "The Crisis of Nuclear Arms Control and its Impact on European Security." *EU Non-Proliferation and Disarmament Papers*, no. 66. Brussels, Belgium: EU Non-Proliferation and Disarmament Consortium, January 2020.

<https://www.nonproliferation.eu/the-crisis-of-nuclear-arms-control-and-its-impact-on-european-security/>.

Brustlein, Corentin. "The Erosion of Strategic Stability and the Future of Arms Control in Europe." *Proliferation Papers*, No. 60, November 2018.

<https://www.ifri.org/en/publications/etudes-de-lifri/proliferation-papers/erosion-strategic-stability-and-future-arms>.

On challenges for arms control related to nonstrategic nuclear weapons:

Pomper, Miles A, et al. "Everything Counts: Building a Control Regime for Nonstrategic Nuclear Warheads in Europe." *CNS Occasional Paper*, no. 55, May 2022.

<https://nonproliferation.org/wp-content/uploads/2022/05/op55-everything-counts.pdf>.



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