Stanton Nuclear Security Fellows Seminar

PANEL 4: Strategic Stability

1. David Allison, Belfer

Emerging Challenges to Strategic Stability

The arrival of the third nuclear age—characterized by emerging technologies, a return to great power competition, and nuclear multipolarity—threatens to upend global order. Policymakers have long relied on the effectiveness of deterrence and scholars have been encouraged by the "taboo talk" of nuclear elites. But how likely are these truths to hold in a changing world? New vulnerabilities and incentives might increase the likelihood of nuclear use. My research examines the potential impact(s) of changing technological and geopolitical conditions on attitudes towards the use of nuclear weapons.

Many of the features that mark this nuclear age are concerning. While it was once the case that only large, fixed sites could be reliably targeted by nuclear weapons, significant progress in targeting and precision guidance have increased the probability that a counterforce strike might be successful.[1] The looming integration of machine learning into the nuclear counterforce kill chain will only accelerate this shift by improving intelligence, surveillance, and reconnaissance and accelerating command, control, and communications in complex environments.[2] Advanced states either can or will soon be able to pierce the veil of secrecy that is critical to Chinese and North Korean second-strike capabilities due to their reliance on mobile missile launchers (transporter erector launchers, TELs).[3]

As first-strike vulnerability increases, should we anticipate increased risks of nuclear use, or can we remain confident that the historic aversion to the use of nuclear weapons—the taboo—will be sufficiently constraining? Although the concept of "splendid counterforce" dates back to the Cold War, the conditions for such a strike have not yet been met.[4] Though (thankfully) there are no historical cases to study, we can learn about likely crisis behavior through the experimental

[1] Lieber, Keir A. and Daryl G. Press. 2017. "The New Era of Counterforce: Technological Change and the Future of Nuclear Deterrence," *International Security*, 41(4): 9-49.
[2] Johnson, James. 2020. "Deterrence in the age of artificial intelligence & autonomy: a paradigm shift in nuclear deterrence theory and practice?" *Defense & Security Analysis*, 36(4): 422–448.
[3] Bracken, Paul. 2020. *The Hunt for Mobile Missiles: Nuclear Weapons, AI, and the New Arms Race*. Philadelphia: Foreign Policy Research Institute.
[4] See e.g., Builder, Carl H. 1979. "Why Not First Strike Counterforce Capabilities?" *RAND Corporation* P-6312.

manipulation of scenarios. I therefore designed a novel survey experiment—building on cognitive methods developed in behavioral psychology—to test the microfoundations of support for counterforce strikes.

In short, I find that emerging technologies that improve the prospects of counterforce success incentivize nuclear first-use, even among self-proclaimed believers in a nuclear taboo. After typologizing respondents based on explicit and implicit measures of their attitudes towards nuclear use, I identify a large segment of the population (43%) who report a belief in the nuclear taboo. These individuals are significantly more risk averse and less willing to support harming innocents in service of a greater good than their peers. However, when given a series of crisis scenarios describing an escalating war with North Korea, these self-reported believers in the taboo are just as responsive to changes in the effectiveness of nuclear counterforce.

This builds on a growing literature on attitudes towards nuclear use, and offers an explanation for the disconnect between archival work on Cold War elite behavior and experimental work on public attitudes. Tannenwald finds a long tradition of a nuclear taboo in the discourse and behavior of American policymakers, while Pauly examines declassified Cold War wargames and demonstrates that both civilian and military elites were reluctant to cross the nuclear threshold.[5] Conversely, experimental work on public opinion towards nuclear use identifies a possible disconnect between elite and public attitudes: Sagan and Valentino, for example, find that a majority of Americans prioritize protecting U.S. forces over enemy civilians, based on a "utilitarian calculation about saving U.S. lives and ending the war promptly."[6]

My work helps resolve this tension by providing evidence that belief in the taboo is contextual rather than fixed. As T.V. Paul notes, political elites historically rejected nuclear use because the costs outweighed any possible benefits.[7] If emerging technologies make counterforce appear less costly and more likely to succeed, policymakers should be aware that the taboo may be much weaker than the historical record suggests. In my study, as counterforce success increases throughout the experiment, the overwhelming majority (63%) of self-proclaimed taboo proponents come to support a nuclear strike on North Korea's arsenal. Support was even higher among taboo non-believers. When including all of the different respondent attitudes towards nuclear use, 78% of the sample approved of a nuclear strike on North Korea's arsenal once counterforce was described as essentially certain to succeed. This is a shocking result. Even

[5] Tannenwald, Nina. 1999. "The nuclear taboo: The United States and the normative basis of nuclear non-use." *International Organization* 53(3): 433–468 and Pauly, Reid B. C. 2018. "Would U.S. Leaders Push the Button? Wargames and the Sources of Nuclear Restraint." *International Security* 43(2): 151–192.
[6] Sagan, Scott D., and Benjamin A. Valentino. 2017. "Revisiting Hiroshima in Iran: What Americans Really Think About Using Nuclear Weapons and Killing Noncombatants." *International Security* 42(1): 41–79.
[7] Paul, T.V. 2009. *The tradition of non-use of nuclear weapons.* Stanford University Press: 64-91.

though much of the public discourse around nuclear use implies a logic of appropriateness, my results suggest that the overwhelming majority of Americans view nuclear use through a logic of consequences.

Even leaders who have previously expressed an aversion to nuclear use likely did so in light of the technology of the time and the expected consequences of launching a nuclear strike. In peacetime, it is unthinkable to launch a strike that would kill thousands or even millions of people. In a crisis, however, what was once unthinkable may not seem as bad as other alternatives. When cities are threatened by a rival's nuclear weapons, leaders who previously engaged in taboo talk might seriously consider counterforce if success seems likely. As in the scenario I test, almost all individuals—including believers in the taboo—may come to support nuclear use as the actual likelihood of counterforce success increases.

Policymakers should therefore be aware that developing new capabilities is not without significant risk to strategic stability. The return of great power competition further complicates decisions on emerging technologies: technological deployments designed to keep pace with near-peer rivals might simultaneously create destabilizing vulnerabilities for non-peer nuclear states. It is very difficult to design a technology to track Chinese TELs that would not also be able to track the movements of North Korean nuclear forces. Similarly, attempts to constrain the behavior of rogue states risk alarming nearby powers; capabilities aimed at North Korea may spark arms races with China. Concerns about falling behind should therefore be tempered with equally strong concerns about upsetting the "delicate balance of terror."[8]

My project is not without challenges. While the cognitive theories tested should apply equally to members of the public and policymakers, crisis simulations never carry the gravity of an actual crisis.[9] Both deterrence and the nuclear taboo are long-standing constructs with many proponents inside and outside of government. Given the complexity of many of these new technologies and the absence of actual cases where leaders believed counterforce was likely to succeed, it can be difficult to demonstrate the magnitude of the threat. These theories have weathered previous so-called revolutions in military affairs, and convincing believers in either that emerging technologies threaten to put an end to nearly eight decades of nuclear non-use will be an uphill battle.

[8] Wohlsetter, Albert. January 1959. "The Delicate Balance of Terror." *Foreign Affairs*.
[9] See Kertzer, Joshua D., Jonathan Renshon, and Keren Yarhi-Milo. 2019. "How Do Observers Assess Resolve?" *British Journal of Political Science* 51(1): 308–330 and Kertzer, Joshua D. 2020. "Re-Assessing Elite-Public Gaps in Political Behavior." *American Journal of Political Science* on similarities in elite and public preferences on political behavior in experimental settings.

2. Lindsay Rand, CEIP

Reinventing Accuracy? Quantum Sensing Implications for Nuclear Deterrence

On what nuclear security issue are you working and why is it important?

My dissertation examines whether and how new technologies could undermine nuclear deterrence. Some policymakers and practitioners claim that new sensing technologies may provide the necessary accuracy and detection capabilities to precisely track and target the delivery systems that constitute a nuclear-armed state's second-strike capabilities.[10] If such claims are correct, the consequences for nuclear force structure planning and arms control policymaking would be profound. In my dissertation I assess the implications for deterrence of one of the most discussed (and hyped) emerging technologies, quantum sensing.

The impact of emerging technologies on nuclear deterrence has prominently influenced recent nuclear force structure and arms control debates. Scholars and analysts have proposed competing frameworks for predicting how various technological advances, such as artificial intelligence, drone swarms, and hypersonic missiles, will affect nuclear deterrence and associated arms control agreements. A key disagreement involves the extent to which new technologies either favor damage limitation and nuclear superiority or necessitate arms control agreements and force structure restraint to manage deterrence instability. Analysts viewing deterrence through a damage limitation lens see emerging technologies as opportunities to enhance counterforce capabilities; to American analysts, this may be seen as yielding a deterrence advantage if the United States can use new technologies to minimize vulnerability and establish an asymmetric advantage.[11] (The same technology could destabilize deterrence if possessed by an adversary.) Proponents of using emerging technologies for damage limitation therefore tend to argue in favor a more robust U.S. nuclear arsenal and in opposition to arms limitation agreements.[12] Conversely, analysts ascribing to the assured destruction deterrence perceive few if any applications of emerging technologies that could alter conditions of mutual vulnerability between the United States, Russia, and China, and thus could not invalidate the

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[10] Keir Lieber and Daryl Press, "The New Era of Counterforce: Technological Change and the Future of Nuclear Deterrence," *International Security*, Vol. 41, No. 4, 2017; Rose Gottemoeller, "The Standstill Conundrum: The Advent of Second-Strike Vulnerability and Options to Address it," *Texas National Security Review*, Vol. 4, No. 4, 2021; Shane Praiswater, "Why We Need a New ICBM," *DefenseOne*, December 7, 2020.

[11] Keir Lieber and Daryl Press, "The New Era of Counterforce: Technological Change and the Future of Nuclear Deterrence," *International Security*, Vol. 41, No. 4, Spring 2017.

[12] For example, discussed in: Brad Roberts, *The Case for U.S. Nuclear Weapons in the 21st Century*, (Stanford, Calif: Stanford University Press, 2016); Barry Pavel and Christian Trotti, "New Tech Will Erode Nuclear Deterrence. The US Must Adapt," *DefenseOne*, November 4, 2021.

retaliatory threats that stabilize deterrence.[13] Rather, from this perspective, emerging technologies incentivize cooperation to address inadvertent escalation risks.

Yet, even as this debate rages, there has been remarkably little detailed, technical analysis into whether new technologies—quantum sensing, in particular—really could undermine the survivability of second-strike capabilities. Realistically, analyzing the likely scale of any disruption will require both technological and social perspectives to understand both the practical and theoretical limits of new technologies and the social and organizational mechanisms that integrate or ignore these technical perspectives in military organizations and governmental policy. Quantum sensors are a key case study because they represent the frontier for accuracy improvements and thus are potentially the most consequential for undermining the survivability of second-strike capabilities secured through either concealment or hardening. Still, only a few articles have explored the implications quantum sensors bear for deterrence, and of those there is very limited technical analysis or discussion of feasible degrees of improvement beyond existing capabilities.[14] My dissertation aims to fill this critical gap.

What is the big question that you are seeking to answer about that issue?

What are the nuclear deterrence implications of quantum sensing technologies?

How are you going to answer your question?

I leverage a multidisciplinary approach to evaluate the technical and social dimensions of emerging technologies and deterrence, including the technical hype surrounding quantum sensing and the social mechanisms that propagate hype. Because the most consequential effects of quantum sensing would be the impacts to assured second-strike capabilities, I focus on the two use cases that could undermine concealment and hardening efforts: detection and tracking of nuclear submarines and inertial navigation to improve missile accuracy.[15] First, I

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[13] For example: Charles Glaser and Steve Fetter, "Should the United States Reject MAD? Damage Limitation and U.S. Nuclear Strategy toward China," *International Security*, Vol. 41, No. 1, 2016; Andrew Futter, "Explaining the Nuclear Challenges Posed By Emerging and Disruptive Technology: A Primer for European Policymakers and Professionals," EU Non-Proliferation and Disarmament Consortium, No. 73, March 2021; Rose Gottemoeller, "The Case Against a New Arms Race," *Foreign Affairs*, August 9, 2022.

[14] Sarah Gamberini and Lawrence Rubin, "Quantum Sensing's Potential Impacts on Strategic Deterrence and Modern Warfare," *Orbis*, Vol. 65, Issue 2, 2021; Katarzyna Kubiak, "Quantum Technology and Submarine Near-Invulnerability," European Leadership Network – Global Security Policy Brief, 2020.

[15] Use-cases identified through surveying relevant literature, including: C.L. Degen, F. Reinhard and P. Cappellaro, "Quantum sensing," *Review of Modern Physics*, Vol. 89, 2017; "Bringing Quantum Sensors to Fruition," Executive Office of the President of the United States, March 2022; Michal Krelina, "Quantum technology for military applications," *EPJ Quantum Technology*, Vol 8, No 24, 2021; Edward Parker, "Commercial and Military Applications for Quantum Technology," RAND Corporation – Research Paper, November 1, 2021.

survey recent experimental results to identify sensitivities of current quantum sensor prototypes that would be relevant to navigation and subsurface detection applications. Next, I review theoretical literature to determine projected performance gains for these prototypes as R&D progresses. Leveraging information in the open-source literature on operational requirements for each of these use cases, I then calculate projected capability gains based on both experimentally observed and theoretically feasible performance levels.[16] Turning to the interaction of technology and policy, I assess the social mechanisms that impact decision-making on assured second-strike capabilities with a review of historical cases where policy choices diverged from technical feasibility assessments. I consider how the dominant social mechanisms in these cases compare to contemporary decision-making on quantum sensor innovation and associated changes to deterrence strategy. Through this methodology, I identify policy recommendations based on the technical analysis and the social and organizational mechanisms which have historically guided decision-making on similarly disruptive technologies.

What is your answer to the question you are asking?

Based on my analysis, quantum sensing technology is unlikely to lead to the revolution in accuracy that has been suggested, yet, because of the hype surrounding the technology, defense institutions are likely to invest in it regardless. This could ultimately lead to disjuncture between U.S. strategy and actual military capability, deterrence instability, arms racing, and excessive/unnecessary defense expenditure. Drawing on methods used in historical analyses of similar technology developments,[17] my research finds that quantum sensing is more likely to produce gradual improvement to existing capabilities than to cause a cataclysmic shift, and thus will be unlikely to alter the main deterrence foundation of assured second-strike. First, in submarine detection applications, quantum sensors may be applied in a number of nuclear submarine tracking tactics, but even assuming the highest gain from quantum entanglement, new sensors would likely only achieve detection ranges of about 5-10km, which would still necessitate an expansive network of detectors to achieve ocean transparency. Quantum sensors may lead to more impactful improvements in inertial navigation, which could shrink the circular error probable missile accuracy estimate, although likely not within the range required for a low casualty disarming first strike.[18]

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[16] For submarine detection and tracking, I assess the viability of achieving complete ocean transparency or persistent tracking capabilities and estimate the infrastructure that would be needed support either initiative. For missile accuracy, I assess the likelihood that quantum inertial navigation could shrink the uncertainty range substantially.
[17] For example, see the various works of Paul Moser on submarine signatures and detection capabilities.
[18] The range for a low casualty disarming first strike is debated, but per Kier and Lieber (2018) it is 10-15 meters.

However, as the hype over quantum sensing indicates, inflated assessments of impact are not strictly rooted in technical analyses. Rather, "hype" is created by social and organizational mechanisms, resulting in positive feedback loops that inflate expectations of a technology's disruptive potential. For example, scientists are prone to lean into hype either due to resource implications or research focus bias. Likewise, because of the process through which military branches evaluate strategic risk, greater costs are linked to failing to prepare (and accepting asymmetric deficits) as compared to over-responding (and arms racing). Finally, this research finds that quantum sensing hype is also driven by co-development of the technology with quantum computing. Quantum computing, which is at a more nascent stage of development thus far, would use similar underlying technologies and methodologies, but for broader applications to improve computational power and speed. Driven by concerns over potential decryption power, U.S. policymakers have already asserted an intent to compete for leadership on quantum computing.[19]

How does your work fit into the existing work on your subject?

My work informs the prominent debate over the impact of new technologies on nuclear deterrence, as well as less conspicuous body of literature on the influence of social dynamics on nuclear decision-making. As scholars have shown, military and defense decisionmakers rarely respond solely to technical assessments in technology development and acquisition decisions. Rather, these processes are also driven by a complex combination of politics, organizational mechanisms, and social constructs. My dissertation offers an updated case study that fits alongside David Rosenberg's seminal 1983 article, "The Origins of Overkill," [20] Donald Mackenzie's 1993 book *Inventing Accuracy,*[21] Lynn Eden's 2004 book *Whole World on Fire*, [22] and Sharon Weinberger's 2017 book *Imaginary Weapons.*[23] My research complements this historical line of work to show that many of the mechanisms influencing current emerging technology debates can be understood through historical case studies.

What policy implications flow from your work? What concrete recommendations can you offer?

The underlying objective of this research is to re-evaluate the narrative that technological disruptions undermine nuclear deterrence and thus require greater modernization efforts or

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[19] "National Security Memorandum on Promoting United States Leadership in Quantum Computing While Mitigating Risks to Vulnerable Cryptographic Systems," U.S. White House - National Security Memo, May 4, 2022.
[20] David Rosenberg, "The Origins of Overkill: Nuclear Weapons and American Strategy, 1946-1960," *International Security*, Vol. 7, No. 4, pp. 3 – 71, 1983.
[21] Donald Mackenzie, *Inventing Accuracy*, MIT Press, 1993.
[22] Lynn Eden, *Whole World on Fire*, Cornell University Press, 2004.
[23] Sharon Weinberger, *The Imagineers of War*, Knopf, 2017.

disincentivize arms control or cooperative risk reduction policies. Technology hype has become a key factor in nuclear deterrence and arms control policymaking. By explicitly analyzing the feasible improvements from quantum sensing, this research finds inaccuracies in damage limitation assessments, suggesting that policymakers should be more critical of technological hype. Additionally, because submarine vulnerability is unlikely in the foreseeable future, modernization efforts driven specifically by concerns over submarine vulnerability, such as road-mobile missiles, would be excessive. However, because inertial guidance navigation could allow lower-yield nuclear weapons to penetrate hardened missile silos, analysts that view increased numbers of smaller nuclear weapons as destabilizing should prioritize arms control agreements on low-yield nuclear weapons.

What do you think is the weakest or most vulnerable aspect of your study and what sort of feedback would be most useful to you?

I am still evaluating the social mechanisms involved and trying to understand their influence in policy decision processes. As a Stanton fellow at Carnegie, I hope to get increased exposure to the social and institutional aspects of nuclear policymaking in which emerging technology hype is mediated.