Nuclear Weapons and Arms Control Today: A U.S. Perspective

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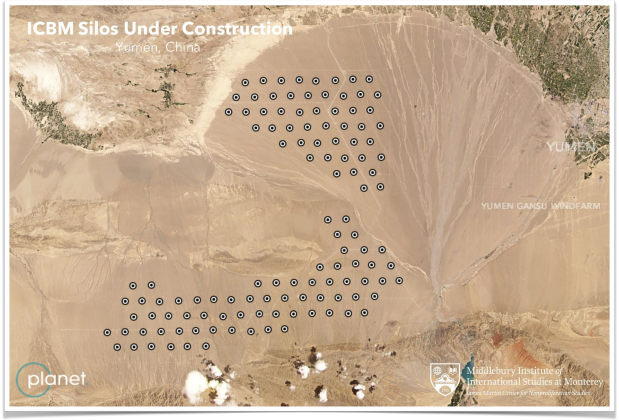
Berkeley
UNIVERSITY OF CALIFORNIA

Agenda

1. Context: The Three Body Problem
2. U.S. Nuclear Force Posture
    a. Today
    b. And Tomorrow (Nuclear Modernization)
3. *Contemporary Debates
    a. Nuclear Numbers
    b. Targeting
    c. Non-strategic Weapons
    d. MD/Hypersonics
    e. AI
    f. The Future of Arms Control

Context:
The “Three Body Problem”



Qualitative shifts in Russian nuclear capabilities;
+non-strategic nuclear weapons

Quantitative and qualitative shifts in Chinese nuclear capabilities

- PLARF → PLAN

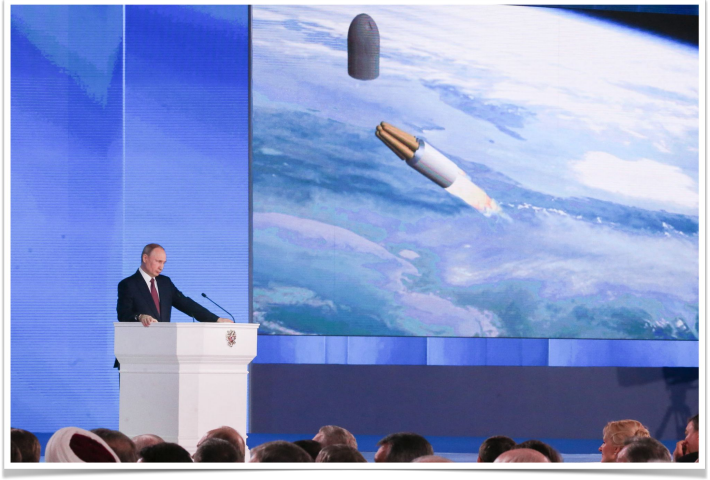
Nuclear Modernization in Russia

Approx. 1,500 deployed nuclear warheads (per the “old” New START limits)

+ Approx. 2,000 non-strategic nuclear weapons

Developing **new capabilities**:

- Sarmat Heavy ICBM (MIRV-ed)
- 9M730 Burevestnik (nuclear-armed/powered)
- Avangard HGV
  - Breaking the INF Treaty
- Poseidon (Status-6) Torpedo



Nuclear Modernization: China

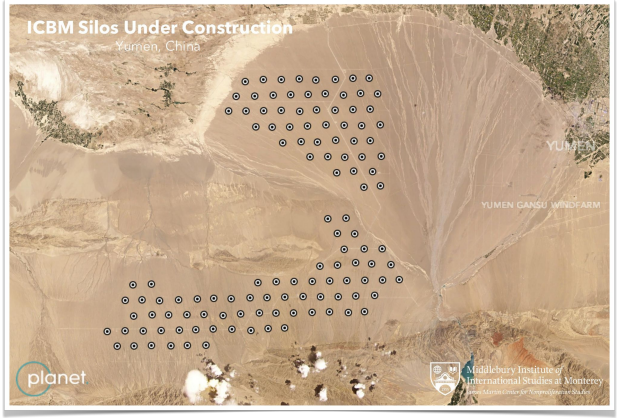
Quantitative increase ("Breakout")

- The rate of this increase is subject to debate
- 300 —> 1,000 warheads (est. by 2030 by U.S. Dept. of Defense)

Qualitative change in force posture

- PLA-RF → PLA-N

Failed attempts to engage Beijing in nuclear arms control talks




EVERYTHING
EVERYWHERE
ALL AT ONCE

Two U.S. Nuclear Posture Documents

2022 Nuclear Posture Review

1. Identifies **Russia**, **China**, **North Korea**, and **Iran** as potential nuclear challenges, focuses on China as a pacing threat;
2. Reasserts U.S. commitments to **nuclear arms control**;
3. Cancels SLCM-N, retires B83-1 Gravity Bomb, and prioritizes plutonium **pit production**;
4. Provides country specific strategies and heavily focuses on collaboration with **allies**.
5. **Nuclear risk reduction and nonpro at the margins**

2023 Strategic Posture Commission Report

1. Focused on Russia and China, including Russo-Chinese nuclear collaboration;
2. Recommends increasing delivery systems numbers across the triad and deploying **more non-strategic nuclear forces**;
3. Calls for active deployment of some active hedge warheads and full funding of NNSA recapitalization efforts (including **pit production**);
4. Recommends increasing and modernizing conventional forces.

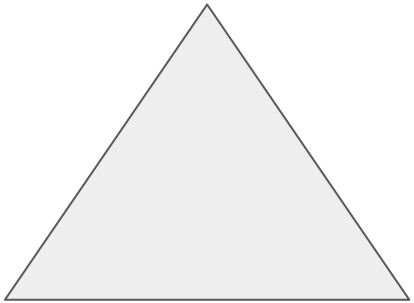
What are Nuclear Weapons For?

The Strategic Posture Commission Report suggests that U.S. nuclear strategy be based upon:

- Assured **second strike**
- **Flexible response** to achieve national objectives
- **Tailored** deterrence to hold at risk what an adversary values most
- **Extended deterrence** and assurance
- **Calculated ambiguity** in declaratory policy
- **Hedge** against risk (geopolitical, technical, operational, programmatic)

U.S. “Nuclear Triad”

Air Based
46 B-52 Stratofortress (carrying up to 20 GM-86B cruise missiles) and 20 B-2A Spirit bombers (carrying up to 16 B61-7 or B61-11 gravity bombs)
**F-15E, F-16C/D, and F-35 carry non-strategic B61 gravity bomb*



Land Based
400 Minuteman III ICBMs in hardened silos, each carrying a W87/Mk21 or W78/Mk12A warhead

Sea Based
14 Ohio Class submarines, each with up to 20 Trident II D5 SLBMs carrying 4-5 W-76-1, W76-2, or W-88 warheads

Table 1. First deployment of nuclear delivery systems and the end of original design lives[208]

Current System	Year First Deployed	End of Original Design Life
MMIII ICBM	1970	1980
B-2A Bomber	1997	None
B-52H Bomber	1961	1981
AGM-86B ALCM	1982	1992
Ohio-class SSBN	1981	2011
Trident II D5	1990	2015
Trident D5LE	2017	2042
F-15E DCA	1988	None

*From Triad to Dyad?

There has been a long-standing debate as to whether the ICBM leg of the triad is redundant

While others suggest that the bomber leg should be abandoned

Either way, the Air Force isn't happy…

The Role of the Triad

Survivability. Ensuring second-strike stability (SSBN via difficulty of detection and ICBM via intercontinental range)

Responsiveness. ICBMs can be launched within minutes and reach target in approx. 30 minutes

Flexibility. Signaling applications (e.g., FONOPs using the air leg)

Coupling. DCAs

Positive Control. NC3 and “Always, Never”

Nuclear Modernization in the United States

Modernizing the “triad”

- Staying within **New START** limits
  - 1,550 warheads
  - 700 deployed missiles and bombers
    - 800 total (incl. non-deployed)

As well as modernizing **C4ISR** and **NC3** capabilities

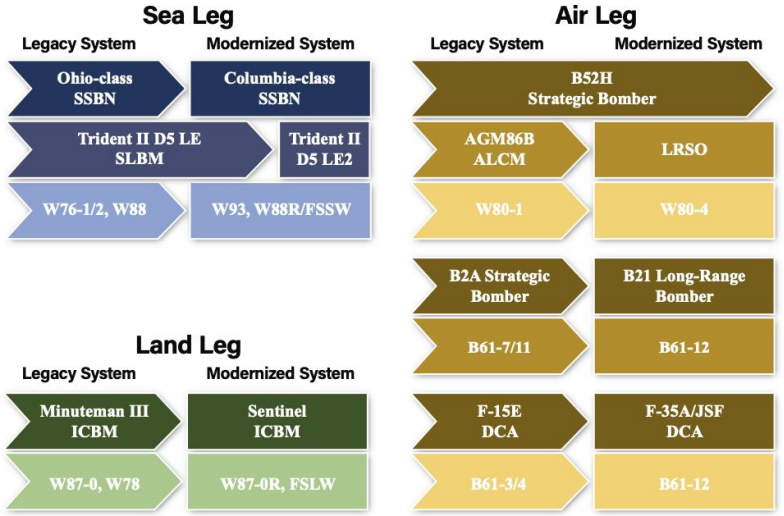


Figure 1. Illustration of the like-for-like transition from legacy to modernized systems.[212]

Progress Report: Nuclear Modernization

Modernization of all three legs have run into problems—with subsequen calls to:

- "Extend" the life of *Ohio*-class
- "Uploading" ICBM and SLBM warheads
- "Re-convert" SLBM launchers and B-52 bombers

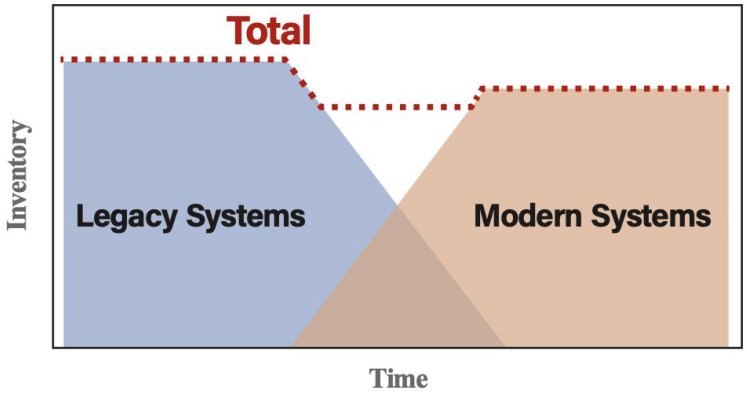
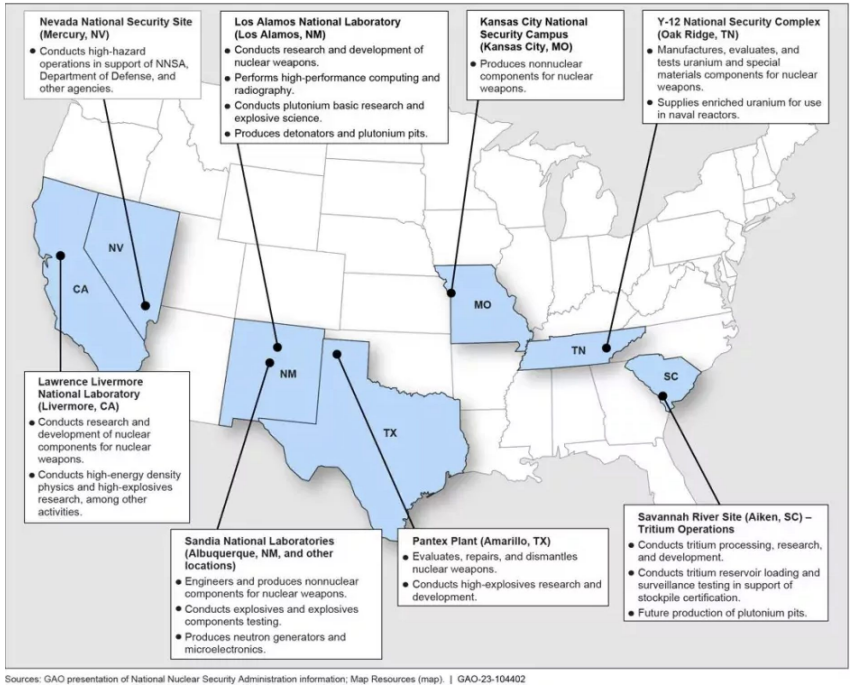


Figure 3: Notional depiction of the transition from a nuclear triad based on legacy systems to triad based on modern systems in the event of a POR delay (or combination of delays). In this case, the total inventory, illustrated by the red dashed line, would experience a shortfall in the late 2020s through early 2030s.

*The U.S. Nuclear Enterprise

The U.S. Department of Defense is not responsible for the production of nuclear weapons, that falls to the the U.S. Department of Energy and the National Nuclear Security Administration (DOE/NNSA).

How is it going?



Sources: GAO presentation of National Nuclear Security Administration information; Map Resources (map). | GAO-23-104402

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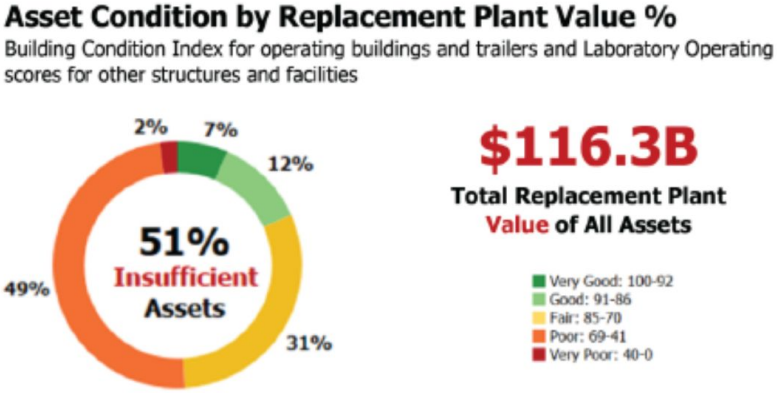
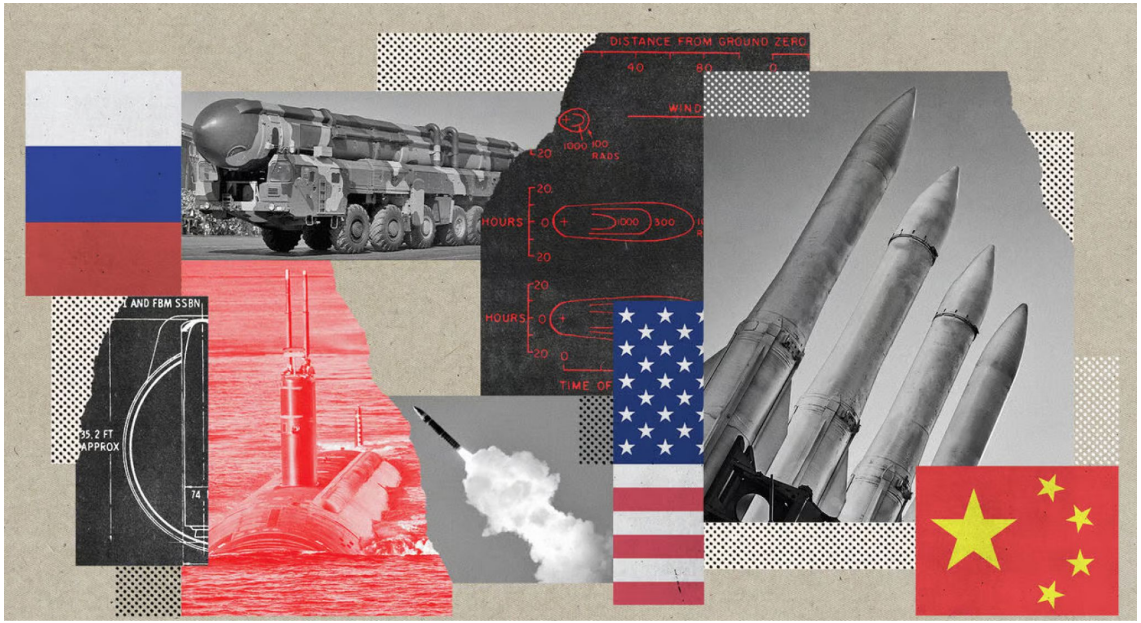


Figure 4. NNSA Asset condition by replacement plant value percentage[240]

*Is More Better?

While official doctrine has remained unchanged, there are increasing calls among conservatives for a quantitative and qualitative increase in the number and type of nuclear forces…



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FOREIGN AFFAIRS

The U.S. Nuclear Arsenal Can Deter Both China and Russia

Why America Doesn't Need More Missiles

By Charles L. Glaser, James M. Acton, and Steve Fetter
October 5, 2023

Posing with nuclear missiles in Beijing, October 2022
Florence Lo / Reuters

*Nuclear “Uses”

Under what conditions would states use nuclear weapons?

- In response to adversary nuclear use?
- In response to adversary attack with “strategic effects”
- For warfighting?

FOREIGN AFFAIRS

The Return of Nuclear Escalation

How America’s Adversaries Have Hijacked Its Old Deterrence Strategy

By Keir A. Lieber and Daryl G. Press November/December 2023

Published on October 24, 2023

Joan Wong

*Nuclear Targeting

Should the US maintain its current nuclear targeting policy of holding at risk China's and Russia's **leaders**, **nuclear command-and-control capabilities**, **military forces**, and **war supporting industry** (WSI), or should it shift to an approach that focuses on **conventional forces** and **WSI**?

https://www.csis.org/events/poni-live-debate-us-nuclear-targeting

Vocab:
Counterforce vs. Countervalue targeting

*Whither SLCM-N?

SLCM-N and non-strategic weapons

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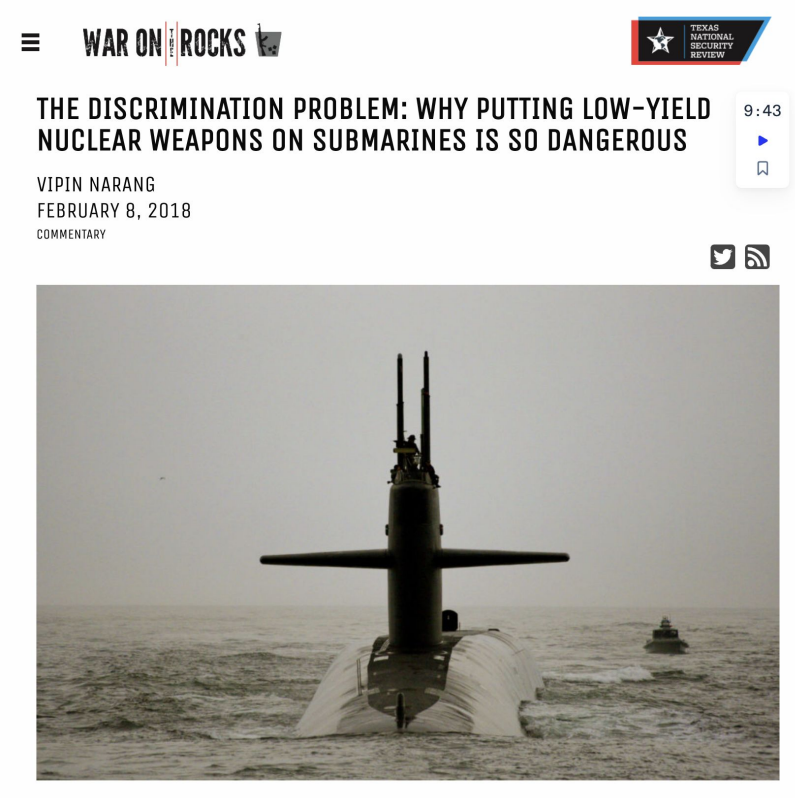
- Included in the 2023 NDAA

SPC report encourages “increased deployment” of non-strategic nuclear weapons (particularly in Europe and the Indo-Pacific).



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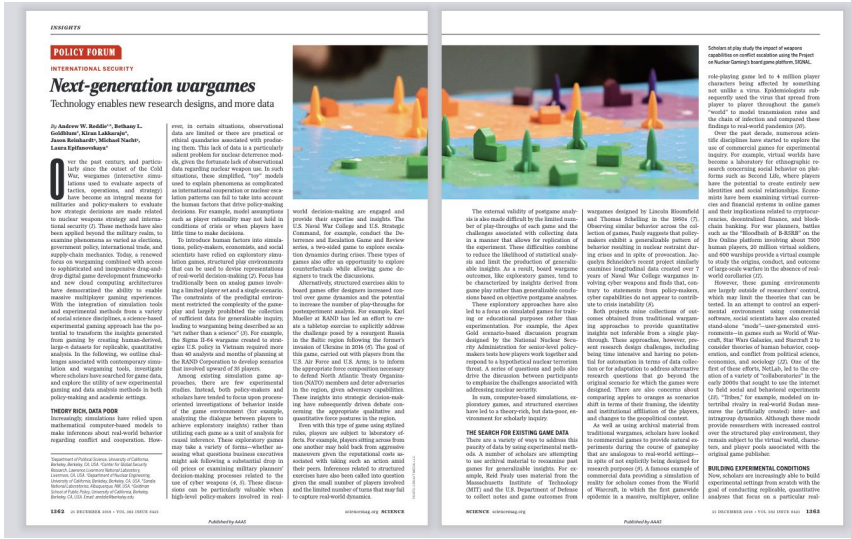

INSIGHTS

POLICY FORUM

INTERNATIONAL SECURITY

Next-generation wargames

Technology enables new research designs, and more data

by Andrew W. Reddie[1*], Bethany L. Goldblum[2], Kiran Lakkaraju[3], Jason Reinhardt[3], Michael Nachtr[3], Laura Epifanovskaya[3]

Over the past century, and particularly since the outset of the Cold War, wargames (interactive simulations used to evaluate aspects of tactics, operations, and strategy) have become an integral means for militaries and policy-makers to evaluate how strategic decisions are made related to nuclear weapons strategy and international security (1). These methods have also been applied beyond the military realm, to examine phenomena as varied as elections, government policy, international trade, and supply-chain mechanisms. Today, a renewed focus on wargaming combined with access to sophisticated and inexpensive drag-and-drop digital game development frameworks and new cloud computing architectures have democratized the ability to enable massive multiplayer gaming experiences. With the integration of simulation tools and experimental methods from a variety of social science disciplines, a science-based experimental gaming approach has the potential to transform the insights generated from gaming by creating human-derived, large-n datasets for replicable, quantitative analysis. In the following, we outline challenges associated with contemporary simulation and wargaming tools, investigate where scholars have searched for game data, and explore the value of new experimental gaming and data analysis methods in both policy-making and academic settings.

THEORY RICH, DATA POOR

Increasingly, simulations have relied upon mathematical computer-based models to make inferences about real-world behavior regarding conflict and cooperation. However, in certain situations, observational data are limited or there are practical or ethical quandaries associated with producing them. This lack of data is a particularly salient problem for nuclear deterrence models, given the fortunate lack of observational data regarding nuclear weapon use. In such situations, these simplified, “toy” models used to explain phenomena as complicated as international cooperation or nuclear escalation patterns can fail to take into account the human factors that drive policy-making decisions. For example, model assumptions such as player rationality may not hold in conditions of crisis or when players have little time to make decisions.

To introduce human factors into simulations, policy-makers, economists, and social scientists have relied on exploratory simulation games, structured play environments that can be used to devise representations of real-world decision-making (2). Focus has traditionally been on analog games involving a limited player set and a single scenario. The constraints of the prestigious environment restricted the complexity of the gameplay and largely prohibited the collection of sufficient data for generalizable inquiry, leading to wargaming being described as an “art rather than a science” (3). For example, the Sigma II-64 wargame created to strategize U.S. policy in Vietnam required more than 40 analysts and months of planning at the RAND Corporation to develop scenarios that involved upward of 35 players.

Among existing simulation game approaches, there are few experimental studies. Instead, both policy-makers and scholars have tended to focus upon process-oriented investigations of behavior inside of the game environment—for example, analyzing the dialogue between players to achieve exploratory insights) rather than utilizing each game as a unit of analysis for causal inference. These exploratory games may take a variety of forms—whether assessing what questions businesses executives might ask following a substantial drop in oil prices or examining military planners’ decision-making processes related to the use of cyber weapons (4, 5). These discussions can be particularly valuable when high-level policy-makers involved in real-world decision-making are engaged and provide their expertise and insights. The U.S. Naval War College and U.S. Strategic Command, for example, conduct the Deterrence and Escalation Game and Review series, a two-sided game to explore escalation dynamics during crises. These types of games also offer an opportunity to explore counterfactuals while allowing game designers to track the discussions.

Alternatively, structured exercises akin to board games offer designers increased control over game dynamics and the potential to increase the number of play-throughs for postexperiment analysis. For example, Karl Mueller at RAND has led an effort to create a tabletop exercise to explicitly address the challenge posed by a resurgent Russia in the Baltic region following the former’s invasion of Ukraine in 2016 (6). The goal of this game, carried out with players from the U.S. Air Force and U.S. Army, is to inform the appropriate force composition necessary to defend North Atlantic Treaty Organization (NATO) members and deter adversaries in the region, given adversary capabilities. These insights into strategic decision-making have subsequently driven debate concerning the appropriate qualitative and quantitative force postures in the region.

Even with this type of game using stylized rules, players are subject to laboratory effects. For example, players sitting across from one another may hold back from aggressive maneuvers given the reputational costs associated with taking such an action amid their peers. Inferences related to structured exercises have also been called into question given the small number of players involved and the limited number of turns that may fail to capture real-world dynamics.

The external validity of postgame analysis is also made difficult by the limited number of play-throughs of such game and the challenges associated with collecting data in a manner that allows for replication of the experiment. These difficulties combine to reduce the likelihood of statistical analysis and limit the production of generalizable insights. As a result, board wargame outcomes, like exploratory games, tend to be characterized by insights derived from game play rather than generalizable conclusions based on objective postgame analyses.

These exploratory approaches have also led to a focus on simulated games for training or educational purposes rather than experimentation. For example, the Apex Gold scenario-based discussion program designed by the National Nuclear Security Administration for senior-level policymakers tests how players work together and respond to a hypothetical nuclear terrorism threat. A series of questions and polls also drive the discussion between participants to emphasize the challenges associated with addressing nuclear security.

In sum, computer-based simulations, exploratory games, and structured exercises have led to a theory-rich, but data-poor, environment for scholarly inquiry.

THE SEARCH FOR EXISTING GAME DATA

There are a variety of ways to address this paucity of data by using experimental methods. A number of scholars are attempting to use archival material to reexamine past games for generalizable insights. For example, Reid Pauly uses material from the Massachusetts Institute of Technology (MIT) and the U.S. Department of Defense to collect notes and game outcomes from wargames designed by Lincoln Bloomfield and Thomas Schelling in the 1960s (7). Observing similar behavior across the collection of games, Pauly suggests that policymakers exhibit a generalizable pattern of behavior resulting in nuclear restraint during crises and in spite of provocation. Jacquelyn Schneider’s recent project similarly examines longitudinal data created over 7 years of Naval War College wargames involving cyber weapons and finds that, contrary to statements from policy-makers, cyber capabilities do not appear to contribute to crisis instability (8).

Both projects mine collections of outcomes obtained from traditional wargaming approaches to provide quantitative insights not inferable from a single play-through. These approaches, however, present research design challenges, including being time intensive and having no potential for automation in terms of data collection or for adaptation to address alternative research questions that go beyond the original scenario for which the games were designed. There are also concerns about comparing apples to oranges as scenarios shift in terms of their framing, the identity and institutional affiliation of the players, and changes to the geopolitical context.

As well as using archival material from traditional wargames, scholars have looked to commercial games to provide natural experiments during the course of gameplay that are analogous to real-world settings—in spite of not explicitly being designed for research purposes (9). A famous example of commercial data providing a simulation of reality for scholars comes from the World of Warcraft, in which the first gamewide epidemic in a massive, multiplayer, online role-playing game led to 4 million player characters being affected by something not unlike a virus. Epidemiologists subsequently used the virus that spread from player to player throughout the game’s “world” to model transmission rates and the chain of infection and compared those findings to real-world pandemics (10).

Over the past decade, numerous scientific disciplines have started to explore the use of commercial games for experimental inquiry. For example, virtual worlds have become a laboratory for ethnographic research concerning social behavior on platforms such as Second Life, where players have the potential to create entirely new identities and social relationships. Economists have been examining virtual currencies and financial systems in online games and their implications related to cryptocurrencies, decentralized finance, and blockchain banking. For war planners, battles such as the “Bloodbath of B-R3B2” on the Eve Online platform involving about 7300 human players, 20 million virtual soldiers, and 600 warships provide a virtual example to study the origins, conduct, and outcome of large-scale warfare in the absence of real-world corollaries (11).

However, these gaming environments are largely outside of researchers’ control, which may limit the theories that can be tested. In an attempt to control an experimental environment using commercial software, social scientists have also created stand-alone “mods”—user-generated environments—in games such as World of Warcraft, Star Wars Galaxies, and Starcraft 2 to consider theories of human behavior, cooperation, and conflict from political science, economics, and sociology (12). One of the first of these efforts, NetLab, led to the creation of a variety of “collaboratories” in the early 2000s that sought to use the Internet to field social and behavioral experiments (13). “Tribes,” for example, modeled on intertribal rivalry in real-world Sudan measures the (artificial) creation, inter- and intragroup dynamics. Although these mods provide researchers with increased control over the structured play environment, they remain subject to the virtual world, characters, and player pools associated with the original game publisher.

BUILDING EXPERIMENTAL CONDITIONS

Now, scholars are increasingly able to build experimental settings from scratch with the goal of conducting replicable, quantitative analyses that focus on a particular real-

Scholars at play study the impact of weapons capabilities on conflict escalation using the Project on Nuclear Gaming’s board game platform, DIGMO.

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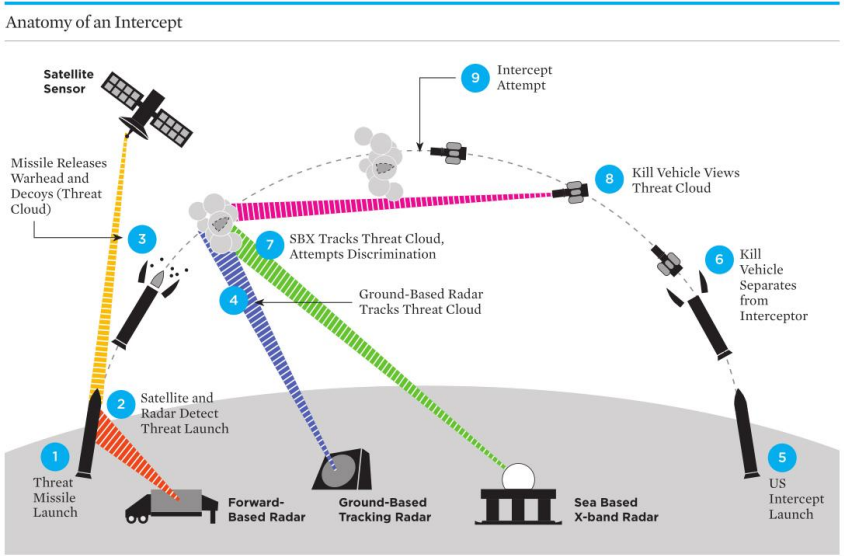
*Whither Missile Defense?



The GMD system involves a complex, global network of components. The launch of the threat missile (1) is detected by forward-based radars, if present, and satellite-based infrared sensors (2). The threat missile releases its warhead and decoys (in this example the decoys are balloons, and a balloon contains the warhead; together they are referred to as the "threat cloud") (3), and the ground-based radar begins tracking the threat cloud (4). Based on information from this radar, the GMD system launches one or more interceptors (5), each of which releases a kill vehicle (6). If a discrimination radar, such as the Sea Based X-band Radar, is in place it will observe the threat cloud to try to determine which object is the warhead (7) and pass this information to the kill vehicle. The kill vehicle also observes the threat cloud to attempt to determine which object is the warhead (8). It then steers itself into the path of the chosen object and attempts to destroy it with the force of impact (9).

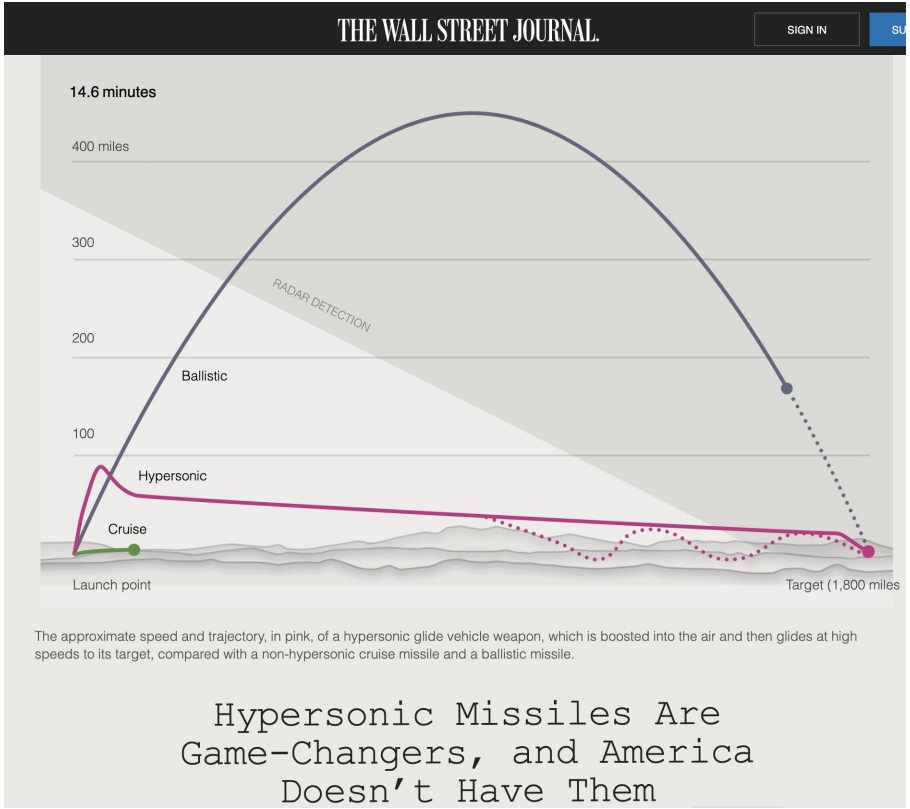
*Hypersonic Weapons

Hypersonic denotes a speech of greater than Mach 5

- Glide vehicles
- Scramjet vehicles

What are the key characteristics of a hypersonic weapon?

What are the missions for the weapon?



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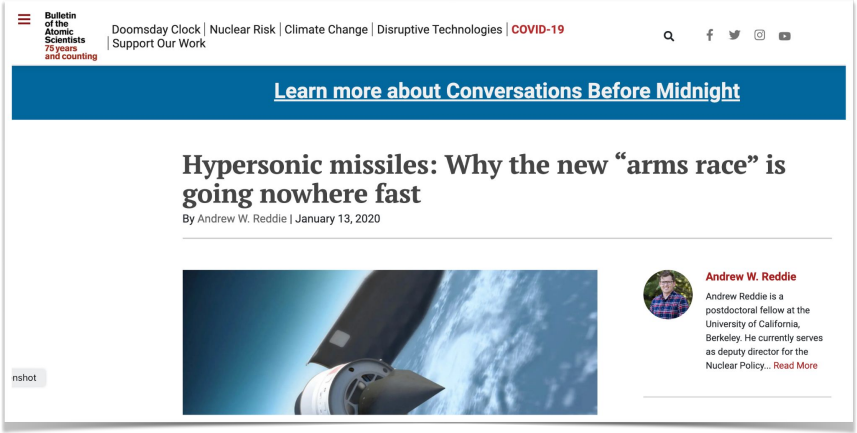
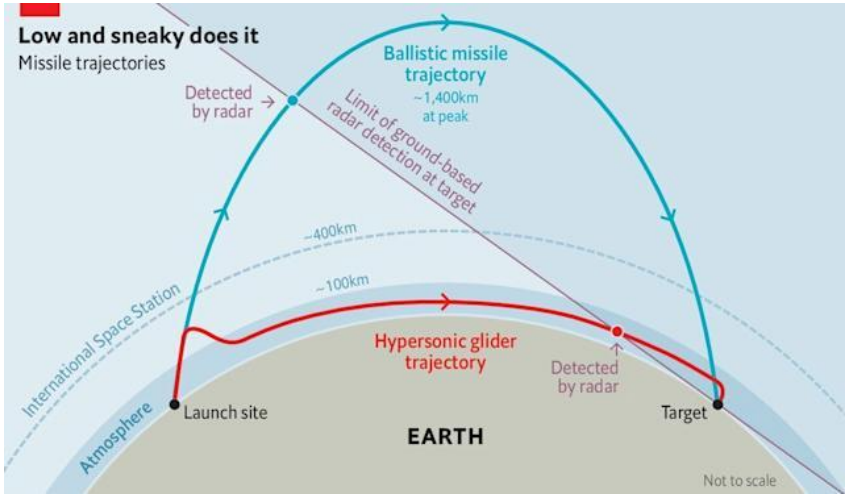
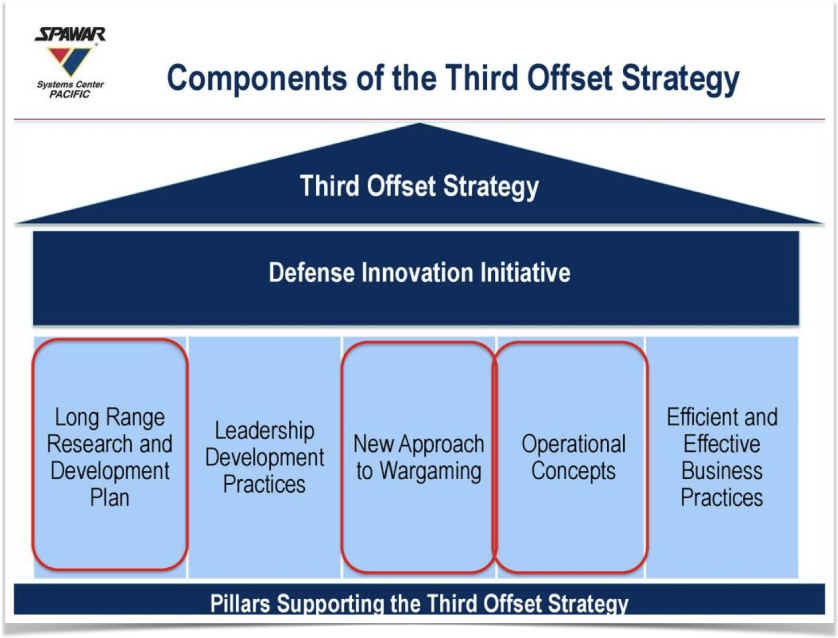




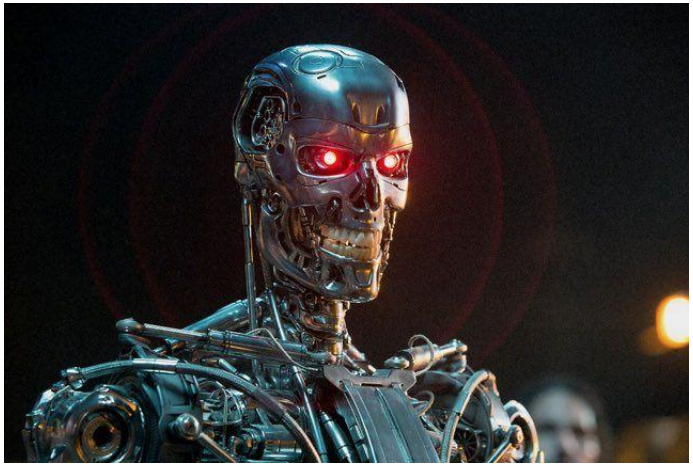
“Offset Strategies”

For the United States, nuclear weapons represent a key way in which technological development allows for substitution of capability and “**offset strategies**”

- First Offset (1950s)
- Second Offset (1970s and 1980s)
- Third Offset (2010s)
    - Robotics, artificial intelligence, miniaturization



*“The AI”



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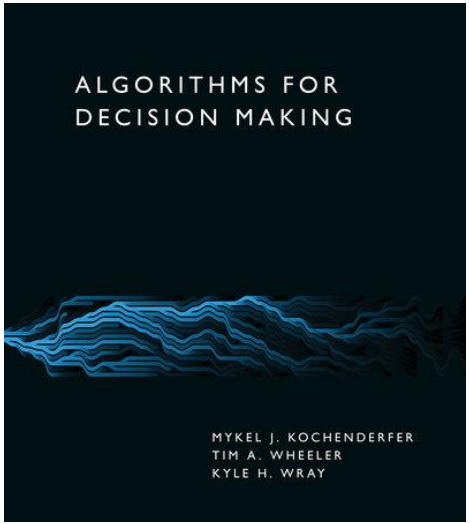


AI applications that are worthy of our attention tend to be the more mundane…

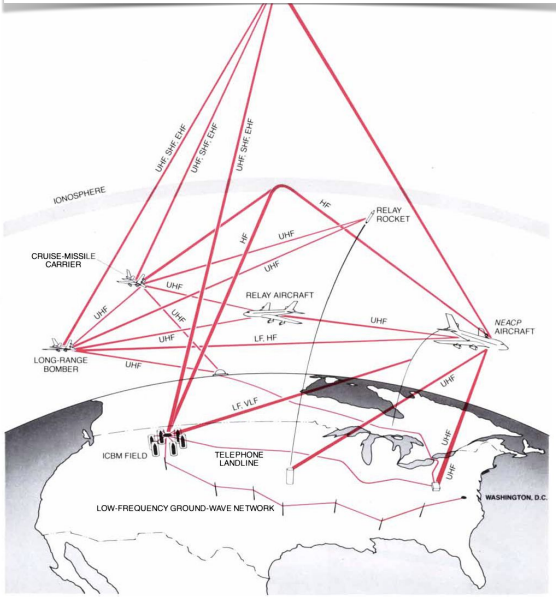
*Machine Learning and AI-NC3 Integration

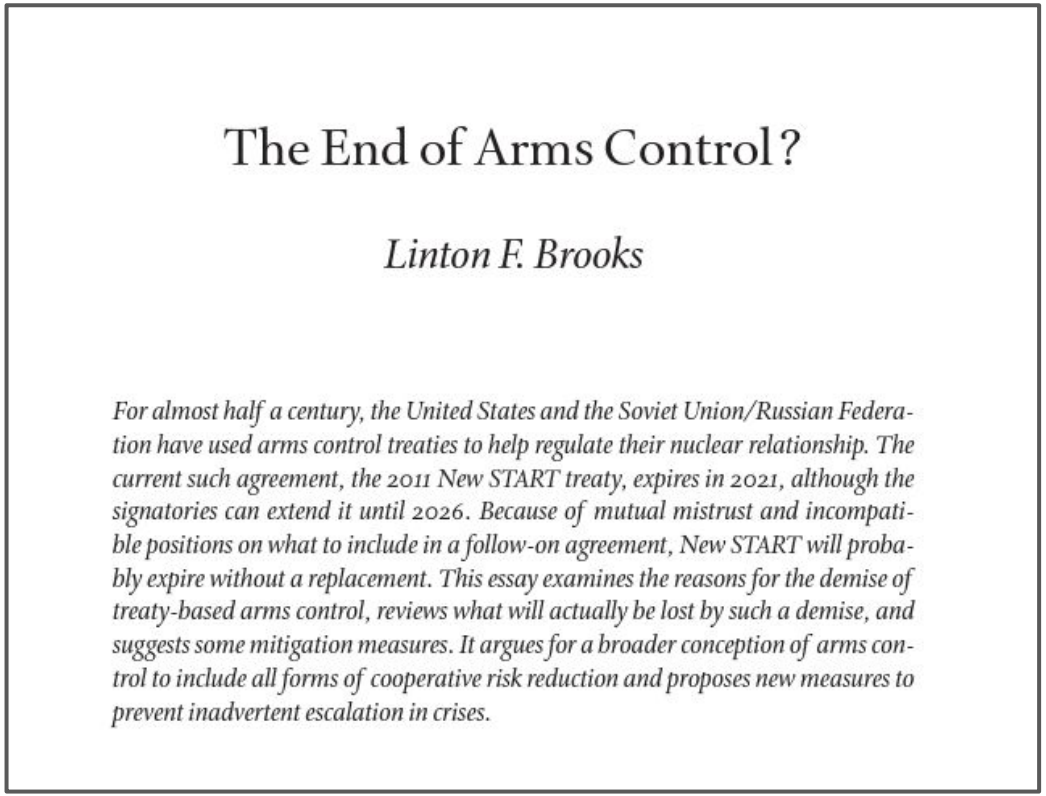
There are three clear intersections between ML capabilities and nuclear weapons:

- Signal/Anomaly detection (early warning)
- Dynamic (Re-)Targeting
- Decision support
    - “Left of launch” operations (prediction)

With consequences for…

- Conflict timelines; Uncertainty (particularly in cases of **data poisoning**)





The End of Arms Control?

Linton F. Brooks

For almost half a century, the United States and the Soviet Union/Russian Federation have used arms control treaties to help regulate their nuclear relationship. The current such agreement, the 2011 New START treaty, expires in 2021, although the signatories can extend it until 2026. Because of mutual mistrust and incompatible positions on what to include in a follow-on agreement, New START will probably expire without a replacement. This essay examines the reasons for the demise of treaty-based arms control, reviews what will actually be lost by such a demise, and suggests some mitigation measures. It argues for a broader conception of arms control to include all forms of cooperative risk reduction and proposes new measures to prevent inadvertent escalation in crises.

Not so fast…

*The Future of Arms Control

It is unlikely that the **strategic imperatives** behind arms control will disappear, though it may look different moving forward…

- Nuclear limits *sans* verification
- Nuclear risk reduction and nonproliferation at the margins
- AI governance and confidence building measures

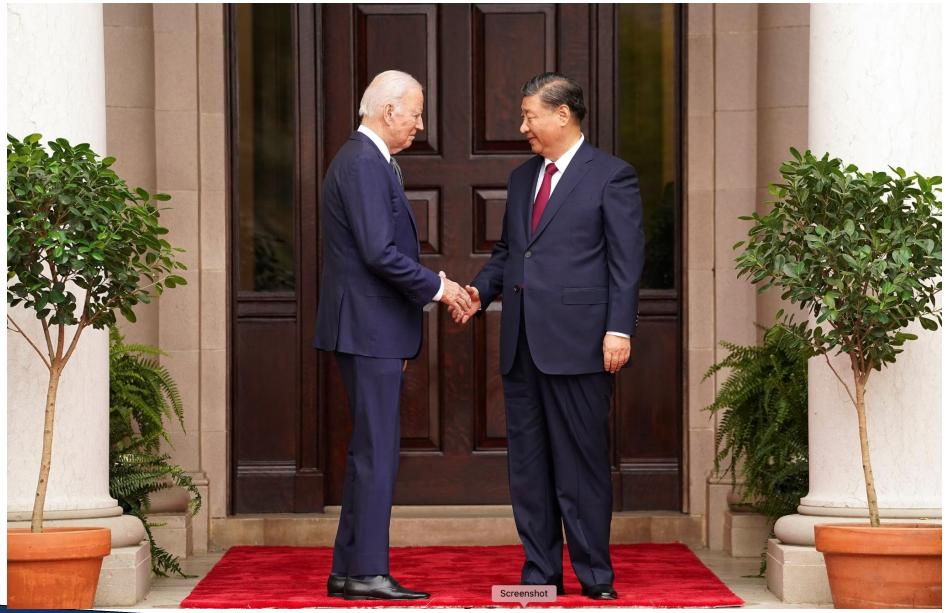
U.S., Russia Agree to Call for Negotiating New START Successor

ARMS CONTROL NOW

Authored by Shannon Bugos and Heather Foye on September 8, 2022

The United States and Russia committed to a statement expressing the need for the world's two largest nuclear-weapon states to negotiate a follow-on arms control arrangement to the 2010 New Strategic Arms Reduction Treaty (New START), which expires in under four years. This commitment came during the monthlong 10th review conference for the 1968 nuclear Nonproliferation Treaty (NPT) held in August, at which U.S. President Joe Biden stated that his administration stands prepared to begin such arms control talks.

"The Russian Federation and the United States commit to the full implementation of the New START Treaty and



Thanks!

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