Project on Nuclear Gaming: Investigating the Impacts of Nuclear Weapons Capabilities on Deterrence

Workshop Summary

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Lawrence Livermore National Laboratory
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The views summarized here are those of the workshop participants and should not be attributed to CGSR, LLNL, LLNS, or any other organization.

Key Questions:

1. What are the implications of adding new capabilities to nuclear arsenals?
2. How do these new capabilities impact nuclear deterrence and conflict escalation dynamics?
3. Can frontier experimental methods using gaming techniques contribute to questions of nuclear deterrence?

Context:

In the future, it may be possible for states to construct nuclear weapons with alternative effects that are optimized for specific military purposes. These nuclear weapon concepts could employ features such as enhanced radiation outputs, electromagnetic pulse (EMP), or other approaches such as high-precision, low-yield systems that reduce collateral damage, but improve lethality to targets. Some have speculated that such weapons could have the effect of lowering the threshold of use for nuclear weapons by reducing the negative incentives, or by providing new military applications for nuclear weapons. A nuclear arsenal that includes weapons with alternate effect regimes may also have an impact on the calculus of escalation in a conflict scenario. The possibility of a nuclear state or states pursuing such weapons, and the potential effects on deterrence and strategic stability, must be considered in order to craft appropriate responses.

To address these questions, the University of California Berkeley (UCB), Sandia National Laboratories (SNL), and Lawrence Livermore National Laboratories (LLNL) are working, through a joint project, to investigate the potential impacts of alternate nuclear weapons effects regimes on deterrence and decision-making in conflict. The purpose of this document is to capture the research questions, assumptions, scenario characteristics, and other details that provide the frame for the approach used to address this challenge presented during the first workshop discussion hosted by the Center for Global Security Research at LLNL with subject matter experts.

Topics discussed during the workshop included the alternative effects of nuclear weapons, existing approaches for modeling and measuring conflict, and the state of the art in experimental game design.

Panel 1: The Alternative Effects of Nuclear Weapons

- What nuclear effects might influence use patterns?
- How can we seek to understand the effects of these capabilities?

The first panel outlined the key differences between various types of nuclear weapons in terms of their effects. Nuclear weapons have primarily been designed to create blast effects that destroy targets. Other effects can also create damage, such as prompt radiation, thermal and fire damage, and seismic shock.

The focus of most targeting calculations and analyses, however, has been on the destructive force of blast overpressures created by the explosion itself, relying on the sheer magnitude of the forces generated to destroy targets. Nuclear weapons that rely on alternate means to destroy targets, however, have also been discussed—whether using radiation effects, electromagnetic pulses, or increasing the accuracy of lower yield weapons. For the purposes of this effort, this group of weapon concepts was referred to as Alternate Effect Regime weapons, or AERs.

Having outlined these differences, the project team outlined the research question of the project: Do AERs alter the threshold of nuclear use?

To answer this question, the project team proposed using a game-based experimental design that balances player knowledge and expertise with the number of gameplays necessary to carry out large-*n* analysis. The project team also presented a secondary series of hypotheses concerning player response to AER use and the impact of symmetrical/asymmetrical arsenals on player decision-making.

During the workshop, participants suggested that the project team disaggregate and broaden the capabilities covered in the study beyond the AERs noted above. Specifically, the workshop participants suggested the inclusion of conventional forces, standoff missiles, EMP, ERW, HPLY, tactical nuclear weapons, and a barrage of nuclear weapons when considering the suite of player capabilities. In particular, participants noted the importance of distinguishing between HPLY capabilities and non-strategic nuclear weapons in gameplay.

Panel 2: Scenarios, Conflict, and Escalation

- What is the scenario space we seek to explore and characterize?
- How do conflicts escalate with and without AERs?
- How can we classify game actions into broad conflict classes to address the research questions?

The second panel introduced the scenario space and conflict escalation. The scenario space is quite large so the project team characterized each scenario into three primary components: power, possession of AERs, and motivation/goals. A two-by-two matrix was introduced with symmetric/asymmetric AER possession and symmetric/asymmetric power. Finally, a non-comprehensive list was introduced as examples of how goals may affect how conflict escalates.

This led into the conflict escalation discussion which introduced how the literature has previously conceptualized conflict stages and how the project team has condensed these into ten conflict classes: peace; non-nuclear threat; AER nuclear threat; traditional nuclear threat; single front, single action armed conflict; multiple front, single action armed conflict; single front, multiple action armed conflict; multiple front, multiple action armed conflict; AER nuclear use; and traditional nuclear use. Various examples of how conflict might progress with the introduction of AERS were put forth in order to justify the classes and coding.

Finally, preliminary results from an extensive game analysis were used to show that two possible theories may emerge in the symmetric power, asymmetric AER case: (1) AER may deter conflict initiation, but provide wider pathways to nuclear use; and (2) AER may strengthen the stability-instability effect.

During the workshop, participants pushed back against the notional motivations that were outlined. These need additional work to include a comprehensive and varied set of state goals. Additionally, they balked at the phrase “traditional nuclear use” preferring terminology like “traditional effects regime” or something similar. There was also discussion around dividing nuclear use into additional classes to represent both limited and large-scale attacks. Many agreed that the single vs. multiple front is a better

proxy for "seriousness" of the conventional conflict as it can represent regional vs. global dynamics, and that effect may be a better measure than number of actions.

Panel 3: Experimental Game Design

- How are Massively Multiplayer Online Games (MMOGs) useful as experimental platforms?
- How do we design a game framework to capture data appropriately for later analysis?
- How do we validate our results?

The second panel discussed the usefulness of online games as experiments, how data from them can be captured and analyzed, and how results of the analysis can be validated. The panel opened with a discussion of MMOGs – the richness and realism of the online game environment, and how that environment often yields behaviors analogous to those that can be observed in the real world. The first panelist showed examples of research demonstrating parallels between online games and the real world, such as parallels in virtual and real-world personality traits, social networks, and commodities pricing. Next, the panelists discussed the strengths of games as experiments as compared with other platforms used to conduct research in disciplines such as social science and public policy. The positive characteristics of online games were discussed, focusing on the characteristics of replicability, controllability, instrumentability, neutrality, and fidelity They then demonstrated how online game data can be gathered and analyzed for research, using results from prior work, and how the results can be compared to results from policy literature. There was discussion about how this type of comparison can be used as one form of validation of experimental results. Finally, the PoNG game design was discussed, and the panelists demonstrated how important features are captured in the game framework. These features include AER use, but also the ability to use conventional military tools and financial incentives to achieve objectives; the game was also designed to incorporate features such as the ability to signal intentions (whether or not you act on them) and uncertainty in outcomes, which the design team learned are important in any real-world deterrence framework.

Participants asked about rational behavior within the game; i.e., is the game designed such that a rational player would occasionally choose to use a nuclear weapon, in order to ensure that the design team incorporated rational moves to use nuclear weapons into the framework. The participants also encouraged the panelists to think about a strategy for keeping players engaged in the game long-term in order to get sufficient data for analysis.

Panel 4: Measuring Thresholds of Nuclear Use

- What data are being collected?
- How will it be analyzed?
- How will those results drive conclusions and policy insight?

This session focused on the data and analytical methods that will be used to address the primary research question of whether or not AERs lower the threshold for nuclear use. The relevant serious gaming approaches—scenario-based discussions, board games, and electronic games—were evaluated in terms of their degree of structure and usefulness for exploratory and quantitative analyses. These gaming approaches were conceptualized on a spectrum of structural integrity, with scenario-based discussions viewed as "softer" but with a highly valuable role in exploratory analyses, board games providing a balance between "free play" and constrained operations, and electronic games as more restrictive in their implementation but with the potential to provide new opportunities for statistically-significant hypothesis testing.

The data collected under this effort was explored in the context of the system to be modeled. Studying real world conflict and deterrence is difficult because there are many factors that go into the decision making of leaders in these situations, and there are many aspects of the situation that can influence a decision maker. For example, economics: whether a country has global economic ties, whether a country is doing well economically and has the money to support a conflict, etc.; geographical: how the physical positioning of countries can influence their likelihood and nature of conflict; political: how the existence of political ties, including alliances, treaties, and common culture can influence likelihood and nature of conflict; capabilities: what military capabilities does a country have; emotional/psychological: what are the characteristics of the leader who is making the decision, are they risk averse, do they understand the consequences, are they veterans, etc. As outlined in Table 1, these factors were summarized with regard to the data collection methods in the game design.

Factors	Data Collection Methods
Geographical	Players are assigned countries with known geographical locations and features
Economic	Players can trade with one another to support their economy; Track income, funds, and trade volume/dependence
Political	Players can create formal and informal alliances; Track agreements and communications between players
Conflict	Track intensity and degree of militarized interstate disputes
Emotional/Psychological	Players assume the role of country leader; Key personality traits assessed via questionnaire

Table 1. Systemic Factors and Data Collection Methods

The analytical framework was defined in the context of a nuclear dyad in a multipolar world, with each nuclear-capable player having either a traditional or AER-enhanced arsenal. Data aggregation with regard to the mapping of player actions to the conflict stages outlined above was outlined in terms of both actor and temporal aggregation. Actor aggregation could be performed on a per game, per dyad, per directed dyad, or per player basis. Temporal aggregation could be performed on a per round, per action, and per action-reaction sequence basis.

To explore the primary research question of whether or not AERs lower the threshold of nuclear use, two main metrics were identified when comparing systems with and without AERs: 1) the maximum conflict stage achieved, and 2) the number of moves prior to nuclear use. For example, if games/players with AERs have a higher probability of reaching higher conflict stages, this would support the hypothesis that AERs lower the threshold for nuclear use. Similarly, if players/games have a lower average time to reach nuclear use when AERs are present in the arsenal/system, this would support the hypothesis that AERs lower the threshold for nuclear use. Data analysis was illustrated using a simple example of a game with four conflict stages that was simulated under Markov assumption for systems with and without AERs. The limitations of this simple example, i.e., neglecting historical interactions between states, limited resolution of conflict stages, and neglecting distinct impacts of different AER weapon types, were outlined.

The panel closed with opportunities for future work. These included an understanding of the differences between different player populations, including the potential bias introduced by non-expert populations; an understanding of confounding variables; and the incorporation of player and model uncertainty in

analysis methods. To understand how the results from experimental gaming might drive policy-relevant conclusions, methods for generating strong quantitative conclusions and determining causal relationships would need to be addressed.

Gameplay: Asymmetrical Arsenals

- What information is vital to provide to participants and how should it be organized?
- Time pressure is key but how to balance between natural and artificial time constraints?
- Communication and messaging are important, but how do we make participants aware that of this before it is too late?

Day two focused on a scenario-based discussion of a fictional conflict scenario between three hypothetical countries, two of which had access to nuclear weapons. This scenario centered around one of these nuclear armed states being threatened by superior conventional forces. The participants found that the variations in capabilities between each of these three states had a significant impact on the decision process and greatly influenced the eventual outcome. However, the final outcome was of less interest to us than the factors that led to decision making in each step and understanding the disconnects between the fictional scenario and reality.

One of the primary goals of this discussion was to understand areas where our framework was lacking in options or unrealistic. We received a great deal of useful feedback from the participants, ranging from organizational issues such as how to best provide the necessary information briefing and how long the groups needed to absorb information to scenario design issues such as realism of provided capabilities and why different control injects were either vital or unimportant to their decision making.

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