NUCLEAR ARSENALS AT LOW NUMBERS:
WHEN LESS IS DIFFERENT

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Disclaimer: The views expressed are those of the author only and do not necessarily reflect those of the United States Air Force, the Department of Defense, or the United States government.
ABSTRACT

President Obama's 2009 speech in Prague is remembered as a call for the eventual elimination of nuclear weapons. It reinvigorated a long-overdue policy debate in the United States and Europe. Unfortunately, that debate is characterized by a focus on arsenal size that borders on numerology, a lack of imagination consistent with presentism, and absence of a common framework to evaluate competing claims.

Nuclear weapons were transformative. They defined the Cold War and a theory of strategic nuclear deterrence emerged to explain their utility. The United States and Russia have since reduced their nuclear arsenals. Direct experience with nuclear weapons among strategists and policymakers has also declined, affecting their ability to evaluate deterrence concepts.

This research project identifies a way to bolster comprehension of nuclear issues. Using a mixed-methods approach, I conducted a quasi-experiment consisting of a game built around a digital artifact. A total of 41 participants were enlisted from the United States Departments of Defense (DoD) and State, think tanks, and universities. All were knowledgeable of contemporary nuclear weapons issues. Data were created from surveys conducted before and after the intervention as well as participant gameplay choices and comments.

The data show that following the quasi-experiment, a significant number of participants had adopted new conceptual frameworks. This indicates that many nuclear weapons experts have misperceptions regarding how they currently think about nuclear issues and that such gaming techniques can generate insights for both players and researchers. I recommend further research to explore nuclear force structure transition points identified by participants and changes to DoD strategic deterrence priorities to emphasize denial of adversary objectives over threat of punishment. Both have significant implications to national security and budget prioritization.
# TABLE OF CONTENTS

**ACKNOWLEDGEMENTS** .............................................................................................................. 2  
**ABSTRACT** .................................................................................................................................. 3  
**Introduction** ................................................................................................................................... 10  
  Problem ....................................................................................................................................... 11  
  Proposed Solution .......................................................................................................................... 16  
  Research Approach ....................................................................................................................... 18  
  Structure of the Thesis. ................................................................................................................ 20  
**Literature Review** ...................................................................................................................... 21  
  Nuclear Deterrence ....................................................................................................................... 21  
  Methods and Tools ....................................................................................................................... 30  
  Summary ..................................................................................................................................... 37  
**Methodology** .............................................................................................................................. 39  
  Research Questions ..................................................................................................................... 40  
  Participants .................................................................................................................................. 41  
  Surveys ....................................................................................................................................... 42  
  Quasi-Experiment/Intervention ................................................................................................. 44  
  Data Collection ............................................................................................................................. 51  
**Conducting the Policy Exercise** ................................................................................................. 54  
  Adapting the Venue ..................................................................................................................... 54  
  Preparation .................................................................................................................................. 58  
  Gameplay .................................................................................................................................... 66
LIST OF TABLES

Table 3.1. Participant Demographics ............................................................................................ 41
Table 4.1. Sessions Conducted In-Person and Online ................................................................. 58
Table 4.2. Values Used to Demonstrate the Digital NEM to the Players .................................. 66
Table 4.3. Limits Placed on Player Defender Choices in Scenario One ..................................... 69
Table 4.4. Limits Placed on Player Defender Choices in Scenario Two .................................... 71
Table 4.5. Limits Placed on Player Defender Choices in Scenario Three ................................. 72
Table 5.1. Movement in Survey Questions 5-8 ............................................................................ 75
Table 5.2. One Sample T-Test and Effect Size for Absolute Change in Questions 5-8 .......... 76
Table 5.3. Aggregate Movement in Survey Questions 9-12 ......................................................... 76
Table 5.4. Movement between T_1 and T_2 in Responses to Survey Question 12 .................... 77
Table 5.5. One Sample T-Test and Effect Size for Absolute Change in Questions 9-12 ........... 77
Table 5.6. Changing Value of the ICBM and SSBN in Survey Question 13 ......................... 78
Table 5.7. Loose Evaluation of Player Arsenal Strategies across the Three Scenarios .......... 80
Table 5.8. Criteria to Assess Player Gameplay Choices as Nonstandard ................................. 81
Table 5.9. Player Perceived Arsenal Strategies and Actual Strategies Employed .................. 83
Table 5.10. Associating Players with Frameworks .................................................................... 85
Table 5.11. Player Movement between Frameworks ................................................................. 87
Table 5.12. Explanatory Power of Comments and Gameplay in Framework Changes ............ 94
Table D.1. Data from Questions 5-8 at T_1 and T_2 Including Change and Absolute Change .. 121
Table D.2. Paired Samples Test: Questions 5-8 Indicating Lack of Statistical Significance .... 122
Table D.3. Data from Questions 9-12 at T_1 and T_2 Including Change and Absolute Change ... 123
Table D.4. Paired Samples Test: Questions 9-11 Indicating Lack of Statistical Significance .... 124
Table D.5. Players Arsenal Strategies from Survey Question 13 and Gameplay Data .............. 125
Table D.6. Evaluated Player Gameplay Arsenal Strategies......................................................... 126
LIST OF FIGURES

Figure 2.1. B-52H and B-2B Nuclear-Capable Bombers ............................................................. 25
Figure 2.2. Minuteman III Intercontinental Ballistic Missile (ICBM) ........................................... 26
Figure 2.3. Ohio-Class Ballistic Missile Submarine (SSBN) ....................................................... 26
Figure 2.4. “Decision Elements” in the Form of a 2 x 2 Game Matrix ........................................ 32
Figure 2.5. U.S. Army North's Interagency Hurricane Response Drill ........................................ 35
Figure 3.1. Survey Question 13 .................................................................................................... 44
Figure 3.2 How Policy Gaming Helps to Master Complexity...................................................... 46
Figure 3.3. Depiction of the Digital NEM Player Interface .......................................................... 50
Figure 3.4. Capturing Player Preferences from T_1 to T_2 ............................................................ 52
Figure 4.1. Defense Connect Online Interface as it Appeared to the Researcher ......................... 56
Figure 4.2. Presentation Slide Used to Set the Context for the Experiment ................................. 59
Figure 4.3. Digital NEM: Explanation of Player Inputs ............................................................... 61
Figure 4.4. Digital NEM: Depiction of Results as Presented to Players ....................................... 65
Figure 4.5. Context for Scenario One ........................................................................................... 68
Figure 4.6. Context for Scenario Two .......................................................................................... 70
Figure 4.7. Context for Scenario Three ........................................................................................ 72
Figure 5.1. Total Change in Framework Membership .................................................................. 87
Figure 5.2. Number of Players Moving between Frameworks..................................................... 88
**LIST OF ACRONYMS**

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRIC</td>
<td>Brazil, Russia, India, and China</td>
</tr>
<tr>
<td>DoD</td>
<td>Department of Defense</td>
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<tr>
<td>DCO</td>
<td>Defense Connect Online</td>
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<tr>
<td>DLP</td>
<td>Doctor of Law and Policy</td>
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<tr>
<td>IAEA</td>
<td>International Atomic Energy Agency</td>
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<tr>
<td>ICBM</td>
<td>Intercontinental ballistic missile</td>
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<td>INF</td>
<td>Intermediate-range nuclear forces treaty</td>
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<tr>
<td>IRBM</td>
<td>Intermediate-range ballistic missile</td>
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<tr>
<td>LCC</td>
<td>Launch control center</td>
</tr>
<tr>
<td>MIRV</td>
<td>Multiple independently-targetable reentry vehicle</td>
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<td>NATO</td>
<td>North Atlantic Treaty Organization</td>
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<tr>
<td>NEM</td>
<td>Nuclear exchange model</td>
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<tr>
<td>New START</td>
<td>New Strategic Arms Reduction Treaty</td>
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<td>NPT</td>
<td>Treaty on the Non-Proliferation of Nuclear Weapons</td>
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<tr>
<td>NSA</td>
<td>National Security Advisor</td>
</tr>
<tr>
<td>Pk</td>
<td>Probability of kill</td>
</tr>
<tr>
<td>POTUS</td>
<td>President of the United States</td>
</tr>
<tr>
<td>PX</td>
<td>Player (number) i.e., P26 = Player 26</td>
</tr>
<tr>
<td>QX</td>
<td>Question (number) i.e., Q5 = Question 5</td>
</tr>
<tr>
<td>SPSS</td>
<td>Statistical Package for the Social Sciences (software)</td>
</tr>
<tr>
<td>SSBN</td>
<td>Ship, submersible, ballistic, nuclear (ballistic missile submarine)</td>
</tr>
<tr>
<td>T1, T2</td>
<td>Time 1 (pre gameplay), Time 2 (post gameplay)</td>
</tr>
<tr>
<td>TGD</td>
<td>Triadic Game Design</td>
</tr>
<tr>
<td>USAF</td>
<td>United States Air Force</td>
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Chapter 1
Introduction

"'Now, I am become Death, the destroyer of worlds.' I suppose we all thought that one way or another"
- J. Robert Oppenheimer (1965)

For decades, nuclear weapons played a prominent role in any national security discussion. The Cold War was a period of almost fifty years of ideological polarization and always-present potential for unfathomable destruction from nuclear war. The huge nuclear arsenals maintained by the United States and the Soviet Union made geopolitics a bi-polar construct. Nuclear weapons had a presence powerful enough to create a zeitgeist among the American public that included *duck and cover* exercises where children found shelter beneath their school desks and the building of single-family bomb shelters in the back yards of suburbanites (Ghamari-Tabrizi, 2005; Federal Civil Defense, 1955).

To military strategists and policymakers nuclear weapons created a culture. Comprehension of nuclear weapons issues was widespread among military strategists and policymakers (Deaile, 2015). Nuclear-specific language, jargon, and theory emerged. Over time, this experience shaped practitioners’ intuition, a quick efficient way to reach conclusions that comes from *learning through experience* bound by neither logic nor theory (Anderson, 2007; Isenman, 1997).

Coincident with the development of nuclear weapons was the emergence of new technologies and analytic techniques. *Operations research* and *game theory* were two that would play prominent roles in analyzing nuclear weapons issues. With traditional methods such as
wargaming, they were used to assist experts in comprehending implications of these new weapons (Bracken, 1977; Ghamari-Tabrizi, 2005). These methods remain useful, but little has been done to integrate modern gaming techniques to improve comprehension of contemporary nuclear challenges. This research employed a quasi-experiment to investigate the potential of one of these modern gaming techniques to improve the comprehension of those who develop and implement nuclear weapons policy.

Problem

The end of the Cold War liberated hundreds of millions of people from routine worry of a possible nuclear apocalypse and brought opportunity for steep reductions in the nuclear arsenals of the United States and Russia. Over the past two decades, policymakers in the United States and Western Europe endeavored to minimize the role nuclear weapons played in their respective national security strategies. Nuclear weapons have been out of favor, the study and practice of deterrence has been not only neglected, but frowned upon (Welch, 2008; Senate hearing, 2008). The United States has increased reliance on its unmatched conventional military forces to ensure its security and that of its allies (DoD, 2010). Meanwhile, some nuclear powers have increased their reliance on nuclear weapons to deter the very overwhelming conventional military capabilities the United States maintains (Bracken, 2012; Kroenig, 2013b; Nechepurenko, 2015).

President Obama publically articulated a desire to further reduce the number and salience of nuclear weapons. This brought resurgence in the debate over the proper role of nuclear weapons in ensuring the security of the United States and its allies. Several factors in this debate affect the arguments made during policy formulation. These include assumptions regarding implications of the end of the Cold War, a strong political imperative to decrease federal expenditures, and public advocacy for the elimination of nuclear weapons by prominent

Advocates for reductions in nuclear arsenals have published many studies, monographs, and opinion pieces (Blair, Esin, McKinzie, Yarynich, & Zolotarev 2011; Cartwright et al., 2012; Chalmers, 2012; Forsyth, Saltzman, & Schaub, 2010; Friedman, Preble, & Fay, 2013; Global Zero, 2015; Pifer, 2013). Their arguments are predominantly about numbers, but often also recommend specific changes to the types of nuclear forces and their operational availability. They assert that a smaller nuclear arsenal is adequate to meet security requirements, is inherently safer than larger arsenals, and that other states will follow our example and either forego development of nuclear weapons or reduce the size of their arsenals.

Conversely, a handful of academics and think tanks argue for larger arsenals. They do so either in pursuit of a capability to disarm a nuclear adversary in a preemptive attack or to increase the chances of prevailing in a contest of will (Spring & Heinricks, 2013; Kroenig, 2013a).

Calls for reductions in arsenal sizes are more common than calls for increases. They also conform to the stated objectives of the President and thus can be expected to resonate among policymakers in the Executive Branch. Therefore, the pertinent policy debate is over how soon arsenals can be further reduced and which delivery systems (i.e., missiles, submarines, and bombers) can be eliminated (Payne, 2011).

The focus on numbers is misdirected (Lowther & Hustus, 2013; Lowther & Hustus, 2014). Arsenal size should be a result of strategy, not an end or goal itself (Mies, 2012). Arguments regarding arsenal size often rely on deductive logic and normative constructs when considering sufficiency of nuclear weapons and utilitarian constructs when evaluating the
financial costs of sustaining nuclear forces (Friedman et al., 2013 Rumbaugh & Cohn, 2012; Wilson, 2013). Critics point out that many of the arguments remain rooted in Cold War assumptions of the role of nuclear weapons, value of different delivery systems, and credibility or utility of nuclear threats in a contemporary context (Lieber & Press, 2009, Payne, 2011). As with arsenal size, the policy decision to pursue or maintain a given nuclear force structure (an assortment of delivery systems), force posture (the readiness or availability of those forces), and corresponding arsenal size should be strategy-driven based on the role nuclear weapons are intended to play within a specific security construct (Mies, 2012).

The debate also lacks a common method to evaluate the effectiveness of competing proposals. The nuclear force structure of the United States is composed of a Triad of three delivery systems, intercontinental ballistic missiles (ICBM), submarine ballistic missiles (SSBN), and bombers. Advocates for this Triad, claim its components generate complementary or even synergistic effect (Mies, 2012; Payne, 2013a). Many participating in the debate fail to consider this complementary or synergistic effect might be an emergent characteristic. It may have emerged from the size and complexity of Cold War arsenals. If so, the ability to generate these effects may unexpectedly diminish or disappear as arsenal size decreases. Less is not just less, less is different. What we think we know about nuclear deterrence is grounded in the large arsenals of the past and may not hold true for smaller arsenals. This lack of recognition poses a danger to our future existence (Robbins, Hustus, & Blackwell, 2013).

If less is different, strategic stability with major nuclear powers, those with comparable arsenals, may be increasingly sensitive to changes in force structure or force posture. In 1958, Schelling pointed out,

“It is not the ‘balance - the sheer equality or symmetry in the situation - that constitutes ‘mutual deterrence’; it is the stability of
the balance. The situation is symmetrical but not stable when either side, by striking first, can destroy the other’s power to strike back; the situation is stable when either side can destroy the other whether it strikes first or second – that is, when neither in striking first can destroy the other’s ability to strike back” (Gerson, 2013, p. 33).

In other words, it is not just the size of the arsenal that is important, but how we operationalize the arsenal using a force structure of ICBM, SSBN, and bombers. Schelling's broader insight remains true today. Changing the number or capabilities of nuclear weapons has profound policy implications (Brooks, 2003; Paine, 2003). Changes to nuclear arsenals involve treaty obligations and potential constraints imposed by international and humanitarian law (Granoff, & Granoff, 2013; Moxley, Burroughs, & Granoff, 2011).

During the Cold War, deterrence of Russia was the priority and both incentives and opportunities to gain experience with nuclear weapons issues were prevalent. Policy priorities have changed to the prevention of nuclear terrorism and nonproliferation (DoD, 2010). The potential for a regional crisis to escalate to use of nuclear weapons is also gaining attention (Bracken, 2012; Lieber & Press, 2009). Still nuclear deterrence, especially regarding Russia has been deemphasized at the highest government levels. This leaves little incentive for officials to seek-out nuclear deterrence experience. During the Cold War, one could gain direct experience in a position working with nuclear weapons or benefit from tutelage of colleagues due to the large number of personnel with experience found throughout the Department of Defense (DoD). Military and civilian officials today have fewer opportunities to gain such experience before crafting and executing deterrent strategies (Senate hearing, 2008; Schlesinger, 2008; Welch, 2008). This lack of experience threatens to render military strategists and policymakers ill-prepared to evaluate contemporary arguments.
Many arguments regarding the proper size of the arsenal, such as *minimum deterrence* (i.e., a small survivable arsenal is sufficient for all purposes), are echoes from the beginning of the nuclear age. Some people advocate for maintaining the same number of warheads as Russia, or *parity*, another Cold War concept that surfaces in contemporary discourse. A small faction even argues for building the arsenal back up to maintain *superiority*, or more warheads than Russia.

Targeting concepts such as *counterforce*, the targeting of adversary nuclear, and nuclear-related, forces and *countervalue*, the targeting of non-military facilities or population centers have also reentered the discussion. In addition to *first-strike stability*, confidence that one need not initiate a preemptive attack for fear of suffering one by waiting, a long-dormant idea that a nuclear force could be vulnerable to a decapitating attack or *splendid first strike*, have resurfaced after more than 50 years (Kahn, 1960; Payne, 2011; Payne, 2013a). These concepts bring with them legacy assumptions, which may not apply to the contemporary security situation. Changes in our security environment and nuclear arsenals require methods that encourage the reevaluation of assumptions and building comprehension of the contemporary deterrence problem set.

The military has not acted to offset diminishing opportunities to garner experience. The default effect has been increased reliance on legacy methods. Forms of wargaming remain a common method to improve comprehension regarding strategic choices. In the context of this research, wargaming is the use of a structured representation of military activities involving many participants conducted to analyze alternatives in an explicit environment, such as Title X wargames. While valuable, such wargaming has limitations and cannot by itself fill the experience gap. Similarly, use of operations research techniques to provide quantitative answers or serve as a foundation to war games continues, but is insufficient to the challenge.
In summary, the Cold War produced a bipolar security environment inhabited by experienced nuclear strategists who armed themselves with the new methods of game theory and operations research and continued use of the legacy method of wargaming to succeed in maintaining deterrence and preventing the use of nuclear weapons. A culture emerged among deterrence practitioners. The current security environment is dissimilar to the Cold War and inhabited by strategists who lack meaningful experience with nuclear weapons and the context and culture provided by the Cold War. Yet they remain armed with the same Cold War methodologies as their predecessors. Maintaining strategic stability while decreasing the size of nuclear arsenals requires new analysis and would benefit from use of new methods.

Proposed Solution

As a solution, I turn to modern gaming and simulation for "the unique power…to capture both the technical-physical and the social-political complexities of policy problems" (Mayer, 2009, p.825). More narrowly, I focus on serious games, which were defined by Zyda (2005) as a “mental contest, played with a computer in accordance with specific rules, that uses entertainment, to further government or corporate training, education, health, public policy, and strategic communication objectives" (p. 26).

The serious game technique used in this research is the Policy Exercise. The policy exercise can provide insight regarding complexity and generate an experiential encounter by revealing relationships between multiple factors within a safe environment for learning. At their best, they can create a "gestalt communications mode" building deep comprehension (Duke & Geurts, 2004). This policy exercise was built around a digital artifact designed to allow participants to explore the implications of various force structures. These methods could offset
declining experience levels and improve the discourse within the nuclear weapons community, ultimately leading to better nuclear weapons policies.

The literature confirms the existence of legacy constructs and their purported applicability in context of small arsenals. It does not provide insight whether these constructs are retained for value or out of habit. If retained for value, a well-designed policy exercise should result in few changes in preferences and reaffirm the constructs. If retained out of habit, preferences should change. I turned to research on people’s tendency to overestimate their explicit knowledge or level of expertise and research on attachment to extreme political positions.

Comprehension at a high level of abstraction does not imply understanding the discrete concrete components that make up the concept or relationships between those concrete components. People can have an *illusion of explanatory depth*, "most people feel they understand the world with far greater detail, coherence, and depth than they really do" (Rosenblit & Keil, 2002, p. 522). Two implications are relevant. This illusion can be decreased through exposure to the concrete components underpinning their conceptual frameworks. Those who understand the concrete components also better understand the interdependencies of those components (Alter, Oppenheimer, & Zemla, 2010).

Additionally, if a person holds a view located at the extreme margins of an issue, getting that person to confront the "mechanisms" supporting that view is critical to opening the door to a change in their views (Fernbach, Rogers, Fox, & Sloman, 2013). Therefore, a change in preferences following an intervention implies a person was not, or is no longer locked into a default position, heuristic, or *illusion of understanding* of overconfidence in their knowledge of how policies work. In both cases of illusion, those who do not well understand the concrete
aspects of the abstract concepts they hold and those who are dogmatic in allegiance to a concept may be affected using the same intervention. Thus my research then required presenting participants with a method of deconstructing their own mechanisms and creating new constructs for adoption.

**Research Approach**

**Research Questions.** Preferences at a high level of abstraction may be disassociated from an individual's comprehension of the relevant concrete details. Individual engagement with concrete details can lead to changes in abstract-level preferences. Would such changes be consistent among participants implying a solution or best alternative? This research focused on change in participant preferences to investigate the viability of using a policy exercise to improve the comprehension of nuclear weapons issues. To do this, I developed two research questions:

1. How do individual participant preferences change when given a tool to evaluate those preferences within a specified framework for analysis?
2. How much commonality exists among changes in participant preferences and what explains this?

**Methodology.** To answer these research questions I employed a mixed-methods approach with a design featuring a quasi-experiment in the form of an intervention conducted as a game. I examined how those involved in the contemporary debate perceived arsenal requirements across five potential future nuclear arsenals. I used surveys to determine participant preferences both before and after the quasi-experiment. Participants used a digital tool during the quasi-experiment that encouraged self-analysis of their preferences and generated gameplay data. I used these data to identify and analyze their preferences and any change following the intervention.
Game Design. A policy exercise gaming technique is appropriate for such a complex issue. Validity in the context of nuclear weapons policy required a topic-specific game mechanism. The nuclear context was narrowed to stability dynamics with Russia directly related to the size of the strategic nuclear arsenals. Gameplay consisted of three Scenarios conducted in a single 90-minute period. In each scenario, players were presented with a narrative describing a future security condition, given a specified number of nuclear warheads, and assigned the task of allocating warheads across the force structure. Players could provide comments following each scenario. These activities were intended to encourage players to confront the interrelationships and in turn the mechanisms of the problem set and their preferences. This provided an opportunity to "confront their lack of understanding, thereby decreasing their commitment" to legacy positions (Fernbach et al., 2013, p. 940).

Data Collection and Analysis. The surveys created data on demographics, participant opinion on arsenal sufficiency relative to Russia, and value of the ICBM relative to the SSBN. The digital artifact created gameplay data reflecting player choices in the three different scenarios. I used quantitative techniques to analyze the survey data, which provided insight into valuation of the ICBM and SSBN and allowed identification of the participants' conceptual frameworks, providing insight into player methods of reasoning. Statistical techniques showed significant change and large effect size regarding changes in player preferences. I used qualitative techniques to analyze player comments to better understand preferences and reasoning. Finally, methods triangulation of the data provided insight regarding changes in players’ conceptual models.
Structure of the Thesis.

In the next chapter, I examine the literature on relevant aspects of nuclear deterrence, relevant methods and tools used to understand nuclear weapons issues, and the potential of new methods and techniques to improve knowledge and policy. In Chapter 3, I outline the research methodology in detail to include the survey questions, a description of the digital game interface, methods used to ensure player commitment, data collection plan, and analytic techniques used in data analysis. Chapter 4 is a detailed account of how the policy exercise was conducted as well as a full description of the logic used by the digital artifact to generate feedback and collect data. In Chapter 5, the results are presented, which include: statistical analysis of survey questions, identification of conceptual frameworks used by players in thinking about nuclear weapons, descriptive analysis and evaluation of gameplay data, and qualitative analysis of changes in the conceptual frameworks of players. Finally, Chapter 6 includes conclusions regarding how nuclear weapons experts perceive the force structure and the meaning of changes in player preferences. Recommendations address use of the policy exercise techniques, research that should be conducted by the DoD, and a call for a major shift in emphasis for how the DoD conceives of nuclear deterrence with small arsenals.
Chapter 2
Literature Review

Over the past six decades, academics, scientists, military strategists, and policymakers relied on game theory, operations research, and other methods to analyze the implications of nuclear weapons. A theory of nuclear deterrence emerged. The frameworks and models deterrence practitioners use today are legacies of those early times. Practitioners rely on techniques such as wargaming and similar tabletop exercises to develop the intuition military leaders and policymakers rely on to prevail (Perla & McGrady, 2011). While these techniques remain of value, advances in both learning theory and digital gaming present new opportunities to improve the knowledge and intuition of decision makers regarding nuclear issues.

Below, I describe the challenges the creation of nuclear weapons presented to thinking about war, define competing concepts, and describe the forces maintained to delivery these weapons. I restrict the discussion to those aspects of deterrence related to my research. Thus, important goals such as extending deterrence guarantees to allies or the multipolar nature of the post-Cold War are not addressed. I then turn to methods and tools traditionally used to make sense of these weapons. Finally, I propose use of modern techniques that form the basis of this inquiry.

Nuclear Deterrence

*Thus far the chief purpose of our military establishment has been to win wars. From now on its chief purpose must be to avert them. It can have almost no other useful purpose."

*Bernard Brodie (1946)*
At its simplest, deterrence is influencing an adversary's decision-making to forego an action through implicit or explicit threat of punishment (Jervis, Lebow, & Stein, 1985). The emphasis is in the threat of violence, not its application. The latency or expectation of that violence is sufficient to influence the adversary's decision-making calculus. Some theorists propose that such threats are more effective than the use of force itself (Schelling, 1966).

The creation of nuclear weapons introduced the ability to threaten the very existence of an adversary state and its population without first defeating its military forces. Shelling (1966) summed it up nicely, "Deterrence today rests on the threat of pain and extinction, not just the threat of military defeat" (p. 23, emphasis mine). The introduction of nuclear weapons was revolutionary because the cost of miscalculation could be existential. Kissinger (1957) noted, "At this scale of catastrophe, it is clear that the nature of war has altered" (p.15). These changes challenged leaders’ conceptual frameworks and led to direct involvement of civilian leaders in crafting military strategy, which had long been the purview of the military professional. New ways to think about competition and conflict between nuclear-armed states were required (Brodie, 1946; Delpech, 2012; Kahn, 1960; Kissinger, 1957; Schelling, 1966).

The lack of precedent or agreed framework for using nuclear weapons to deter war, especially nuclear war, led to disagreement among military strategists and policymakers about what constituted nuclear deterrence and how to best achieve it (Ghamari-Tabrizi, 2005). Initially, some thought deterrence a natural occurring result of the existence of nuclear weapons; something automatic that came with the production of atomic bombs. Therefore, a small arsenal and a means to deliver the bomb were sufficient to deter. This was a rudimentary, or parsimonious, capabilities-based perspective (Pauling, 1963; Alsop, 1958).
Others extended the capabilities-based approach by adding the characteristic of speed to the ability to deliver the destructive power of the bomb. This faction valued the capability to conduct a preemptive strike on an adversary's nuclear forces. Throughout the early 1960's, the United States developed sufficient first-strike capabilities and the Soviet Union followed soon afterward. Not only did the bomber force grow, but also the speed was provided by development of the intercontinental ballistic missile (ICBM) and submarine-launched ballistic missile (SSBN).

Others disagreed about both automaticity and the ability of first-strike capabilities to deter. Among other objections, they pointed out that a risk-acceptant aggressor might be willing to hazard a low-probability, high-consequence event like a nuclear war. Those challenging the developing deterrence is automatic paradigm also countered that it was the ability to retaliate following a nuclear attack, not strike first, that was vital (Brodie, 1946; Kahn, 1960; Wohlstetter, 1958). In other words, an actor that could retaliate need not maintain capabilities to conduct a first strike against the adversary.

These arguments were joined by the concept of Minimum Deterrence. Adherents argued the destructive force of nuclear weapons did not make deterrence automatic, but did make it unnecessary to maintain more than a fixed, small number of scores to several hundred of deliverable warheads to deter an adversary. This concept is not inconsistent with a focus on retaliatory capabilities (Cartwright et al., 2012; Chalmers, 2012; Forsyth et al., 2010; Friedman et al., 2013).

Policymakers over the decades have desired to maintain strategic stability (i.e., condition where neither actor discerns an incentive to initiate a nuclear attack, even during a crisis) with Russia, but they did not pursue minimum deterrence to achieve it. Instead, they relied on an ever-
increasing number of warheads and mix of first-strike and second-strike capabilities to threaten a massive retaliation from which the Soviet Union could not survive. An arms race ensued and over time, the United States acquired a diverse and large number of delivery systems constituting its nuclear force structure. The long-term adoption of nuclear deterrence as a strategy led to the implementation of policies, development of doctrine, and procurement of vast numbers of warheads and weapons systems supporting massive retaliation and successor strategies (Delpech, 2012).

Arguments over automaticity, first strike, second-strike retaliation, and minimum deterrence are capabilities-based arguments. Nuclear capabilities are manifest not just in the warheads, but also in the systems used to deliver them to their intended targets. Many tactical, or battlefield nuclear weapons such as air-to-air missiles, artillery shells, and fighter-delivered bombs were developed, deployed, and retired. My research focuses on issues surrounding not those forces, but strategic nuclear forces, or those capable of conducting attacks at intercontinental distances.

**Force Structure.** The strategic force structure of the United States became known as the Triad and it was built on three Legs: the bomber, the intercontinental ballistic missile, and the ballistic-missile submarine.

The current air-breathing leg of the Triad consists of a mix of approximately 95 nuclear-capable B-52H and B-2B bombers based at Minot Air Force Base, North Dakota; Barksdale Air Force Base, Louisiana; and Whiteman Air Force Base, Missouri (Figure 2.1). These bombers can travel intercontinental ranges at high sub-sonic speed (U.S. Air Force, 2005a; U.S. Air Force, 2005b). The bomber force is considered flexible, able to deliver a diverse range of weapons. It is
also valued for its *visibility*, used to signal resolve through movement to overseas bases or overt flight operations during crisis (Mies, 2012; U.S. Strategic Command, 2015).

**Figure 2.1. B-52H and B-2B Nuclear-Capable Bombers**

![B-52H and B-2B Nuclear-Capable Bombers](image)

U.S. Air Force photo.

The current *ground-based* leg of the Triad is the Minuteman III intercontinental ballistic missile force based at F.E. Warren Air Force Base, Wyoming; Malmstrom Air Force Base, Montana; and Minot Air Force Base, North Dakota (Figure 2.2). It has a range of over 6,000 miles traveling up to 15,000 mph, or 23 times faster than the speed of sound (U.S. Air Force, 2014). Deterrence practitioners regard the ICBM as the most *responsive* leg, able to launch within minutes if directed by the president. Many also consider it *stabilizing* because it requires a large-scale nuclear attack on the United States to eliminate. Others consider it destabilizing because it can be targeted, which they claim incentivizes premature launch (Global Zero, 2015; Mies, 2012; U.S. Strategic Command, 2015).

The *sea-based* leg of the Triad is the Ohio-Class Submarine, referred to as the SSBN, which is short for "ship, submersible, ballistic, nuclear." The fleet is has two ports, Kings Bay, Georgia and Bangor, Oregon (Figure 2.3). At 560 feet in length and displacing over 16,000
Figure 2.2. Minuteman III Intercontinental Ballistic Missile (ICBM)

U.S. Air Force photo.

pounds, the SSBN can patrol at sea for over two months. The SSBN is considered the most survivable leg, designed to be hidden at sea, safe from attack and ready to retaliate (Mies, 2012; U.S. Navy, 2014; U.S. Strategic Command, 2015).

Figure 2.3. Ohio-Class Ballistic Missile Submarine (SSBN)

U.S. Navy photo by Ray Narimatsu.
Since the introduction of the SSBN, the Triad has been the force structure construct for the United States. Common rationales for retaining the Triad include: it complicates adversary targeting strategies by presenting diverse and dispersed capabilities, it provides a hedge against technological failure (e.g., limits chances of a single malfunction will paralyze the entire nuclear force), and it promotes strategic stability (House hearing, 2013; Mies, 2012; U.S. Strategic Command, 2015).

**Minimum Deterrence.** The arms race is long over and the United States has reduced its nuclear arsenal by 85 percent since 1967 (Department of State, 2014). As the contemporary debate over the proper role for nuclear weapons continues, new questions emerge including whether the potential smaller arsenals of the future erode the credibility of United States' security assurances to its allies and whether weakened assurances could encourage them to develop their own nuclear weapons. The prominent contemporary debate again centers on minimum deterrence with adherents asserting that a fixed, small number of nuclear weapons are sufficient to generate deterrence in today's security environment (Bracken, 2012; Forsyth et al., 2010; Kroenig, 2013b; Mies, 2012; Payne, 2011; Payne, 2013b).

Minimum deterrence is attractive because seems to comport with President Obama’s call for the elimination of nuclear weapons and provides rationale for reduced spending on nuclear weapons in a time of diminishing budgets. Suggested minimum deterrence force structures run the spectrum from an SSBN only Monad, one form of delivery system, to retention of the Triad (Blair et al., 2011; Cartwright et al., 2012; Forsyth et al., 2010; Friedman et al., 2013; Obama, 2009; Pifer, 2013).

Those critical of minimum deterrence oppose further reductions to our nuclear arsenal and support retention of the Triad (Mies, 2012; Payne 2011, Payne 2013b). Less common, but
not unknown, are calls for an increase in our nuclear arsenal. One justification of a larger arsenal is to ensure the United States retains enough weapons to conduct a disarming preemptive first-strike against Russia if necessary (Spring & Heinricks, 2013). Such a change in strategy would require abandonment of current arms control treaties (White House, 2010). Another rationale is that superiority leads a state to run greater risks in crises and the actor willing to run the greater risk is victorious in a test of wills; his adversary will back down (Delpech, 2012; Kroenig, 2013a; Kroenig, 2013b). The risk-seeker might not overtly brandish nuclear superiority, but would be confident in knowledge of the superiority, as would be the adversary.

**Contemporary Considerations.** But if deterrence is about influencing an adversary's decision-making calculus, it requires more than mere the capabilities of warheads and the Triad. As Kissinger (1961) concisely stated, "Deterrence requires a combination of power, the will to use it, and the assessment of these by the potential aggressor. Moreover, deterrence is the product of those factors and not the sum. If any part is zero, deterrence fails." (p. 12, emphasis mine). The warfighting ability to employ nuclear weapons is the capability critical to generating deterrence, but only insofar as it contributes to making the threat credible. Deterrence is about influencing behavior, not warfighting (Art, 1996; Schelling, 1966).

The adversary's perception of an opponent's nuclear capabilities and will to employ them is the important factor in achieving deterrence through threat of retaliation, or threat of punishment. Traditionally, the United States and Russia have postured large, diverse force structures to credibly threaten intolerable destruction if attacked. At the same time, the trend has been periodic bilaterally-negotiated reductions. The most recent, the New Strategic Arms Reduction Treaty (New START), will bring the number of deployed warheads down to 1550 (White House, 2010).
At current, or even smaller arsenal sizes, it may not be possible to maintain strategic stability using the legacy force structure in the same way. Legacy assumptions about the effectiveness of the Legs of the Triad may breakdown. Ensuring stability in this context requires fresh thought. First strike stability, confidence that one need not initiate a preemptive attack for fear of suffering one by waiting (i.e., no use or lose condition) should become increasingly sensitive to changes in force structures and therefore increasingly tenuous. First strike stability could be the most important factor when dealing with small arsenals. Another factor to consider at low numbers is the potential to inadvertently invite an attack, what Kahn (1960) termed, a Splendid First Strike. This refers to emergence or creation of a significant vulnerability that an adversary interprets as an opportunity to successfully land a disarming or decisive blow. Changes to force structures affect first strike stability and the potential for a splendid first strike condition. Thus, changes to nuclear force structure are highly pertinent to contemporary policy decisions regarding smaller nuclear arsenals (Mies, 2012; Robbins et al., 2013).

Additionally, the need to shift from a punishment only view of nuclear deterrence has been acknowledged. Current DoD guidance supports the National Security Strategy statement, "Our deterrence strategy no longer rests primarily on the grim premise of inflicting devastating consequences on potential foes" (White House, 2006, p. 22). To augment the traditional approach to deterrence of threatening punishment, DoD noted the need to incorporate denial of benefits and encouragement if restraint, "…to decisively influence the adversary’s decision-making calculus in order to prevent hostile actions against US vital interests" (DoD, 2006, p. 5).

The concept of maintaining strong military capabilities to dissuade military challenges by would-be adversaries is ancient. However, comprehension of the implications of injecting nuclear weapons into that calculus grew fitfully following World War II. From Hiroshima to the
fall of the Berlin Wall, policymakers and military strategists used a variety of methods to improve their comprehension of nuclear deterrence. Over the course of these decades, the U.S. military had a significant portion of its personnel dedicated to the nuclear mission. Actual experience with the weapons systems and war plans provided generations of military strategists and some civilian policymakers with direct, practical experience. Warhead testing was regularly conducted and witnessed by many of these personnel. However, experience with nuclear weapons is not the same as experience with nuclear war. A distinction reportedly leading an assistant secretary of defense to rebuke an Air Force general with, "General, I have fought just as many nuclear wars as you have" (Kaplan, 1983, p. 254). Methods beyond direct experience were required.

**Methods and Tools**

**Operations Research.** From inception, analysis of nuclear deterrence employed both quantitative and qualitative methodologies. *Operations research*, the use of mathematical methods to support decision-making, became a prominent quantitative approach. The burgeoning influence of operations research coincided not just with the development of nuclear weapons, but also with the technology that made it possible, modern computing. The ability to analyze increasingly large amounts of data fed the analysts and their quantitative methods (Bracken, 1977; Ghamari-Tabrizi, 2005).

Much of this quantitative effort would attempt to assess adversary capabilities, develop and evaluate war plans and force structure, and inform acquisition choices. Generally, the methodology resulted in a numerical answer to use in selecting a course of action. A well-known successful early example was an aircraft-basing study done for the U. S. Air Force (USAF) in 1953 by the Rand Corporation. In the event of war with the Soviet Union, the USAF planned to
move nuclear bombers forward to large bases in Europe. Rand's research found a better option was to operate from bases in the United States and use fewer, austere locations, overseas. This would increase the projected effectiveness of the bombers and be less expensive than the existing plan. It eventually led to a major policy change (Wohlstetter, Hoffman, Lutz & Rowen, 1954; Zarate & Sokolski, 2009).

While valuable for answering quantifiable questions, the success or failure of nuclear deterrence rests in human decision-making. The most important aspects of this complex strategic problem have neither numeric inputs nor outputs; they are not reducible to a numerical answer. How to best posture bombers can be answered using these techniques, but not whether such a posture will influence the adversary's decision calculus. Quantitative techniques such as operations research are not very helpful in understanding these complex questions (Geurts, Duke & Vermeulen, 2007). Or as Payne (2011) notes, "At the risk of shattering widespread illusions, it is important to understand an inconvenient truth: there is no basis for confident, definitive answers to any of these fundamental questions" (p.14).

**Game Theory.** Emergence of *Game Theory* also coincided with development of nuclear weapons. It provided a method to explain what we now consider as acting in a *strategic manner*, or *accounting for the actions of others* (von Neumann & Morgenstern, 1953; Schelling, 1960).

The decision matrix in Figure 2.4 is an early example of a game theoretic approach to a general deterrence problem. The variables in the Wait/Strike cells, or *payoff boxes*, represent expected U.S. or Soviet Union utility for that choice, the $(q)$ and $(p)$ variables represent probabilities. Although small in size and number of variables, it can generate profound insights into this complex problem. One can assign values to the variables and evaluate alternative courses of action.
Some were skeptical as to the value of applying such superficially simple constructs to questions regarding nuclear deterrence. Critics claimed that simplification of the diverse factors exerting influence on adversary decision-making threatened the validity of these models. Even filling the payoff boxes in game matrices with valid data could be challenging. Non-numerical data must first be converted to numbers. Furthermore, the data must all be of the same type (Williams, 1954). Additionally, modeling beyond two players, or n-player game matrices, is difficult as in reality there are many players selecting their own strategies and thus influencing all outcomes.

As Wohlstetter (1964) pointed out, game theory was one important tool among many useful for analyzing nuclear issues, especially at the concept level. For several reasons, deterrence practitioners and policy-makers are rarely proficient at applying game theory to their problems and are wary of basing decisions on game theoretic techniques. First, game theoretic models reside at a high level of abstraction; distant from the almost tangible decisions policy-makers face (Avey & Desch, 2015; Ellsberg, 1961; Wohlstetter, 1964). Second, exceptions to expected outcomes can be easily proposed further eroding confidence in the technique. Contemporary examples of the second abound in studies of behavioral economics (Kahneman, 2011; Kahneman & Tversky, 1979). One example is inequity aversion, how perceptions of
fairness can lead someone to choose an outcome less advantageous for oneself in order to
diminish the outcome of another, or cut off one's nose to spite one's face (Wright, 2015).

Game theory does not well account for such real-world motivations and resultant
strategies; additional approaches were needed. Thus the primary criticism of using game theory
to model nuclear issues was that it was too crude. Similar to operations research, it was also seen
as an effort to mathematize a non-mathematical problem. Despite these criticisms, the ability to
provide insight regarding complex problems make game theoretic methods a valuable tool still in
use today (Kahn & Mann, 1958; Robbins et al., 2013; Williams, 1954).

**Nuclear Exchange Models.** There is a genre of digital tools specifically designed to
model nuclear wars. They are known as nuclear exchange models (NEM). Highly complex and
classified versions might inform war planning and several NEMs have been designed specifically
to inform public discourse.

The Kent-Thaler Model NEM published in 1989 is noteworthy for being comprehensive
and transparent. Using unclassified sources, it was based on actual United States and Soviet
Union weapons system capabilities. As with many such models, it dealt solely with counterforce
targeting or the targeting of adversary nuclear forces, not economic or population centers. This
allows for comparison of like data (i.e., warheads or weapons systems destroyed), but does not
address the added complexity of introducing qualitative factors such as the "value" of
populations or civil infrastructure (Kent & Thaler, 1989).

Several factors limit the contemporary value of this NEM. It is too complex, designed for
detailed investigation of specific force structures, and not easily comprehended or manipulated.
A complex NEM might be useful in support of actual war planning, but has limited utility as a
tool to improve the comprehension of strategists and policy-makers regarding macro-problems
associated with nuclear deterrence (Bracken, 1977). Additionally, the force structure modeled is obsolete. This NEM was designed and published when arsenals were an order of magnitude larger than they are today.

**Wargaming.** In various forms, wargaming has been used for millennia with both Chess and the Chinese game Go commonly cited as examples of ancient wargames. In its current form, wargaming was adopted as a standard tool by the United States military during the twentieth century (Glick & Charters, 1983; Homans, 2011). The term "wargame" can refer to a wide range of activity. It can take the form of a small tabletop exercise where 10-20 participants respond to given circumstances in a series of "moves." It can also involve thousands of participants acting out their roles across a theater of operations to assess the efficacy of a military war plan. In this research, I refer to activities focused on participant decision-making and its consequences, not field maneuvers or other activity involving the actual movement of military forces. For deterrence practitioners, certainly among the military, wargaming has been a common method to improve comprehension and assess alternative strategies (Bracken & Shubik, 2001, Perla & McGrady, 2011).

Tabletop exercises are frequently planned by a small group of experts and conducted over the course of 4-8 hours in a conference room close to where many of the participants work. These tabletop exercises are relatively inexpensive and pose little opportunity cost on participants. Larger wargames, such as combined military-civilian efforts like that depicted in Figure 2.5 require a large staff and many months to plan (note the use of individual computers, wall displays and even a chart on the floor). These wargames can be composed of multiple periods of play requiring continuity and a longer commitment of time by numerous participants.
Wargames can help discover trends or assess weakness and strengths of proposed courses of action. They allow low-risk exploration of a problem from multiple perspectives. They focus participants on issues, not solutions and derive their power as a tool from being a form of storytelling (DellaVolpe, 2014; Mobley, 1988; Perla & McGrady, 2011).

Some significant limitations are inherent in wargaming techniques. Wargaming brings an inherent risk of unintended consequences. Although proponents stress that wargames are not predictive, participants can often leave believing they have not only insights, but also answers (Bracken, 1977; DellaVolpe, 2014). Or, "their surface plausibility seduces those who enter them skeptically, "merely looking for hypotheses," into leaving them with conclusions" (Levine, Schelling, & Jones, 1991, p. 1).
Wargames are misused when employed to find specific answers to questions. Bracken and Shubik (2001) propose that improvements in technology have encouraged such misuse. Wargame designers continue to add complexity. Yet, such complexity can obscure the strengths of the technique as well as the assumptions hidden in the game design, threatening validity. The trend has been a focus on "optimization" and management of large amounts of data even while "too much was left out that was important" (p. 51) meaning the pursuit of realism crowded out the purpose of the activity, which was to provide general insights.

Duke (1974) notes that gaming in general “…permits the individual to approach complex problems from whatever perspective seems germane and to do so in a context from which is coherent and logical, and to experiment in an environment which is basically safe. It permits the individual to gain some sense to how the system responds to his particular proposal (pp. 171-172). This focus on the individual is important to improving comprehension and traditional wargaming techniques do not have this individual focus. Other gaming techniques can supplement or even outperform wargaming in this realm.

The Policy Exercise. Modern gaming techniques can be powerful tools to increase comprehension of complex problems and integration of new technologies and approaches in gaming could improve our comprehension of deterrence issues. These methods focus on communication among participants regarding a future condition, have an inherent educational aspect, elicit information or opinions from participants, and they motivate (Duke, 1974; Duke & Geurts, 2004). Furthermore, gaming methods are “able to support both the technical-physical complexity and the social-political complexity of policy making…integrated as two sides of the same coin” (Mayer, 2009, p. 845).
This especially true of the *Policy Exercise*, a game design for macro-problems, those requiring intuition, and involving many variables and decision makers. These are precisely the type of problems facing nuclear deterrence practitioners today. Duke and Geurts (2004) outline five criteria for policy exercises. In addition to the ability to *convey gestalt*, they are *problem specific, inherently spontaneous, adaptable* to a wide array of contexts, and *present a future's orientation* allowing rich analysis of strategic alternatives (pp. 204-205).

Gaming techniques such as the policy exercise allow participants to recognize and release legacy assumptions. This is especially pertinent to a complex field like nuclear deterrence that is crowded with legacy theories and constructs. The policy exercise can also provide the *safe environment*, both in a literal sense and figurative sense, required critical for reflection. This environment encourages assessment of value and allows a player to explore the topic in his or her own way. It allows players to adopt an inductive approach and test theories and assumptions, even those too controversial to explore in public (Clapper, 2014; Harteveld, 2011).

Nuclear weapons are so destructive, that every aspect of them has a political angle. Strategists and policymakers may be hesitant to participate in highly visible exercises or explore strategic alternatives due to fear of being portrayed as insubordinate or attempting to undermine or question articulated policies. Policy exercises can be small-scale and conducted online and confidential in nature, allowing practitioners to explore relationships between alternatives in an environment insulated from political backlash.

**Summary**

Nuclear weapons systems and the number of personnel steeped in nuclear deterrence theory and resultant doctrine grew with the arsenals and budgets. We are now on the opposite side of that trend and find ourselves in a situation where fewer and fewer strategists and
policymakers have direct experience with nuclear weapons and nuclear deterrence (Schlesinger, 2008). The value of a weapon is easy for military strategists to judge when its effects are visible. Nuclear weapons are intended to shape the environment and influence adversary decision-making without tactical effect and are therefore difficult to value. It is not just the experience level of strategists and policymakers that has changed, so has the problem set. Some questions originally debated during the early years of the Cold War have reemerged in a new context. Some important questions are new. This might bring us to join Delpech (2012) and wonder, "What kind of advice would a political leader get from the military in a nuclear crisis?" (p. 15).
Chapter 3
Methodology

Those who cannot change their minds cannot change anything”

George Bernard Shaw

The development of nuclear weapons generated a tremendous amount of analysis that formed the foundation of theory, doctrine, operating procedures, and acquisition strategies. The then new methods of operations research and game theory were used as well as traditional wargaming to build the comprehension of military strategists and policymakers. Recent progress in reducing the size of the nuclear arsenals introduced new challenges, reintroduced old concepts, and reopened debates long dormant.

Today, there are fewer nuclear weapons experts to share their knowledge and manage the research and analysis needed to comprehend current and future nuclear dynamics. Our contemporary security environment, budgetary pressures, and political desire to decrease the size of nuclear arsenals mandate a thoughtful analysis of the implications of the disparate recommendations and their underlying theories. If game theory fails to draw support from policymakers, operations research remains too focused on quantitative answers, and wargaming is insufficient, what course should we pursue? Adoption of new techniques and tools can improve our understanding.

To investigate these issues, I designed a quasi-experiment in the form of a game built around a digital artifact. The quasi-experiment was conducted as an intervention to allow before and after measurement to detect change. Here I provide details of the research design, to include the participants, the surveys, gaming method, and the structure of the game itself.
Research Questions

Nuclear deterrence is a narrow discipline. The number of practitioners and depth of experience has diminished. However, the need to develop and implement nuclear weapons policies continues. How well prepared are contemporary experts? Two components are of interest here, the preferences of these experts and whether the preferences are appropriate for the problem set. This research focused on participant preferences; what they were, why they were, and how permanent were they? I endeavored to discover how preferences might change if participants were compelled to evaluate them against a specific problem set. To explore this issue, I developed two research questions:

1. How do individual participant preferences change when given a tool to evaluate those preferences within a specified framework for analysis?
2. How much commonality exists among changes in participant preferences and what explains this?

To answer these questions, I designed a quasi-experiment in the form of an intervention and created data from participants brought together in small groups. The intervention included two surveys and three periods of play, or Scenarios, which included use of a digital tool. Both quantitative and qualitative data were created from survey results, participant choices captured during gameplay, and player comments.

Due to the small sample size and narrow scope of the intervention, I did not attempt to draw conclusions regarding which arsenal strategy was superior or relevant to real-world conditions. I focused on what players found important given the restricted conditions I asked them to consider during the quasi-experiment.
Participants

I was concerned that participation by those unfamiliar with nuclear deterrence would require an inordinate amount of time to explain basics and elevate the risk of introducing spurious data based on poorly informed choices. To avoid those pitfalls, my sample consisted of people that understood the theoretical and conceptual foundations of nuclear deterrence. Participants were United States federal employees, uniformed military personnel, those in think tanks and universities, but primarily Department of Defense personnel working in the Pentagon.

I used email to solicit participants (Appendix A). Initially, I relied on a snowball technique. That approach was successful, but for three data collection sessions, I contacted candidates individually to get their participation. Participation achieved $n=41$. Table 3.1 contains the demographic data provided by participants. I did not ask participants to declare their

<table>
<thead>
<tr>
<th>Table 3.1. Participant Demographics</th>
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<tbody>
<tr>
<td>Characteristic</td>
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<tr>
<td>Age Group</td>
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<tr>
<td>25 to 34 years</td>
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<tr>
<td>35 to 44 years</td>
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<tr>
<td>45 to 54 years</td>
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<tr>
<td>55 to 64 years</td>
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<tr>
<td>Frequency of considering nuclear issues</td>
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<tr>
<td>Daily</td>
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<tr>
<td>Weekly</td>
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<td>Monthly</td>
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<tr>
<td>Never</td>
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<tr>
<td>Affiliation</td>
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<td>Fed Government</td>
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<tr>
<td>NGO or IO</td>
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<tr>
<td>Think Tank</td>
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<tr>
<td>University</td>
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<tr>
<td>Total</td>
</tr>
</tbody>
</table>
citizenship, but instead asked national affiliation for their position or employment. All claimed affiliation with the United States.

The design allowed for at least confidentiality and many times achieved anonymity. All players were asked to abide by *Chatham House Rules*, (i.e., participants were free to use the information received, but neither the identity nor the affiliation of the speaker(s), nor that of any other participant, may be revealed).\(^6\) This is a construct they were all familiar with and one explicitly defined during the introduction to the experiment. This construct was used primarily to protect players regarding comments posted during online play visible to all, or statements made during in-person sessions. Additionally, players invented a user name allowing all gameplay choices and comments to be anonymous.\(^7\)

**Surveys**

I conducted two surveys; the first is reproduced at Appendix C. Participants completed the first survey consisting of thirteen questions before the intervention. These responses represented participants' pre-intervention preferences at Time 1 \((T_1)\). The first four questions created demographic data. The next four \((Q5-Q8)\) generated data on player perspectives regarding proper sizing of nuclear arsenals.

**Q5:** There is a number of nuclear weapons sufficient to deter adversaries, regardless of the number of nuclear weapons they possess. Beyond that number, additional weapons provide little or no additional benefit.

**Q6:** To maintain strategic stability, the U.S. nuclear arsenal does not have to be superior in number to Russia’s nuclear arsenal.

**Q7:** To maintain strategic stability, the U.S. nuclear arsenal does not have to be at least equal in number to Russia’s nuclear arsenal.
Q8: The number of nuclear weapons possessed by a potential adversary is irrelevant to determining the appropriate size of the U.S. nuclear arsenal.

Questions 9-12 provided player positions on the attribute of survivability and importance of the SSBN relative to the ICBM. There are many attributes associated with the Triad, such as Flexibility or Responsiveness. These questions included only the attribute of Survivability to focus on its changing nature as arsenals get smaller and highlight distinctions between the ICBM and SSBN.

Q9: The submarine-launched ballistic missile fleet (SSBN) is the most survivable of U.S. nuclear forces.

Q10: Survivability is the most important attribute for a nuclear weapons system.

Q11: The submarine-launched ballistic missile fleet (SSBN) is the most valuable component of U.S. nuclear forces.

Q12: The value of the land-based intercontinental ballistic missile (ICBM) force diminishes as arsenal size decreases.

The final question (Q13) was a compound question that asked players to make choices among nuclear weapons delivery systems by constructing simple strategies for five different arsenal levels ranging from 2200 warheads to 300 warheads (Figure 3.1). At each arsenal level participants were directed to prioritize either the SSBN or the ICBM for that size arsenal. Second, they selected a desired number of Triad Legs (i.e., 1, 2, or 3). Finally, they identified which Legs of the Triad they would employ (i.e., ICBM, SSBN, and bomber). They were free to select one, two, or all three delivery platforms.
Following the intervention, participants completed a second survey. Participants were not told in advance that a second survey would follow the quasi-experiment. The second survey was identical to the first, but for the absence of the four questions eliciting demographic data. I used data from the second survey along with gameplay telemetry data and participant comments to determine participant preferences at Time 2 (T₂).

**Quasi-Experiment/Intervention**

**Overall Design.** Both the security environment and sizes of nuclear arsenals have changed considerably over the past several decades. The experience military strategists and
policymakers gained when arsenals were larger may be inappropriate or inadequate to current and future circumstances. Yet they develop and implement policy based on their current best assessment.

My goal was to get participants to think about a problem more deeply than they might in their day-to-day setting. If I simply conducted a survey, I could not prevent participants from indulging in what Kahneman (2011) refers to as *Thinking Fast*, shallow cognitive responses employing heuristics. To encourage participants to think about the problem in a more meaningful way I needed to get them to engage with the "mechanistic" aspects of their thinking that results in preferences (Fernbach et al., 2013).

**Rationale for the Game Design.** Games can be very effective in revealing both those mechanistic aspects and conveying an understanding of the whole. "The power of games is that they organize and convey a holistic perspective on a given problem in a format that allows the direct translation of these insights into strategic action" (Geurts et al., 2007, p. 552). Harteveld (2011) notes, that serious games provide a method to gain insight into complex systems and well-designed games encourage transfer of learning from game to reality, "the beliefs people have about their "reality" matter. You see what you believe" (p. 19). Thus gaming can facilitate learning regarding complex policy questions and encourage transfer of that new knowledge to the real world.

The design included an opportunity following each scenario for players to pause and think about the experience itself. This *reflection-in-action* can increase individual interest in the activity and encourage learning and application of that learning in following activity (Clapper, 2014). Furthermore, feedback provided by the digital tool allowed players to immediately “experience the effects” of their choices (Mayer, 2009, p. 825). Full transfer of learning from
games to reality is not immediate, but these techniques provided an opportunity for some transfer to occur within the intervention for measurement at T2, which was immediately following the last period of play. Interaction with participants ended at T2, so this design does not attempt to measure long-term effects of the intervention.

**The Policy Exercise.** A *Policy Exercise* "uses gaming/simulation and other methods to assist with organizational decision making of ill-structured problems" (Tsuchiya & Tsuchiya, 2000, p.516). Ill-structured problems have many variables and are uncalibrated and therefore resistant to mathematical or linear analytical techniques. An intervention designed around this technique is appropriate for this problem set for the many reasons included in (Figure 3.2). It can

**Figure 3.2 How Policy Gaming Helps to Master Complexity**

<table>
<thead>
<tr>
<th>Effective ingredient of the Simulation element in Policy Gaming</th>
<th>Effective ingredient of the Gaming element in Policy Gaming</th>
<th>Impact of each effective Ingredient on Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regarding Complexity</td>
<td></td>
<td>Gaming and Simulation help to:</td>
</tr>
<tr>
<td>• Develop a systems perspective on a strategic issue</td>
<td>• Conveys a systems perspective</td>
<td>• Create, integrate, and analyze a specific decision and broad knowledge base</td>
</tr>
<tr>
<td>• Integrate/organize knowledge base</td>
<td>• Integrate hard and soft data</td>
<td>• Arrive at logically sound and actionable conclusions</td>
</tr>
<tr>
<td>• Ability to test and assess strategies by getting an idea of possible effects and side effects</td>
<td>• Understand the dynamic characteristics of the system</td>
<td>• Allow for evaluation of effects and side effects based on many different criteria</td>
</tr>
<tr>
<td>• Helps us to understand and explore the future as a set of uncertainties and possibilities</td>
<td>• Allows to look back from many different futures</td>
<td>Gaming and Simulation help to prevent:</td>
</tr>
<tr>
<td>• Reveals potential differences between short term and long-term effects</td>
<td></td>
<td>• Jump-starting from a biased and narrow knowledge base</td>
</tr>
</tbody>
</table>

provide a safe environment to explore complex or politically charged issues. I expected participants to arrive with strong preconceptions regarding the issues under investigation. I wanted players to not just explore possible constructs, but test their own beliefs or theories (Harteveld, 2011). A well-designed policy exercise could force players to confront component-level aspects of their preferences. It would also provide a common analytical framework in which to compare their policy prescriptions to those made in competing arguments. The policy exercise allowed me to impose a common structure on the problem and require use of common methodology among participants.

**Triadic Game Design.** Triadic Game Design (TGD) is an approach that balances the worlds of *Reality, Meaning, and Play* within a serious game. *Reality* is the game’s relationship or relevance to a real-world condition or situation. *Meaning* refers to the sensemaking and discovery that occurs while playing the game and its connection to purpose or importance. *Play* concerns the level of engagement or immersion players experience (Harteveld, 2011, pp. 22-23). This balance should be designed-in concurrently across these 'three worlds." Achieving such a balance is requisite to creating a serious game that succeeds in its purpose.

The digital tool was not particularly engaging on its own. By themselves, the narratives used to introduce the scenarios and the discussions that followed were little different than a typical *Tabletop* design. I used TGD to assess the strengths and weakness of my initial approach and improve the balance of the game. Initially, the game was heavy on *Reality; Meaning* was obscured and *Play* almost non-existent.

The world of *Reality* dominated my initial design. Being a simple calculator, the digital artifact was heavily skewed to *Reality*. The task, which consisted of players using the calculator to evaluate answers, was simple and likely to produce predictable responses. To increase the
presence of Meaning, I made several modifications, which together clarified the purpose for the players. I provided a framework for players to use in assessing value and sufficiency of the preferences. I clearly explained that player goals were to recognize a potential for instability, explore potential alternatives, and recommend a course of action. Players were forced to make individual recommendations, which increased commitment. Time for reflection was expanded between each period of play. Solicitation of comments during gameplay encouraged the players to articulate rationales for their choices, allowing improved learning.

Finally, Play was bolstered in several ways. I provided a framework for success (i.e., warheads surviving post-attack), but players defined success. Players had latitude to approach the game from their own perspective. The game logic was fixed, but players could create alternatives through use of the comments, such as “I used this force structure because I believe we would have strong missile defenses.” To increase player engagement, I integrated a story and role-playing element all oriented to the game’s three decision-making points.

Participants were nuclear weapons experts; however, they did not serve in the senior official capacities that allowed them to make policy inputs consistent with those considered in the game. One purpose of establishing a “role” for the players was to substitute for this lack of responsibility (Duke & Geurts, 2004, p. 248).

The scenarios had purpose beyond increasing player engagement, they provided a "realistic" context to allow players to "suspend disbelief" and explore uncharted territory. Duke (1974) points out that a role, supported by the use of scenarios, encourages players to suspend their disbelief, which is “essential for player involvement” (p. 145). Common across the three scenarios was the positioning of Russia as a potential nuclear threat. The element of change was an increasing restriction of player choices by limiting the number of available warheads.
**Purpose of the Digital NEM.** I created a digital nuclear exchange model (NEM) tailored to the problems presented to the players during the intervention. It provided players a method of analyzing the given problem and crafting a strategy to recommend as a solution. It was also intended to reveal to players their own rationalizations and mechanistic or reflexive aspects of their current preferences. Finally, it allowed me to impose a common framework and method on players to better assess change over time and commonalities across participants. Figure 3.3 depicts the user interface for gameplay and data collection. A more detailed description of the digital tool, to include its internal logic, is presented in the next chapter.

**Validation.** I conducted three validation sessions with the assistance of approximately 15 volunteers. Several people participated in two sessions. As a result of these sessions, I shortened the experiment from five scenarios to three, concealed some capabilities of the digital tool to simplify both gameplay and data analysis, and modified the vignettes used during the three scenarios. The NEM logic and mathematical calculations were also checked. Personnel that assisted in the validation did not participate in actual data collection sessions.

The digital tool played the primary role in getting participants to examine their preferences. The requirement to use the tool to enter data and evaluate outcomes was intended to prevent participants from jumping straight to an answer. It ensured participation in a process of exploration that could lead to discovery or learning.

**Venue for the Intervention.** I designed the intervention to be conducted in-person using groups of 5-20 participants. In-person sessions would facilitate troubleshooting, give me access to non-verbal communications, and encourage cross-table discussion among players. Participants required individual access to the Internet (e.g., laptop, smartphone). I also required Internet access and the ability to project PowerPoint slides for players to view.
The planned setting for the intervention was a conference room. I conducted several sessions in person as planned. Due to logistical constraints limiting participants' ability to access the Internet from conference rooms within DoD facilities, I redesigned the intervention and conducted five out of the eight sessions using online interactive software.
The entire interaction with participants was designed to take 90 minutes, 45 minutes of which was for the intervention itself. The remaining time was used to introduce the topic, explain the digital artifact, and conduct the two surveys.

**Data Collection**

Data were created from the surveys, gameplay, and players’ comments. I linked all data to specific players through usernames the players themselves created, which allowed for anonymity. Data generated through use of the website (survey responses and gameplay telemetry) were converted to .csv format and organized in Excel before importing to IBM's Statistical Package for the Social Sciences (SPSS) for quantitative analysis or Dedoose online software for qualitative analysis.

My data collection plan is depicted in Figure 3.4. The first Survey was used to create data at T₁. These data defined pre-intervention baseline for player preferences of arsenals size and relative value of the ICBM and SSBN. During the three periods of gameplay, data were created by player gameplay choices and comments. These data were used to provide insight regarding player assigned value to Legs of the Triad and identify most popular options across players in the three scenarios. Following Scenario 3, players completed the second survey. Those data revealed player preferences at T₂ and were compared to game choices and comments to more fully understand player preferences.

**Inclusion and Exclusion.** Several players failed to complete the experiment or failed to submit data during gameplay. I eliminated data from participants who failed to compete both surveys because it denied me an ability to analyze change between T₁ and T₂. One player completed both surveys, but created no gameplay data and did not experience the full
intervention. I treated those data as unlike the rest and therefore invalid. Another player completed both surveys, but generated data for only the third period of play. This was likely due to player selection of an incorrect option (e.g.; selecting Edit instead of Recommend) at the end of a scenario. Because this player participated in the entire intervention and completed both surveys, these data were included in my analysis.
**Qualitative Analytical Techniques.** I conducted *First Cycle* and *Second Cycle* coding of qualitative data using Dedoose software. I employed both *Primary* codes and *Second Order* codes. I used some *Versus* coding and *Evaluation* coding, a form of *Hypothesis* coding. For example, the statement "I was surprised to find..." would be coded as *Participation - In Game – Meaning* and given a score of +3. A player comment, "This must be fixed before proceeding" would be coded as *Participation - Outside Game - Game Adjustments* and given a score of -5 based on the use of "must be fixed." I then took a *Variable-Oriented Approach* to discover areas of commonality or divergence among players regarding the same situation (Miles, Huberman, & Saldaña, 2014; Saldaña, 2013).

**Quantitative Analytical Techniques.** In addition to descriptive statistics, I used Paired Samples T-Tests to test for statistical significance of change within the survey data. As the data do not follow a normal distribution, I instead relied on One Sample T-Tests to assess the significance of change in survey responses between T₁ and T₂. Because I was interested in absolute change more than direction of change, or net change, I used absolute values of change in each survey question for that analysis. I also used Effects Size analysis on data from Q5-Q12. Cluster analysis used to investigate association between player age and conceptual framework. While providing some confirmation, results were weak and that analysis was set aside for future review.
Chapter 4

Conducting the Policy Exercise

As described in the previous chapter, to answer my research questions, I created a quasi-experiment. It was designed as a 90-minute intervention built around a digital tool. That tool was a Nuclear Exchange Model (NEM) or calculator. The intent was to conduct the data collection sessions in-person with small groups. My target population was people with high-levels of interest and knowledge of nuclear weapons and the policies surrounding them. The vast majority of participants were drawn from the Washington DC area. To gain participation from a critical subset of my target population, I had to transform the intervention to an online experience. Ultimately, both in-person and online sessions were conducted.

Coordinating data collections sessions was complicated, but participants displayed very high levels of interest and goodwill. Three validation sessions identified disconnects in the digital tool that were eliminated prior to data collection. Extended interaction with my web designer provided the knowledge needed to address several game-related difficulties that occurred during gameplay, some of which threatened to end a session and result in lost data.

For each of the three scenarios constituting the intervention, players were given a narrative that described the security environment and asked to recommend an arsenal strategy for that situation. Strategies consisted of a distribution of warheads across delivery systems. All narratives located the scenarios in the future. Before proceeding to a discussion of results, I use this chapter to describe the mechanics of conducting the experiment.

Adapting the Venue

I designed the experiment to be conducted in-person with small groups of 5-10 participants, all having individual access to the Internet for the entire data collection session. The
design employed a PowerPoint presentation intended for display on a large screen or as paper copies provided to individual players. When attempting to schedule the first in-person session at the Pentagon, it became apparent that it was very difficult to obtain a facility where Department of Defense (DoD) personnel could all access the Internet. As these participants represented a critical segment of the target population, I redesigned the intervention to conduct it online as well as in-person.

**Advantages of In-Person Sessions.** The in-person sessions were richer than those conducted online. They contained non-verbal communication that made it easier to detect when a player was having trouble or deeply engaged with the activity. It was easier to keep faster players occupied while more curious, deliberate, or tech savvy players took more time to complete a scenario. In-person play generated much better interaction between players than online sessions. These players were more likely to assist each other with interface problems, enter into short discussions on deterrence concepts, or comment on the game experience itself.

**Defense Connect Online Interface.** For online sessions, I used Defense Connect Online (DCO), an online collaborative tool familiar to DoD personnel. That system allowed me to present information using PowerPoint slides while participants simultaneously accessed the website hosting the digital tool. They could do this from their respective work location. Figure 4.1 depicts the online interface as seen by the researcher when conducting the experiment.

The left-center box, or "pod" in DCO vernacular, displays the list of participants (by name and affiliation). The lower left pod was used as a chat room. The largest pod, top center, was where the PowerPoint presentation was displayed to pace the sessions and convey information to the participants was displayed. Below and left was a pod for conducting polls,
which I used to determine when players were complete. The final pod, File Share, is where I posted the consent form for those who desired to print it out.

Figure 4.1. Defense Connect Online Interface as it Appeared to the Researcher

Advantages of Online Sessions. There were benefits to conducting data collection online and using DCO. Moving to online sessions was the only practical method of gaining participation by DoD personnel within the timelines I had established for data collection. Because it imposed no travel time, permitted play from their offices, and was an interface known to most, the opportunity cost for participation was low. This allowed me to get participation from personnel at the Pentagon and Barksdale, Air Force Base, LA, location of the primary Air Force organization responsible for the nuclear deterrence mission.
**Disadvantages of Online Sessions.** There were limitations to conducting the sessions online and using DCO. The ability of people to participate from their normal work desks lowered a barrier for participation, but increased the potential to lose players during gameplay due to interruptions from within their offices. Lack of non-verbal information limited my situation awareness during the experiments and interaction among players was restricted. Finally, my unfamiliarity with DCO introduced a training requirement.

The biggest limitation regarding online sessions was my inability to see the players. Unless they keyed their microphone or typed text into the chat box, I could not tell if they were finished and ready to move on or if they were having problems. Another downside was having players drop out mid-game. Several players left during the game saying their supervisors had just come by their desk and needed their immediate assistance. Another reality with the online sessions was that players "multi-task." They may scan the news or social media websites or have conversations with officemates during the scenarios.

I required training and used online tutorial resources to learn how to schedule and conduct DCO sessions. This introduction provided based skills and did not prevent several minor missteps. In an early session, I unintentionally gave the players control of the presentation. This permitted some players to move ahead of the scripted play without my knowledge. Several times I unintentionally injected confusion into the game by not realizing that when I moved the pods around the screen, they also moved on the players’ screens. I also several times failed to unmute my microphone when providing information, leading to periods of non-gameplay where players patiently waited for me to "return."

One more unexpected obstacle surfaced, management of DoD Internet firewalls is distributed. I conducted these sessions from the Pentagon using DoD equipment and had no
problem connecting to the website. I had to cancel one session with participants from Louisiana and Alabama 30-minutes in after discovering that the website was blocked locally for these players. Using formal DoD coordination procedures took one week to get the site unblocked.

I conducted the quasi-experiment eight times with a total of 41 participants (Table 4.1).

<table>
<thead>
<tr>
<th>Table 4.1. Sessions Conducted In-Person and Online</th>
</tr>
</thead>
<tbody>
<tr>
<td>Session</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>1 (online)</td>
</tr>
<tr>
<td>2 (in person)</td>
</tr>
<tr>
<td>3 (online)</td>
</tr>
<tr>
<td>4 (online)</td>
</tr>
<tr>
<td>5 (in person)</td>
</tr>
<tr>
<td>6 (online)</td>
</tr>
<tr>
<td>7 (in person)</td>
</tr>
<tr>
<td>8 (online)</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

Preparation

**Groundwork.** The first 30-minutes of each session were used for preparation and introduction. I ensured players had functioning equipment (e.g., Internet connection, could hear the audio if DCO), acknowledged informed consent, described what to expect over the next 90-minutes. I made it clear that I was not acting in an official capacity in conducting this research and my statements did not necessarily reflect the views of the U. S. Air Force or U. S. Government. The first two sessions went over 90-minutes, leading me to shorten the preparation to allow more time for gameplay and data collection. I had some success, getting to 20-minutes for one session and 25-minutes for another.

I wanted players focused on the game, not the digital tool. I delayed giving them access to the NEM until after providing the context for the intervention. Before providing that context, I
presented a brief description of the digital tool. A simple NEM, it simulated a *single shot*, or one-move game. In calculations it treated all nuclear warheads as equal.

**Creating a Game Environment.** To set the general context for the entire experiment, I juxtaposed two photos the participants would recognize (Figure 4.2). The first was of Reagan and Gorbachev during the 1986 summit in Reykjavik, Iceland. I used this image to remind that the Cold War was long over and that during that summit Reagan proposed elimination of all nuclear ballistic missiles (Gwertzman, 1986). The second photo was of Obama at Prague where he called for the eventual elimination of all nuclear weapons (Obama, 2009). I used this image to emphasize the contemporary relevance of achieving further nuclear reductions. Together, these images conveyed that reductions were neither a partisan political issue nor were they a new policy goal. The papers displayed alongside the photos were of recent monographs and reports recommending policy changes to our nuclear forces. The participants were familiar with many of these papers and associated arguments.

**Figure 4.2. Presentation Slide Used to Set the Context for the Experiment**
Introducing Players to the Digital NEM. I next introduced players to the web-based interface and explained its logic in detail. The digital decision aid permitted players to manipulate 14 interdependent variables. An additional two variables are programmed, but were hidden after the initial data collection session to simplify data analysis. Players were asked to use this artifact to analyze a given problem and recommend a solution. Specifically, players were asked to create a Defender force strategy and then design an Attacker strategy to test the quality of their Defender choices. Based on their analysis, players then recommend a Defender strategy for the given scenario.

The web-based interface with the digital NEM (Figure 4.3) was organized in two columns, the left to create a Defender strategy and the right an Attacker strategy. The Defender strategy consists of total warheads available, ICBM force levels and characteristics, bomber force levels and characteristics, and finally SSBN force levels and characteristics. The Attacker strategy includes whether to target Defender ICBM and related facilities, effectiveness of attack, and an option to target other unspecified Defender capabilities.

Player Inputs to the NEM. Players were instructed to work from the top down to create a Defender strategy, then do the same on the left to create the Attacker strategy. The first player inputs were values for Total Warheads, which were assigned and always the same for both Defender and Attacker.

Creating a Defender Strategy. The ICBM force is first shaped by player input of the number of ICBM (a list of authorized values was provided during gameplay) and a Multiple independently-targetable reentry vehicle (MIRV) rate of 1, 2, or 3 warheads per missile. Next, the Bomber force was sized (a list of authorized values was provided during gameplay). Players then determined whether to Generate and Survive the bombers (rate between 0.1 and 1.0) and
Figure 4.3. Digital NEM: Explanation of Player Inputs

Inputs
- Total # of ICBM [Player selected, from a list of values provided]
- Warheads assigned each ICBM [Player selected from three options: 1, 2, and 3]
- Total # Warheads for period of play [Assigned by me, but entered by player]
- Three options: 0:1 (do not target ICBMs), 1:1 (use 1 warhead against each ICBM), and 2:1 (use 2 warheads against each ICBM) [Player selected]
- Does player target Defender ICBM Launch Control Facilities? [Player selected, options: Y/N]
- Probability of effective attack on each Defender ICBM [Player selected]
- Warheads used against targets other than ICBM (e.g., SSBN ports, Bomber bases) [Player selected with a minimum of 10 to destroy all Defender warheads not at sea on SSBN or on alert on Bombers]
- Total # of Bombers [Player selected, from a list of values provided]
- Option to put Bombers on alert to survive any attack. If selected, a drop-down requires player to determine the alert rate (i.e., percentage surviving) and total # of warheads assigned to Bomber force [Player selected]
- The # missile "tubes" (i.e., missiles) on each SSBN [Player selected, from a list of values provided]
- Rate of SSBN at sea to survive any attack [Player selected, from a list of values provided]
assign a number of warheads across the force. Finally, an SSBN fleet was built by determining the number (a list of authorized values was provided during gameplay), the percentage of time spent at sea, and number of missile tubes per SSBN.

Creating an Attacker Strategy. The player then changes perspective and creates an attack on the Defender strategy to test its sufficiency. Staring at the top right in Figure 4.3, the player selects a ratio of attack on the Defender ICBM force (0, 1, or 2). Next, players select a yes/no option to target the Launch Control Centers (LCC), the command and control node from where missileers would actually direct the launch of ICBM. The Attacker Pk, probability that each warhead targeting ICBMs will destroy the target. Finally, an additional number of warheads can be employed for unspecified targets such as command and control capabilities, leadership, or population centers.

Inside the Black Box. The digital tool executes calculations and stores data. The selection of specific calculations and the logic used to organize those calculations were perspective or framework dependent. The framework was counterforce-centric, the targeting of adversary military, primarily nuclear forces. The United States shifted from a countervalue strategy of targeting adversary population or economic capabilities to counterforce targeting in the early 1960s. Although the player is not forced to adopt a counterforce targeting strategy by the Attacker, the metric of sufficiency is strongly suggested to be Defender vs. Attacker warheads remaining post-attack. This makes the scenario numbers-centric. There is disagreement as to whether a nuclear attack, or credible threat to attack, would require counterforce targeting (Gallagher & Sorice, 2014). Indeed, current Russian doctrine indicates the potential to use nuclear weapons in a conventional crisis (Sokov, 2014). For purpose of this research, a narrow counterforce construct was used. The scenarios were further narrowed by restricting analysis to a
two-player, nuclear-peer situation. During gameplay, these factors were brought to players’ attention. While not comprehensive, the restricted framework was adequate to its purpose of focusing players on tradeoffs, specifically between the ICBM and SSBN.

The players were tasked to use this tool to develop and analyze arsenal strategies. The digital NEM uses player input and internal logic to allocate warheads across the Defender force structure and calculate the result of a strike by the Attacker. Player recommendation of a Defender strategy concluded each scenario.

**Calculating Warhead Distribution for the Defender Strategy.** The NEM first subtracts the number of ICBM × MIRV from the Total Warheads. From that number, it subtracts the warheads assigned to bomber force and assigns the remaining to the SSBN fleet. It distributes warheads evenly across both the bomber force and SSBN fleet. In summary: Total Warheads − (ICBM × MIRV) − warheads assigned bombers = warheads assigned SSBN fleet.

**Calculating Warhead Usage for the Attacker Strategy.** The first calculation is to allocate a number of warheads to target Defender ICBM, an attack ratio of 0, 1, or 2. This total is subtracted from Total Warheads. If the Defender LCCs are targeted, the NEM calculates the number of LLCs (Defender ICBM/10) and subtracts that number of warheads from the Attacker's total. Finally, the value for Attacker weapons targeted on bases and other critical assets was subtracted (minimum of 10).

**Calculating Results of the Attack.** The NEM processed the results of the opposing strategies whenever the **Execute** button was activated. First, warheads were subtracted from the total for any attack on the Defender ICBM force, including LCCs. If targeted, the LCCs were considered destroyed at a rate of 1.0. The Defender ICBM were destroyed at the Attacker Pk rate selected by the player (0.1 – 1.0). Next, the number of warheads targeting **Bases and Critical**
Target were subtracted. This accounted for destruction of all Defender SSBN capability not at sea or Bombers not generated.

In summary:

1. Defender warheads remaining post-strike equaled the Total Warheads minus the warheads on the ICBM (ICBM × MIRV) that were targeted by the Attacker at the Attacker Pk rate, minus the warheads on bombers not on alert and SSBN warheads not at sea.

2. Attacker warheads remaining post-strike equaled the Total Warheads minus the warheads targeting Defender ICBM, minus the warheads targeting Defender LCC, minus warheads targeting Bases and other Critical Targets.

Communicating the results to players was done through the NEM as depicted in Figure 4.4. The top section, Your Arsenal Strategy Following Attack contains the most important feedback for players, Defender and Attacker warheads remaining, Defender advantage (could be negative number), and post-attack ratio. The second section presents the Defender warheads surviving across the player created force structure of ICBM, bombers, and SSBN, and the number of Attacker warheads expended in the strike. The third box summarizes player inputs and reveals the number of warheads that were assigned to the Navy, a calculated value as described above.

**Demonstration.** I demonstrated the functionality of the digital decision aid while explaining its logic as described above. For the demonstration, I selected a force structure familiar to all players, the one planned to comply with New Strategic Arms Reduction Treaty (New START). This is the most recent nuclear arms control treaty between Russia and the
Figure 4.4. Digital NEM: Depiction of Results as Presented to Players

Results

Players were instructed to use these numbers to assess the adequacy of their strategy.

Supplemental data for use by players in assessing their strategy.

Player decides either to further explore options (Edit) or make a choice (Recommend) and continue to next period of play.

Calculated value based on player selection of ICBM and Bomber values (SSBN warheads = Total Warheads - (#ICBM x MIRV) - Warheads assigned Bombers)

Summary of Player inputs.
United States and sets limits on strategic nuclear forces. The limits used for the demonstration are found in the Table 4.2. Using the New START force structure to explain the tool helped demonstrate the validity of the tool's algorithms because it is grounded in current-day reality and provided outputs the participants expected; there were no surprises.

Table 4.2. Values Used to Demonstrate the Digital NEM to the Players

<table>
<thead>
<tr>
<th>Defender Values</th>
<th>Attacker Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Warheads</td>
<td>Total Warheads</td>
</tr>
<tr>
<td>1550</td>
<td>1550</td>
</tr>
<tr>
<td>Number of Defender ICBM</td>
<td>Targeting Ratio on ICBM</td>
</tr>
<tr>
<td>400</td>
<td>0.9</td>
</tr>
<tr>
<td>MIRV Ratio on ICBM</td>
<td>Bases &amp; Critical Targets</td>
</tr>
<tr>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td>Number of Bombers</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Warheads Assigned Bombers</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Operational SSBN</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
</tr>
<tr>
<td>At Sea Rate</td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Bombers</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td></td>
</tr>
</tbody>
</table>

**Gameplay**

Players then proceeded to the website to confirm they were at least 18-years old and to acknowledge consent. They then were directed to create a nonsense username and complete the first survey (Appendix C). Players were not told there would be a second survey or that the activity was a form of experiment or intervention.

Each data collection session included three periods of play, or Scenarios. The scenarios were not narratively sequential, meaning each was presented as a stand-alone new situation not linked to the previous. Below, I cover two elements for each scenario. First, I provide the description of the security environment, or Context for Play, presented the players and the rationale for use of that particular narrative. I detail the Limits on Player Choice or restrictions I placed on the options the players should explore during each period and the rationale for those limits. At the end of each period of play, questions were posed to encourage reflection as well as
provide the researcher insight into player decisions. As data from the reflection periods was not
further analyzed, I omit further description here.

**Scenario One (1000 Warheads).** By this time, participants had already spent 30-minutes
in what might be considered just another dreary briefing. I had to set the stage in a way that
piqued their interest and got them to jump into the game. To help do that, the first narrative was
the longest and most detailed of the three.

**Context for Play.** For the first period of play, I presented the graphic in Figure 4.5 while
reading the following script:

In 2015, Russia annexed the Eastern half of Ukraine, including the
total Black Sea coastal region and deployed a new nuclear-
capable Intermediate Range Ballistic Missiles (IRBM) to
Kaliningrad in an obvious violation of the Intermediate-Range
Nuclear Forces Treaty (INF). NATO Allies expressed deep
concern and the Alliance pulled together in face of Russian
adventurism. Continued economic decline, exacerbated by
sanctions resulted in domestic political turmoil and the
replacement of Putin with more conciliatory leadership.

It is now five years later and the long desired "Reset" with Russia
may be about to arrive. Relations with the United States and
NATO show signs of improvement. The IRBMs have been
removed from Kaliningrad. A still rising China's nuclear arsenal
remains below 500 with their SSBNs conducting irregular sea
duty. The president believes that if Russia and the US could again
decrease the size of their arsenals, China would stay at its current
level and perhaps divert military spending on nuclear weapons to
other purposes.

It's Wednesday, January 8, 2020. As part of transition team efforts
for the president elect, her NSA asked for your assistance in
developing the administration's nuclear arsenal strategy. The
president elect believes there is opportunity for further reductions
in U.S.-Russian arsenals. As did her predecessor, she believes a
reduction to 1,000 warheads would not create instability. Her team
is confident they can get Russia to agree to a like reduction.
Rationale for the Narrative. The president has stated publically that the United States could decrease its nuclear arsenal by one-third (Obama, 2013). Therefore an arsenal of 1,000 is a logical and valid excursion to explore. In reality, the recent Russian incursion into Ukraine and seizure of its territory highlight the fragility of the West's current relationship with Russia. The current security environment provides little reason to be optimistic for additional reductions in the near future. Therefore, to encourage players to seriously consider reductions to an arsenal of 1,000 warheads, I provided a narrative of hope to replace current conditions. Thus I reintroduced the metaphor used early in the Obama Administration, the possibility of a "Reset" in the relationship with Russia concurrent with a present, but diminishing Russian threat. Finally, I injected a mild role-playing component to liberate players from their present responsibilities and
emphasize that they would be making an individual recommendation. That served to increase
player commitment and motivation to find quality solutions.

**Limits on Player Choice.** I limited the options players could recommend (Table 4.3). I
did this to limit variation in arsenal strategies to a level manageable for this research. The ICBM
options reflect current deployment levels of 150 missiles at each ICBM *wing*, or base. Players
could opt to zero any delivery system and still employ the entire arsenal of 1,000 warheads (i.e.,
you could put all 1,000 warheads on any of the three delivery systems). Players accepted the
limits for this round without complaint.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Warheads</td>
<td>1000</td>
</tr>
<tr>
<td>Number of Defender ICBM</td>
<td>0, 150, 300, 450, 600, 750</td>
</tr>
<tr>
<td>Number of Bombers</td>
<td>0, 50, 100</td>
</tr>
<tr>
<td>Operational SSBN</td>
<td>0, 10, 12, 16, 20</td>
</tr>
</tbody>
</table>

**Scenario Two.** Once players had completed entering comments, I proceeded to the next
period of play.

**Context for Play.** For Scenario Two, I presented the graphic in Figure 4.6 and read the
following script:

It is 2025 and U.S. – Russia cooperation has improved. Economic
globalization is strong and the BRICs are more cooperative
regarding international norms. The president senses an opportunity
to further reduce our nuclear arsenal. Russia is receptive to a
similar reduction.

Multilateral treaties are strong and the IAEA is achieving greater
access globally for monitoring and verification.
**Rationale for the Narrative.** I needed to show an improved security environment to allow players a credible reason to explore such a reduction in arsenal size. An arsenal of 500 warheads is well within the realm of minimum deterrence. Arguments for a minimum deterrence construct vary regarding the size of the arsenal. Some describe a range of tens to 1,000 warheads. Many monographs and papers actually settle on a lower number. The Global Zero recommendation is for 900 warheads, but half would be in deep storage leaving a daily deterrent force of about 450 (Cartwright et al., 2012). Others do not explicitly propose an arsenal size, but their general arguments place them in this region. For example, a recent paper from the Cato Institute declined to propose a number, but did recommend an SSBN-only force along the lines of current DoD plans for the future (Friedmen et al., 2013). An at sea rate of 0.5 would place the total numbers of warheads available for deterrence on a daily basis at about 500 as well.
**Limits on Player Choice.** I again imposed similar limits on player choice (Table 4.4). Players had latitude to exclude one or two delivery systems.

**Table 4.4. Limits Placed on Player Defender Choices in Scenario Two**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Warheads</td>
<td>500</td>
</tr>
<tr>
<td>Number of Defender ICBM</td>
<td>0, 150, 300, 450</td>
</tr>
<tr>
<td>Number of Bombers</td>
<td>0, 50</td>
</tr>
<tr>
<td>Operational SSBN</td>
<td>0, 8, 12</td>
</tr>
</tbody>
</table>

**Scenario Three.** Once complete with comments, we proceeded to the last period of play.

**Context for Play.** For the third scenario, I presented the graphic in Figure 4.7 and read the following script:

It's 2028 and the world has changed considerably. Despite many predictions of United States decline, the nation is resurgent as the world's clear economic and military superpower. The innovation brought on by U.S. domination of nanotechnology has rendered great power competition impossible for the foreseeable future. Nanotechnology has brought near-free energy to large parts of the world. With such energy, water, heat, and food production have soared promising an end to the most dire poverty.

A post-Putin Russia is still in turmoil and facing severe economic pressure that has forced them to make significant reductions to their conventional and nuclear military forces. China's economic rise brought political change and they have ended the rogue regime in North Korea. Iran has accepted IAEA monitoring and its nuclear program appears focused on peaceful production of energy.

It’s early January 2028 and as part of transition team efforts for the president elect, her national security advisor (NSA) asked for your assistance in developing the administration's nuclear arsenal strategy and making further progress toward meeting our obligations under the NPT.
**Rationale for the Narrative.** An excursion to 300 required something transformational, so I used nanotechnology as a *Deus ex Machina*. While painting a picture of positive change, I left some instability within Russia to drive the need for thoughtful consideration of an arsenal strategy for this environment. An arsenal of 300 is another minimum deterrence number that is offered up in the contemporary debate (Forsyth et al., 2010).

**Limits on Player Choice.** I imposed similar limits concerning standard deployment of forces and allowed players to exclude one or two delivery systems (Table 4.5).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Warheads</td>
<td>300</td>
</tr>
<tr>
<td>Number of Defender ICBM</td>
<td>0, 150, 300</td>
</tr>
<tr>
<td>Number of Bombers</td>
<td>0, 50</td>
</tr>
<tr>
<td>Operational SSBN</td>
<td>0, 5, 10</td>
</tr>
</tbody>
</table>

Table 4.5. Limits Placed on Player Defender Choices in Scenario Three
Chapter 5

Results

In the previous chapter, I described the mechanics of conducting the intervention, which may be of interest to those designing similar quasi-experiments or improving the one presented here. Originally designed to be conducted in-person, I adapted the design to conduct online data collection sessions as well.

I provided a digital tool, or nuclear exchange model, for participants to use within a specific context. I provided scenarios that included a minor role-playing element and narrative regarding a future condition. The scenarios and tasks assigned the players were related to nuclear weapons and all participants were very knowledgeable of that topic. Combined, the design elements were intended to generate a game experience turning participants into players to elicit deeper insights.

In the context of nuclear weapons strategy, my interest is with the choices players made and why they made them. To investigate these factors, I developed two research questions, "How do individual participant preferences change when given a tool to evaluate those preferences within a specified framework for analysis?" and, "How much commonality exists among changes in participant preferences and what explains this?"

To answer these questions I used a mixed-method approach. I designed a quasi-experiment in the form of an intervention using entry (T₁) and exit (T₂) surveys to detect change. The data were derived from survey responses, participant comments, and gameplay telemetry generated during the intervention sessions.

Here I first present results from analysis of participant responses to the two surveys. This is done in three parts as the surveys were designed to create data regarding three aspects of the problem space. Survey data also revealed conceptual frameworks used by the players. Analysis
of gameplay data follow, first as it was perceived by the players and second as evaluated against historical metrics. Finally, using methods triangulation, on data from the surveys, gameplay, and comments to understand the rationale for changes in player preferences.

**Survey Data**

The surveys generated data on demographics, preferred arsenal size, relative value of delivery systems, and effective force structures across different futures. The two surveys were identical with one exception; in the second survey I did not repeat the questions on demographics. I achieved $n = 40$ for all but Question 12, which one player failed to answer at T$_2$ resulting in $n = 39$.

**Eliminated Data.** I did not include demographic data in my analysis. With one potential exception the participants were a homogenous sample of nuclear weapons savvy individuals. That exception relates to age and player adoption of conceptual frameworks and will be briefly addressed below. As I am interested in participant change, I also eliminated data from the three participants that left before the intervention ended and the one that did not complete the second survey. The former were not subject to the complete intervention and the latter provided no T$_2$ survey data to compare with T$_1$.

**Arsenal Size.** Questions 5-8 created data on participants' preferences regarding an appropriate measure for the size of the nuclear arsenal of the United States. Options included a small number regardless of the size of the Russian arsenal, equivalency (i.e., the same number as Russia), and superiority (i.e., more than Russia). The raw data are in Appendix D, Table D.1.

**Movement in Responses to Questions on Arsenal Size.** I first conducted Paired Sample T-Tests, which indicated no statistical significance to the movement in these questions (Appendix D, Table D.2). However, this approach is non-optimum for two reasons. First, such
tests assume normal distribution of data and these data do not conform to normal distribution. If the sample is large, parametric statistical techniques can be effective with non-parametric data, but at \( n = 40 \) my sample size is too small for such techniques to provide insight. Second, such analysis is linked to the sum of the movement. A player’s move in one direction may negate another’s move in the opposite. I am more interested in the total amount of movement regardless of direction.

The data in Table 5.1 illustrate this point. Using the questions as units of measurement provides a net movement across the four questions of -6, 4, -9, and -1. If the unit of measurement is the participant, not the question, one discovers much more absolute movement across the questions at 22, 16, 17, and 19. More interestingly, the number of participants that changed preferences between T1 and T2 totaled 17, 12, 14, and 18. Thus, 40% of participants changed their Q5 preference, 28% in Q6, 33% in Q7, and 43% in Q8.

<table>
<thead>
<tr>
<th>Question</th>
<th>Net Movement</th>
<th>Absolute Movement</th>
<th>Players Changing</th>
<th>Percent Changing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q5: fixed number</td>
<td>-6</td>
<td>22</td>
<td>17</td>
<td>40%</td>
</tr>
<tr>
<td>Q6: Superiority</td>
<td>4</td>
<td>16</td>
<td>12</td>
<td>28%</td>
</tr>
<tr>
<td>Q7: Parity</td>
<td>-9</td>
<td>17</td>
<td>14</td>
<td>33%</td>
</tr>
<tr>
<td>Q8: Adversary arsenal irrelevant</td>
<td>-1</td>
<td>19</td>
<td>18</td>
<td>43%</td>
</tr>
</tbody>
</table>

To determine the significance of the absolute movement in Q5-Q8, I conducted One Sample T-Tests and calculated Effect Size. Results shown in Table 5.2 suggest the amount of change in all four questions was statistically significant and the effect size Large.
Table 5.2. One Sample T-Test and Effect Size for Absolute Change in Questions 5-8

<table>
<thead>
<tr>
<th>Question</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
<th>Mean Difference</th>
<th>95% Confidence Interval</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q5AbsChg</td>
<td>4.642</td>
<td>39</td>
<td>.000</td>
<td>.550</td>
<td>.31 -.79</td>
<td>0.60</td>
</tr>
<tr>
<td>Q6AbsChg</td>
<td>3.766</td>
<td>39</td>
<td>.001</td>
<td>.400</td>
<td>.19 -.61</td>
<td>0.52</td>
</tr>
<tr>
<td>Q7AbsChg</td>
<td>4.226</td>
<td>39</td>
<td>.000</td>
<td>.425</td>
<td>.22 -.63</td>
<td>0.56</td>
</tr>
<tr>
<td>Q8AbsChg</td>
<td>5.019</td>
<td>39</td>
<td>.000</td>
<td>.475</td>
<td>.28 -.67</td>
<td>0.63</td>
</tr>
</tbody>
</table>

Note: For T-Tests the Test Value = 0

SSBN and ICBM Value. Questions 9-12 created data on participant perception of the importance of the SSBN and ICBM. The first three (Q9-Q11) probed participants’ perceptions of Survivability, the characteristic of being difficult to target and destroy, and the value of the SSBN in embodying this trait. Responses to question 12 indicated whether participants expected the ICBM to increase or decrease in value as arsenal size decreased (Table 5.3). The raw data are in Appendix D, Table D.3.

Table 5.3. Aggregate Movement in Survey Questions 9-12

<table>
<thead>
<tr>
<th>Question</th>
<th>Net Movement</th>
<th>Absolute Movement</th>
<th>Players Changing</th>
<th>Percent Changing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q9: SSBN most survivable</td>
<td>-11</td>
<td>23</td>
<td>15</td>
<td>38%</td>
</tr>
<tr>
<td>Q10: Survivability most important</td>
<td>7</td>
<td>23</td>
<td>15</td>
<td>38%</td>
</tr>
<tr>
<td>Q11: SSBN most valuable</td>
<td>-2</td>
<td>22</td>
<td>16</td>
<td>40%</td>
</tr>
<tr>
<td>Q12: ICBM decreases in value</td>
<td>-21</td>
<td>51</td>
<td>31</td>
<td>78%</td>
</tr>
</tbody>
</table>

Movement in SSBN and ICBM Value. Again we find that a closer look at the data provides a more interesting picture. The net movement across questions 9-12 was -11, 7, -2, and -21 respectively. Using instead the participant as the unit of measurement, reveals absolute movement of 23, 23, 22, and 51. The number of participants changing preferences between T₁ and T₂ totaled 15, 15, 16, and 31. Said another way, 38% changed their preference in Q9 and Q10, 40% in Q11, and 78% in Q12.
Question 12 contained both more change and more players that changed than Q5-Q11. The statement for Q12 was, "The value of the land-based intercontinental ballistic missile (ICBM) force *diminishes as arsenal size decreases.*" In response, 31 of 40 players, or 78%, changed between T₁ to T₂ creating a total of 51 units of absolute change. The change was strongly in one direction with a net change of -21. Table 5.4 indicates the shift in player responses. At T₁ 18% of participants were Undecided and 41% Strongly Disagreed/Disagreed that the statement presented in Q12 was accurate. By T₂, this clustering was more pronounced with Undecided at 10% and Strongly Disagreed/Disagreed at 62%.

Table 5.4. Movement between T₁ and T₂ in Responses to Survey Question 12

<table>
<thead>
<tr>
<th>Response</th>
<th>Value</th>
<th>T₁ Frequency</th>
<th>T₂ Frequency</th>
<th>T₁ Percent</th>
<th>T₂ Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree</td>
<td>1</td>
<td>4</td>
<td>13</td>
<td>10</td>
<td>33</td>
</tr>
<tr>
<td>Disagree</td>
<td>2</td>
<td>12</td>
<td>11</td>
<td>30</td>
<td>28</td>
</tr>
<tr>
<td>Neither</td>
<td>3</td>
<td>7</td>
<td>4</td>
<td>18</td>
<td>10</td>
</tr>
<tr>
<td>Agree</td>
<td>4</td>
<td>13</td>
<td>7</td>
<td>33</td>
<td>18</td>
</tr>
<tr>
<td>Strongly Agree</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>8</td>
<td>10</td>
</tr>
</tbody>
</table>

I also conducted Paired T-Tests on questions 9-12 (Appendix D, Table D.4). But, as with Q5-Q8, that approach is non-optimum for these data. To determine the significance of the absolute movement in Q9-Q12 I returned to One Sample T-Tests and Effect Size. Results depicted in Table 5.5 suggest the amount of change in all four questions was statistically significant and the effect size *Large*.

Table 5.5. One Sample T-Test and Effect Size for Absolute Change in Questions 9-12

<table>
<thead>
<tr>
<th>Question</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
<th>Mean Difference</th>
<th>95% Confidence Interval of the Difference</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q9AbsChg</td>
<td>4.162</td>
<td>39</td>
<td>.000</td>
<td>.575</td>
<td>.30 to .85</td>
<td>0.55</td>
</tr>
<tr>
<td>Q10AbsChg</td>
<td>4.473</td>
<td>39</td>
<td>.000</td>
<td>.575</td>
<td>.32 to .83</td>
<td>0.58</td>
</tr>
<tr>
<td>Q11AbsChg</td>
<td>4.642</td>
<td>39</td>
<td>.000</td>
<td>.550</td>
<td>.31 to .79</td>
<td>0.60</td>
</tr>
<tr>
<td>Q12AbsChg</td>
<td>7.243</td>
<td>38</td>
<td>.000</td>
<td>1.308</td>
<td>.94 to 1.67</td>
<td>0.76</td>
</tr>
</tbody>
</table>

Note: For T-Tests the Test Value = 0
**Allocation of Warheads across Legs of the Triad.** To respond to question 13, participants were directed to select delivery platforms to use (i.e., SSBN, ICBM, and bombers) for five separate arsenal levels of 2200, 1550, 1000, 500, and 300 (Figure 3.1). The last three arsenal levels (1000, 500, and 300) correspond to the three scenarios used in gameplay. Individual player responses are in Appendix D, Table D.5.

I was interested in the perceived value of the ICBM *vis-à-vis* the SSBN. Bombers played an insignificant role in this dynamic (e.g., only one player selected a Bomber Monad in Q13) and were excluded from this analysis. The data revealed changes between T1 and T2 in value a player placed on the SSBN and ICBM (Table 5.6).

**Table 5.6. Changing Value of the ICBM and SSBN in Survey Question 13**

<table>
<thead>
<tr>
<th></th>
<th>2200</th>
<th></th>
<th>1550</th>
<th></th>
<th>1000</th>
<th></th>
<th>500</th>
<th></th>
<th>300</th>
<th></th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Percent</td>
<td>Number</td>
<td>Percent</td>
<td>Number</td>
<td>Percent</td>
<td>Number</td>
<td>Percent</td>
<td>Number</td>
<td>Percent</td>
<td>Number</td>
</tr>
<tr>
<td>&gt; ICBM</td>
<td>3</td>
<td>8%</td>
<td>2</td>
<td>5%</td>
<td>5</td>
<td>13%</td>
<td>11</td>
<td>28%</td>
<td>16</td>
<td>40%</td>
<td>37</td>
</tr>
<tr>
<td>&gt; SSBN</td>
<td>3</td>
<td>8%</td>
<td>2</td>
<td>5%</td>
<td>2</td>
<td>5%</td>
<td>5</td>
<td>13%</td>
<td>3</td>
<td>8%</td>
<td>15</td>
</tr>
<tr>
<td>Neutral</td>
<td>34</td>
<td>85%</td>
<td>36</td>
<td>90%</td>
<td>33</td>
<td>83%</td>
<td>24</td>
<td>53%</td>
<td>21</td>
<td>53%</td>
<td>148</td>
</tr>
<tr>
<td>Players</td>
<td>40</td>
<td></td>
<td>40</td>
<td></td>
<td>40</td>
<td></td>
<td>40</td>
<td></td>
<td>40</td>
<td></td>
<td>200</td>
</tr>
</tbody>
</table>

The greatest amount of change is at the 500 and 300 levels, corresponding to scenarios two and three in gameplay. Furthermore the change is greater in one direction - that of increased value ascribed the ICBM (e.g., 40% of the players at 300). The direction of change corresponds to data from Q12. Both indicate increased perceived value of the ICBM at T2.

**Summary of Survey Results.** Data from the surveys indicated change in player preferences following the intervention. Statistical analysis using One Sample T-Tests showed the level of change to be significant and calculation of Effect Size a large effect. The direction of
change was unclear with exception of questions 12 and 13 that indicate an increase in player value assigned the ICBM following the intervention.

**Gameplay Data**

I used the digital tool to collect data on player gameplay choices and their comments. With these data, I examined player decision-making in the context of three scenarios equating to arsenal levels of 1000, 500, and 300 warheads. The results shed light on what force structure choices they made over the three scenarios and why? Initial analysis focuses on player choices to employ a Triad, Dyad, or Monad. I next describe evaluation criteria and rationale for evaluating player choices.

**Scenarios.** As detailed in the previous chapter, the three scenarios were not narratively sequential; they were discrete vignettes. The first depicted an improving security environment, yet contained a credible potential threat from Russia and was used to explore an arsenal of 1,000 warheads. The second presented players with an improving security situation that included a cooperative Russia to investigate arsenals at 500. The third and final scenario introduced cooperation on a global scale with the exception of instability in a declining Russia and was used to provide players a rationale for developing arsenal strategies at 300 warheads.

**Player Choices.** Players were given wide latitude to design their arsenal strategies. Upper limits were placed on the number of SSBN, ICBM, and bombers players could use in each scenario, but they could assign warheads across the force in any fashion (i.e., each scenario allowed placing all warheads on one Leg of the Triad or distributing them across two or three Legs). Players also had complete flexibility in how they tested their strategies through designing the attack plans.
Player force structure preferences are presented in Table 5.7. They are depicted at the highest level of abstraction (i.e., Triad, Dyad, or Monad), across the three scenarios. Players did not explicitly select Triads, Dyads, or Monads during gameplay. They assigned warheads to SSBN, ICBM, and bomber forces. To interpret their choices in the context of a Triad, Dyad, or Monad, assignment of any number of warheads, even one, was considered evidence of inclusion of that delivery system in their strategy. I refer to this as a *Loose* evaluation of player preference. The intent was to interpret the arsenal in a manner most favorable to capability as possible.

**Table 5.7. Loose Evaluation of Player Arsenal Strategies across the Three Scenarios**

<table>
<thead>
<tr>
<th></th>
<th>At 1000 Warheads</th>
<th>At 500 Warheads</th>
<th>At 300 Warheads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triad</td>
<td>25</td>
<td>18</td>
<td>3</td>
</tr>
<tr>
<td>Dyad</td>
<td>14</td>
<td>20</td>
<td>31</td>
</tr>
<tr>
<td>Monad</td>
<td>0</td>
<td>1</td>
<td>6</td>
</tr>
</tbody>
</table>

The first game scenario, at 1000 warheads appears to have posed little challenge for the 25 players desiring to retain a Triad. A Dyad structure was selected by 14 players and no one opted for a Monad. At 500 warheads, 18 players sustained a Triad and the Dyad picked up 6 of the 7 defectors to become the preference of 20 Players. The Monad picked up its first supporter at 500. This trend continued at 300 warheads with the Triad dropping to 3, a Dyad increasing to 31, and 6 players opting for a Monad.

**Evaluating Player Choices.** At first appearance, there seemed to be some commonality in preferences across players. However, closer examination of player strategies revealed two factors that brought that commonality into question: divergence and variation. The first was presence of a significant number of choices that created force structures divergent from historical standards. The second related factor was the large variation in the manner players assembled their forces. This compelled analysis beyond identification of player choices to evaluation of choices themselves.
During gameplay players were instructed to recommend their optimum strategy, unrestrained by cost or feasibility. However, they were told to use their comments to address cost or other factors that needed to be overcome to make the strategy successful. Some players did include such *alibis* in their comments noting that advances in technology would allow very high at sea rates and the like. The criteria in Table 5.8 were used to evaluate whether gameplay choices reflected historical levels and rates or were *Nonstandard*. The criteria were applied separately for each scenario.

### Table 5.8. Criteria to Assess Player Gameplay Choices as Nonstandard

<table>
<thead>
<tr>
<th>Factor</th>
<th>Standard</th>
<th>Nonstandard</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSBN Fleets</td>
<td>≥1 MIRV &amp; ≥1/3 of Arsenal</td>
<td>&lt;1 MIRV or &lt;1/3 of Arsenal</td>
<td>Cost Prohibitive</td>
</tr>
<tr>
<td>At Sea Rate</td>
<td>0-0.7</td>
<td>&gt;0.7</td>
<td>Historic rate ≈ 0.66</td>
</tr>
<tr>
<td>Bomber Alert Rate</td>
<td>0-0.4</td>
<td>&gt;0.4</td>
<td>Historic rate ≈ 0.3</td>
</tr>
<tr>
<td>Wpns on Bombers</td>
<td>≥10% of Arsenal</td>
<td>&lt;10% of Arsenal</td>
<td>No Effect</td>
</tr>
</tbody>
</table>

**Rationale for the Standards.** The Triad has been the nuclear force structure since the early 1960s. Historical rates of operation and readiness postures were derived from mission requirements as well as limitations of the force (e.g., manned aircraft cannot stay airborne indefinitely). I applied the following logic to distinguish *Standard* from *Nonstandard*.

**SSBN Standards.** Players designed an SSBN fleet by selecting a number of submarines, the number of missile tubes on each submarine, and the time they spend on patrol at sea. An SSBN fleet is very expensive to procure and operate. Over the past several decades a majority of the strategic warhead arsenal has been assigned to the SSBN fleet (Mies, 1999). The MIRV rate was used as a proxy for another measure of feasibility. In gameplay, warheads assigned the SSBN fleet were distributed evenly across the missile launch tubes (one per missile). Regardless of historical rates, a MIRV rate below 1.0 indicates empty missile tubes, a clear inefficiency. The at sea rate has historically been 0.6 - 0.5 (Mies, 1999; U. S. Navy, 2014). The time spent in port,
which is one minus the at sea rate is used for maintenance, training, and other necessary purposes. The value zero was included in Standard because players not employing an SSBN fleet had a zero at sea rate. No player including SSBN in their strategy used an at sea rate of zero.

**Bomber Standards.** Bombers were removed from alert in 1992. The historical alert rate was approximately 0.3 (Bender, 2015). Players assigned warheads to the bomber force in total, not per aircraft. A commitment of 10% of the Defender arsenal was chosen because historically bombers on alert were fully loaded. Today, that would equate to approximately 800 warheads. Ten percent was chosen to represent a non-trivial commitment to the capability.

**Nonstandard Choices.** I defined nonstandard in two ways. First as a choice that affected the potential post-attack outcomes, those values displayed by the digital tool to assist players in evaluating the sufficiency of their strategy. Second, I include the presence of a hollow force, when a player fails to provide adequate resources to the force structure or refuses to pay in warheads for capability that is claimed. Thus, by not meeting the Standard, players could manipulate the game to provide an actual benefit of more warheads or a perceived benefit of retention of an attribute such as flexibility or survivability without cost. An example of the first might be an increase in time the SSBN fleet spends at sea to survive more warheads. The second could be done by claiming to retain a Triad while providing insufficient warheads to the bomber force. I characterize this level of evaluation of player choices as a "Strict" evaluation.

Table 5.9 presents player intended arsenal strategy, which was derived from the Loose evaluation process, compared to the arsenal strategy derived from the Strict evaluation process. An extract of individual player gameplay data is presented in Appendix D, Table D.6. Use of nonstandard choices account for the high level of divergence between Loose and Strict implementation among this knowledgeable group. In all three scenarios, few players employed
Triads and use of Dyads was strong. Monads did not receive strong support until Scenario Three. Players' perceptions (Loose evaluation) appear not to match their actual (Strict evaluation) choices.

**Table 5.9. Player Perceived Arsenal Strategies and Actual Strategies Employed**

<table>
<thead>
<tr>
<th>At 1000 Warheads</th>
<th>At 500 Warheads</th>
<th>At 300 Warheads</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Loose</td>
<td>Strict</td>
</tr>
<tr>
<td>Triad</td>
<td>25</td>
<td>9</td>
</tr>
<tr>
<td>Dyad</td>
<td>14</td>
<td>28</td>
</tr>
<tr>
<td>Monad</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

**Summary of Gameplay Results.** Gameplay data revealed selection of Nonstandard choices by players in all three scenarios. There was apparent commonality across players in their preferences. Using Loose criteria, the picture was of strong support for the Triad in Scenario One and an affinity near equal to that for a Dyad in Scenario Two. Applying Strict criteria based on historical factors provided different results in all scenarios with very low support for the Triad and very strong support for the Dyad. It also revealed use of a Monad rising sharply to meet the challenge presented in Scenario Three.

**Triangulation**

Data were collected from each participant using three methods: surveys, gameplay choices, and comments. Survey data provided insight on player preferences for arsenal size and value of the ICBM relative to the SSBN. The survey data also indicated change in player preferences between T₁ and T₂. Gameplay data revealed preference for the Triad across players, but also disclosed the frequent use of Nonstandard choices to achieve those preferences.

Below, all three sources of data were used in a methods triangulation analysis (Patten, 2012). This analysis identified conceptual frameworks used by individual players when thinking
about nuclear weapons issues. These data were also used to analyze the quality of the changes in player preferences and identify potential rationales.

**Cognitive Frameworks Used by Participants.** There are several ways to think about nuclear sufficiency, or "How many warheads are enough or what type of force structure do we need?" Previous analysis indicates players pursued similar strategies in differing ways. Players arrived to the game with their own assumptions regarding the ability of SSBN to remain at sea undetected in the future or the potential for deception or rapid change in Russia's arsenal. Providing further insight into the amount, quality, and rationale behind player choices required blending of deductive and inductive approaches.

The primary data relevant to these questions are in the responses to Q5-Q8, which presented direct statements on arsenal size relative to Russia or another adversary. The first step in associating participants with frameworks was analysis of individual responses to Q5-Q8 at T₁. Responses to Q8 provided little differentiation among participants. It had the lowest cumulative T₁ and T₂ scores (72/71) of all questions. That indicated the 40 responses were heavily skewed to Strongly Disagree and Disagree at both times. This led me to eliminate Q8, adversary arsenal size is irrelevant, from further analysis. Criteria used to associate players with frameworks are found in Table 5.10.

Definitions of the four frameworks are:

1. Minimum Deterrence: At current arsenal levels (<2000 deployed warheads) and lower, a small fixed number of warheads is sufficient to generate deterrence regardless of the size of the adversary arsenal. Note this definition does not address circumstances of large arsenals.

2. Superiority: The United States arsenal should be larger than Russia's arsenal.
3. Parity: The United States arsenal should be at least roughly equal in size to Russia's arsenal.

4. Qualitative Edge: The United States arsenal should be of higher quality or better capability than Russia's arsenal. Numbers are not irrelevant, but matter less.

Table 5.10. Associating Players with Frameworks

<table>
<thead>
<tr>
<th>Framework</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Deterrence</td>
<td>Three requirements:</td>
</tr>
<tr>
<td></td>
<td>1) Q5 Answer 4, or 5</td>
</tr>
<tr>
<td></td>
<td>2) Q6 Answer 4 or 5</td>
</tr>
<tr>
<td></td>
<td>3) Q7 Answer 3, 4, or 5</td>
</tr>
<tr>
<td>Parity</td>
<td>Two requirements:</td>
</tr>
<tr>
<td></td>
<td>1) Q7 Answer 1 or 2</td>
</tr>
<tr>
<td></td>
<td>2) Q6 Answer 3, 4, or 5</td>
</tr>
<tr>
<td>Superiority</td>
<td>One requirement:</td>
</tr>
<tr>
<td></td>
<td>Q6 Answer 1 or 2</td>
</tr>
<tr>
<td>Qualitative Edge</td>
<td>Three requirements:</td>
</tr>
<tr>
<td></td>
<td>1) Q5 Answer 1, 2, or 3</td>
</tr>
<tr>
<td></td>
<td>2) Q6 Answer 3, 4 or 5</td>
</tr>
<tr>
<td></td>
<td>3) Q7 Answer 3, 4, or 5</td>
</tr>
</tbody>
</table>

Players that indicated support for equal or superior arsenal sizes were easiest to identify. Those indicating that relative size was unimportant were also identified. This initial cycle of analysis confirmed the presence of three specific legacy frameworks: *Minimum Deterrence*, *Parity*, and *Superiority*.

Eight players were left without association and further insight required a bottom-up inductive approach. The next cycle of analysis started with player comments, which were all collected post-T1. This cycle identified a fourth framework, *Qualitative Edge*, which was consistent with Q5-Q7 survey responses.

Qualitative Edge, meaning total capabilities build from superior technology, training, command and control, etc., are more important than numbers, is neither a new concept nor truly a legacy framework. Historically it was associated with Parity and the phrase, "second to none,"
which meant equal in number, but superior in operational effectiveness or deterrent effect (Nacht, 1998). Distinguishing the framework in this research is that these participants rejected or were unsure of the need for either Parity or Superiority, but did not think relative numbers unimportant. Another distinction is that contemporary versions of qualitative advantage focus on niche capabilities such as low-yield warheads that do not directly relate to the deterrence problem in this research (Lieber & Press, 2009).

Next, a third cycle of analysis was conducted on all players using these criteria to validate exclusivity. All players were now associated with a single framework at T1. Retaining the four frameworks, the same criteria were used to assess players at T2 to detect any change. These T2 associations were then assessed against player comments and gameplay choices for consistency.

**Player Movement between Frameworks.** In this section, I analyze player movement between the four frameworks. Comparing association at T1 and T2 revealed that some players changed frameworks during gameplay (Figure 5.1). Consulting the definitions above, and in the context of this research, Minimum Deterrence and Superiority can be considered near opposites. The former holds that a small fixed-number of warheads regardless of the size of the adversary's arsenal is sufficient. The latter holds that one needs more warheads than the adversary. Parity and Qualitative Edge fall somewhere between the two. It is clear that the player movement in aggregate is from the outside (Minimum Deterrence and Superiority) to the center.

A summary of player movement between frameworks is in Table 5.11. It indicates that 16 players adopted a new framework at T2. Only 1 participant was newly labeled a *Superiority* adherent at T2 and 6 prior (T1) adherents were reclassified to other frameworks dropping its representation of participants from 35% to 23%. One participant defected from *Parity* and 6
joined sending membership from 18% to 30%. Although there was more movement in both
Minimum Deterrence and Qualitative Edge, there was smaller net change.

**Figure 5.1. Total Change in Framework Membership**

![Bar chart showing the total change in framework membership.]

<table>
<thead>
<tr>
<th>Framework</th>
<th>T₁</th>
<th>Join</th>
<th>Defect</th>
<th>Net</th>
<th>Total</th>
<th>T₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Deterrence</td>
<td>11</td>
<td>2</td>
<td>5</td>
<td>-3</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Superiority</td>
<td>14</td>
<td>1</td>
<td>6</td>
<td>-5</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Parity</td>
<td>7</td>
<td>6</td>
<td>1</td>
<td>5</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>Qualitative Edge</td>
<td>8</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

The distinctions between frameworks are not equal. For two players, the difference
between Minimum Deterrence and Qualitative Edge in survey data came down to selection of
Neither Agree nor Disagree on Q5. But for that difference, Table 5.11 would indicate Minimum
Deterrence starting with 13, sustaining 8 and still ended with 9 making a larger relative loss.
Qualitative Edge would have started at 6 and still ended at 10 making a larger relative gain.
Assessing Individual Player Travel. It is clear from the data that most players (60%) do not "travel," or move from one framework to another. Additionally, some frameworks (e.g., Superiority) receive few new adherents at T2. Figure 5.2 adds an additional layer of detail by mapping player travel between frameworks. To better understand player movement, I first consulted their comments looking for direct explanatory power (i.e., clear statement of preference) or indirect explanations. I also searched for contradictory data. This analysis is presented below. By framework, I assessed individual comments and gameplay choices from the 16 players that changed frameworks for explanatory power regarding the movement.

Figure 5.2. Number of Players Moving between Frameworks
Defecting from Minimum Deterrence: Five players abandoned this framework. Three adopted Qualitative Edge and two opted for Parity.

P8: Analysis of gameplay choices and comments indicate that at T2, this player fit squarely in the Qualitative Edge camp. Comments indicate a focus on qualitative aspects such as ICBMs increasing the cost of attack and nature of the construct of survivability regarding the SSBN. Additionally, gameplay choices favored ICBM force structures, which is uncommon among adherents to Minimum Deterrence.

"...it seems that the larger numbers of ICBMs in general produced "better" numbers...forces adversary to spend a lot of warheads to attack...Decreasing ICBM numbers to increase subs lowered survivability...It seems that MIRVing the ICBMs increases value of attack for adversary - take out more warheads with less of theirs.

P36: Analysis of comments confirmed survey data indicating this player preferred the SSBN over the ICBM, which is common among minimum deterrence adherents. However, P36 gameplay choices reveal use of an ICBM Monad at 300 and comments display clear interest in the qualitative aspects of the arsenal. These data explain this player's switch to Qualitative Edge.

"...liked minimal bomber and ICBM presence that maintains the advantages/flexibility they bring and maximizing the SSBN survival capacity...uncomfortable going to just SSBNs though...One critical materiel problem can cause too much vulnerability so I kept one missile wing as well."

P39: This player changed to Qualitative Edge, but left few comments to analyze. There was little evidence in gameplay choices and comments to explain the move. This player perceived using the Triad in all three periods of play, but at 1000 and 500 actually resourced a Dyad and at 300 an ICBM Monad. This player did incorporate technology into the strategy. These data are consistent with a Qualitative Edge perspective.

"Reduce ICBM force to reduce cost and keep submarine force highly manned...I assumed a more advanced missile defense system."
P33: Although analysis of gameplay choices and comments indicate a continued Minimum Deterrence perspective, this player traveled to Parity. P33 was the most emphatic of all participants regarding the importance of survivability, which strongly suggests a Minimum Deterrence perspective. P33 also integrated technology into the recommended strategies, which is consistent with support for Qualitative Edge. Finally, P33 was realistic during gameplay with choices matching what was actually resourced.

"...deemphasizes ICBMs, focus on more survivable legs...Total emphasis on survivability...survivability essential...scenario could be stronger with consideration of Defenses, accuracy"

P34: This player joined P33 in moving to Parity. This player, like P33, was also realistic during gameplay with choices matching what was actually resourced. Analysis of comments indicates a weak affinity for Qualitative Edge, meaning another similarity with P33 is the lack of insight into what prompted the move.

"...Triad maximizes deterrence by imposing huge cost to attack (ICBMs), ability to signal intent (bombers), ability to engage in limited nuclear exchange (bombers), and assurance of retaliatory strike (SSBNs). # of warheads surviving first strike provides credible retaliatory capability and deterrence against China and others...Retained triad characteristics..."

Defecting from Superiority: At T2, six players left Superiority and one joined.

P3: The data are inconclusive regarding this player's move to Minimum Deterrence. At 1000, P3 placed two warheads on each ICBM (i.e., MIRV=2). The result was an under-resourced SSBN fleet and doubled the loss of Defender warheads on ICBM with no increase in cost to the Attacker. The player's claim to have spread risk across the Triad is incorrect. The comments regarding "have something left for future deterrence" and value of ICBM are not indicative of Minimum Deterrence.

"Spreading risk among the three legs of the triad...Because I was able to have more survivable weapons...Because of the number of
surviving warheads…I wanted to be sure to still have something left for future deterrence…didn't expect to be at a defender disadvantage…No ICBMs in the mix could lead to numerous other target options for the Attacker…Having an ICBM field would soak up a lot of their weapons"

P13: This player's move to Qualitative Edge is supported by gameplay choices and comments. The player was comfortable with Dyads in all three periods of play, under-resourcing at 300 to create an ICBM Monad. P13 twice accepted below average post-attack ratios. Data points to player focus beyond arsenal size.

"More SSBNs didn't necessarily mean more survivable weapons…Fewer ICBMs didn't necessarily mean more weapons destroyed…best balance between forcing complexity into attacker and keeping survivable weapons"

P23: Analysis of gameplay choices and comments fail to illuminate this rationale for player's move to Parity.

"Reflects realistic Pk bias…At 500 total warheads, most warheads would be on subs at sea. So I chose high ratios of warheads on SSBNs…Takes a balanced approach to force structure, to maximize flexibility at low numbers. Results are very sensitive to Pk, to MIRV ratio, and bomber survivability."

P29: Player comments explain transition to Qualitative Edge. The focus is clearly on complementary effects and how they change at different arsenal levels. The comment on the tool also highlights the player's belief that a focus on numbers is insufficient. Despite stating a requirement for a Triad and choosing a Triad in gameplay, P29 Never adequately resourced a Triad inadvertently creating a Dyad in two periods and a Monad at 300.

"max'ing ICBMs is required for crisis stability purposes (and best insurance option for POTUS), and max'ing bombers for flexibility purposes is appropriate. At 1,000 total, the attribute of survivability is decreased…Such a tool, with enough data and agreed-upon assumptions (tho' simplistic), may yield a measure of "most deterrence per unit of force structure…I probably put too much value on flexibility, even at this level, so I went beyond the pale to keep a Triad."
P35: Analysis of gameplay choices and comments have only weak explanatory power for this player's jump to Parity. Every comment, but one, referred to generating (i.e, surviving) forces. Two of those comments did indicate that a strategy without ICBM was undesirable. The remaining references to high readiness rates articulate an explicit goal of increasing warhead survival. Several comments refer to "defender advantage." Those comments seem to rule out both Superiority and Minimum Deterrence. The clear focus on numbers does not support a not Qualitative Edge perspective.

"significant advantage to defender…generating all bombers and SSBNs with no ICBMs presents the best scenario…Generated/at sea bombers and SSBNs have a much greater chance of survival than ICBMs…Moving to a dyad (no ICBMs) has clear advantages for a defender (providing the dyad is generated/at sea)"  

P37: This player moved to Parity. Analysis of comments supports a move to Parity, but could be interpreted to support Qualitative Edge. Although the comments do indicate player appreciation for the complementary effects of the Triad Legs, they mostly involve the issue of stability as it relates to an adversary's ability to gain an advantageous post-strike ratio. It is more about numbers than qualitative aspects, which leans toward Parity.

"ICBMs require greater than 1:1 exchange to destroy all…We are guaranteed an advantage. The math says all in on ICBMs...most interesting!" ICBMs are a weapon soak--it costs the adversary more weapons than they kill; SLBMs assure retaliation…Subs put us at a serious disadvantage unless you can put all at sea"

Defecting from Parity: Only one player defected from Parity and six players joined. The defector traveled to Qualitative Edge.

P1: Review comments and gameplay choices reveal that P1 was concerned with post-attack warhead ratios. However, the player did not make strategy recommendations based on those ratios alone. P1 articulated an interest in how the mix of delivery systems might need to
change at lower numbers to create desired effects. This aligns weakly with transition to Qualitative Edge.

"any combination minimizing ICBMs looks to be an opportunity for the attacker to be more successful due to minimizing the defenders ability to retain a force…uploading additional warheads to bombers can increase the warhead ratio in favor of the defender, I must assume this is at a much higher cost versus deployment on subs or ICBM. Therefore my recommendation only utilizes a small bomber force (I value a full triad more than other options)"

**Defecting from Qualitative Edge:** Four players defected from Qualitative Edge and six joined.

P4: After reviewing the gameplay choices and comments, this player's realignment to Superiority is not surprising. While Parity is mentioned once in the comments, they reveal a desire to find post-attack ratios that favor the Defender, a numerical advantage, and a desire to retain a substantial ICBM force. In all three periods of gameplay this player committed at least 50% of the warhead total to the ICBM force.

"approaches parity in post-strike forces 500: very favorable post-strike ratio 300: favorable post-strike balance…number of subs relatively low impact on ratio" Did you find any combinations an adversary might consider especially vulnerable? "Large reductions in ICBMs…0 ICBMs"

P25: This player was one of two mentioned above that was borderline Minimum Deterrence at T2. P25 traveled to Minimum Deterrence, which is consistent with analysis of comments and gameplay. The comments indicate the player has modest goals regarding relative post-attack ratios. The emphasis is on minimizing a disadvantage, not maximizing an advantage.

"maintains relative parity…lowest disadvantage to defender…relative parity at low number…difficult to reach a lower disadvantage for the defender at these numbers"

P28: This player was also one of two mentioned above that was borderline Minimum Deterrence at T2. Adoption of Minimum Deterrence is strongly supported by gameplay choices
and comments. In gameplay, this player was comfortable with Monad force structures at 500 and 300. While many other players unwittingly used Monads, this player did so deliberately and was the only player to explicitly declare smaller arsenals more advantageous. These characteristics are all consistent with a Minimum Deterrence perspective.

"I find it interesting that the attacker's advantage narrowed so quickly at lower levels. Actually, I take this as an advantage of the lower level over the higher level. An adversary might find this structure vulnerable, but I believe not"

P38: With the exceptions of this player's strong use of ICBM forces during gameplay at 500 and 300 and focus on numbers over qualitative issues in the comments, neither gameplay choices nor comments well explained the transition to Parity.

"Balanced yet survivable…Retains high retaliatory strike capability…Balanced approach…Seems to be a wash for both sides…Subs provided the highest survivability…The probability of kill on ICBM targets had a huge impact…At lower number of warheads, survivability is key…I increased the probability of kill due to tech benefits over time…This took away from the ICBM survivability…Placing all the warhead on subs made them survivable in the scenario, but also places all the 'eggs' in one basket making them the highest priority target"

As summarized in Table 5.12, analysis of gameplay choices and comments provided some insight into rationale of 10 of 16 players that changed frameworks. The data were insufficient to make conclusions regarding the other six players.

<table>
<thead>
<tr>
<th>Destination Framework</th>
<th>Explanatory Power</th>
<th>P25, P28</th>
<th>P3</th>
<th>P37, P35</th>
<th>P23, P33, P34, P38</th>
<th>P8, P13, P29, P36</th>
<th>P39</th>
<th>P1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Deterrence</td>
<td>Strong*</td>
<td></td>
<td></td>
<td>Present**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Superiority</td>
<td>P4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qualitative Edge</td>
<td>P25, P28</td>
<td>P3</td>
<td>P3</td>
<td>P37, P35</td>
<td>P23, P33, P34, P38</td>
<td>P8, P13, P29, P36</td>
<td>P39</td>
<td>P1</td>
</tr>
<tr>
<td>Total</td>
<td>7</td>
<td>3</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Strong: Direct statements in comments or clear gameplay choices related to the movement
**Present: Comments and gameplay choices could be interpreted to explain movement.
***Ambiguous: Comments and gameplay choices were contradictory, uninformative, or absent
Summary

There was significant change in player preferences following the intervention. Those manifest primarily in responses to survey questions and comments during gameplay. The gameplay choices of many players reveal a tendency to select what I classified as "nonstandard" options, meaning the actual capabilities of the choices do not reflect intended capabilities. This is most apparent in the number of players choosing a Triad as their strategy. Finally, data indicates that not only do many players change preferences; they also change the conceptual framework they used to analyze nuclear weapons issues.
Chapter 6

Conclusions and Recommendations

The United States and Russia have periodically taken steps to reduce the size of their nuclear arsenals. The role of nuclear weapons in providing for our security has been deemphasized (DoD, 2010, Welch, 2008). The security environment and technologies have changed dramatically since the early 1960s, when nuclear arsenals were last this small. The debate, in public, and among policymakers is focused on arsenal size, with the goal of further reductions (Cartwright et al., 2012; Chalmers, 2012; Forsyth et al., 2010; Obama, 2009; Pifer, 2013)

Military strategists and policymakers have preferences regarding nuclear weapons issues that are influenced by experience. They now have fewer opportunities to learn through direct experience with nuclear weapons (Senate hearing, 2008; Schlesinger, 2008). This leaves them vulnerable to reliance on legacy constructs and assumptions and there are reasons to question the applicability of Cold War constructs and assumptions to our contemporary problem sets. If their experience is inadequate, how confident should we be in their policy preferences? How confident should they be in the soundness of their preferences and the policies they develop? Traditional methods of supplementing experience remain valuable, but new methods of could improve comprehension and intuition among military strategists and policymakers.

To explore this issue, I developed two research questions. "How do individual participant preferences change when given a tool to evaluate those preferences within a specified framework for analysis?" and "How much commonality exists among changes in participant preferences and what explains this?" To answer these questions, I designed a quasi-experiment in the form of a policy exercise game with a web-based digital nuclear exchange model. I enlisted forty-one
personnel, all very knowledgeable of nuclear weapons issues to participate in one of eight data collection sessions.

The results indicated that individual preferences changed and there was some commonality in across participants. Quantitative analysis of survey responses demonstrated significant absolute change in individual preferences. With the exception of one survey question, this absolute change was not in a common direction indicating participants drew different conclusions from the similar experience. Qualitative analysis of player comments confirmed $T_2$ preferences and provided clues into player insights and motivation. There was evidence that a significant number of players changed the conceptual framework they used to analyze nuclear weapons issues. Change was not to a common framework, but from the margins to the center.

The policy exercise was intended to encourage participants to examine their perspectives regarding a narrow, but classic, nuclear weapons challenge. It was neither designed to encourage participants to reach similar conclusions, nor be generalizable to other nuclear weapons challenges. The results lead to conclusions about the perceptions nuclear weapons experts have regarding conceptual frameworks they use to understand this specific nuclear weapons challenge, value of the ICBM, and viability of the Triad. Based on these conclusions, I offer recommendations for use of policy exercise methodology, future research, and nuclear weapons policy to improve our security and lessen pressure on the federal defense budget.

Conclusions

The data clearly showed changes in participant preferences and conceptual frameworks. There was some commonality across participants' force structure choices, but evaluation of those choices caution against having confidence in the prescriptions of these experts.
**Impermanence of Conceptual Frameworks.** "People construe or represent the environment along a continuum from abstractly to concretely" (Alter et al., 2010, p. 437). Frameworks are used to categorize familiar information and find like-situations when confronted with something new. Heuristics and intuition are mechanisms that operate within these frameworks (Evans, 2013; Kahneman & Klein, 2009; Vosniadou, 2014). I identified four nuclear weapons specific frameworks used by participants to contextualize complex nuclear weapons problems. Those frameworks were:

1. **Minimum Deterrence:** A small fixed number of warheads is sufficient to generate deterrence regardless of the size of the adversary arsenal.

2. **Superiority:** The United States arsenal should be larger than Russia's arsenal.

3. **Parity:** The United States arsenal should be roughly equal in size to Russia's arsenal.

4. **Qualitative Edge:** The United States arsenal should be of higher quality or better capability than Russia's arsenal.

In the context of this research, Minimum Deterrence and Superiority were near opposites, or the extremes. The first preferring a small arsenal and the second an arsenal larger than the adversary's. Parity and Qualitative Edge are located somewhere in the center.

Survey questions 5-7 were the primary sources of data for association of players with frameworks. Analysis of responses to those questions indicated statistically significant levels of change at T2. That translated to 40% of the participants adopting a new framework following the policy exercise. Participants did not move to a common destination, but did, in general, move from the extremes of Minimum Deterrence and Superiority to the center of Parity or Qualitative Edge. This movement may well be understated in the results as the association of two players to frameworks came down to one very minor distinction. Analysis of gameplay choices and player
comments confirmed the frameworks held at T2 and provided insight into player rationale, which indicate learning during the policy exercise. There are several potential explanations for the lack of a common destination in movement across the participants.

First, is the design of the quasi-experiment itself. The intervention was not designed to prompt or nudge participants in a particular direction. Players were given maximum flexibility to pursue strategies consistent with their interpretation of the objectives. The design was numbers-centric. They were not explicitly told to "maximize" surviving warheads or reach a specific target, but left to define success themselves. Given such latitude, there were likely different interpretations and goals across players and diversity in player strategies. Said another way, "…meaning is in the eye of the beholder" (Harteveld, 2011, p. 56).

Second, it could be that the realm of nuclear weapons is inhabited by experts who think in differing manners. The group could contain both Hedgehogs that "knew one big thing and sought...to expand the explanatory power of that big thing to 'cover' new cases" and Foxes that "knew many things and were content to improvise ad hoc solutions" (Tetlock, 2005, p. 21, emphasis mine). The nuclear culture could be predominately populated by experts who have more depth of knowledge than breadth. Such Hedgehogs resist changing their policy preferences when given new or conflicting data. Instead, they reinterpret the data to conform to their perspective or modify the definition of their construct to allow inclusion in the existing framework. Those players who had more breadth than depth of knowledge, may be have been open to both changing preferences and taking risk. There is little reason to suppose change across these Foxes would be to a similar destination.
My first conclusion:

1. The preferences of and conceptual frameworks used by nuclear weapons experts are not fixed and can be influenced by participation in a policy exercise.

**Confidence in the Frameworks of Experts.** Following that conclusion, one can question whether military strategists and policymakers have the proper understanding and intuition when entering into an analysis of nuclear weapons issues. Recalling Rumsfeld (2004), "As you know, you go to war with the Army you have. They’re not the Army you might want or wish to have at a later time" (para. 28). The same is true for those that shape policy. They make decisions based on current knowledge and the conceptual constructs they hold at the time of decision.

Participants made recommendations based on their internalized framework at $T_1$, yet 40% had adopted a new framework at $T_2$. Would they not have wanted to use the new framework at $T_1$ if possible? Tetlock (2005) points out, "Correspondence theories of truth identify good judgment with goodness of fit between our external mental representations and corresponding properties of the external world (p. 10). This research indicates that "goodness of fit" may be lacking. Thus, I also conclude:

2. A substantial percentage of personnel who currently work on nuclear weapons issues use a misperceived conceptual framework to support their decision-making.

**Discounting of the ICBM.** The third conclusion derives from how the force structure choices of participants changed and is based on the analysis of survey data from questions 12 and 13. In Q12, participants responded to a proposition that the ICBM decreased in value as arsenals got smaller. This conjecture is consistent with conventional wisdom in the public debate (Cartwright et al., 2012; Friedman et al., 2013). Following the policy exercise, players did not agree with the conventional wisdom. At $T_2$, 78% changed their preferences and the net
movement across players was strongly directional with 62% selecting *Strongly Disagree/Disagree* that ICBM had a diminishing value. In Q13, 43% increased the value they place on the ICBM. The change from T₁ to T₂ indicates that nuclear weapons experts did not successfully predict the value they would place on the ICBM in small arsenal constructs. This discounting of ICBM value could lead to poor strategy and budget decisions. My third conclusion:

3. Personnel knowledgeable of nuclear weapons issues underestimate the value of the ICBM as a force structure element of small nuclear arsenals.

**Perceived Force Structure Transition Points.** The Triad of ICBM, SSBN, and bombers has been the force structure construct since the early 1960s. Its complementary, or even synergistic, traits are touted as its enduring contribution. The data revealed that players preferred to retain the Triad as arsenal size decreases. As a group, players' perceptions were to favor the Triad in Scenario One (1000 warheads). In Scenario Two (500 warheads), the Triad faded, but was a close second behind the Dyad. At some small arsenal size the Triad will become infeasible for cost reasons or perhaps unnecessary (Friedman et al., 2013). There is no common understanding of where that inflection point is. This research reveals the arsenal level at which experts no longer think the Triad viable. I conclude:

4. Nuclear weapons professionals perceive the proper place for a transition in force structure from the Triad to a Dyad is between arsenals of 1000 and 500 warheads.

**Limitations**

There are several limitations with this research project. The sample of \( n = 40 \) experts on nuclear weapons issues is not insignificant relative to the population, albeit a population of unknown size. But the sample size did limit the applicability of parametric statistical techniques.
The use of both in-person and online data collection raises questions regarding potential influence of group dynamics present in the former and not the latter. The intervention sessions had little extra time built in to absorb delays. As a result, the player reflection time was hurried during several sessions. This may have dampened player change by limiting real-time learning.

The small number of survey questions did not provide detailed insight into player perspectives from which the frameworks were determined. Based on the results of this research, the survey questions could be improved to provide more fidelity.

The web-based digital tool was programmed to save data only when the player made a final selection. It captured player decisions, not player decision making. Players interacted with the tool differently. Capturing the strategies players explored, but did not select, would have provided insight into how players approached the problem (i.e., their game strategy). This would provide increased confidence in assessing that player choices reflected player intentions.

The digital artifact and structure of the game focused on arsenal size and post-attack Defender-Attacker warhead ratios. While valid to explore player perspectives related to the contemporary debate, different results and insights might emerge if the game were more explicitly linked to adversary decision making.

This research addressed a narrow, but critical slice of the nuclear deterrence problem set. Expansion to include potential adversaries beyond Russia, potential alliances (allied and adversary), potential escalation from conventional to nuclear use in a regional conflict would all be of value.

**Recommendations**

**The Policy Exercise.** Use of legacy methods and tools such as operations research, game theory, and wargaming will continue to prove valuable for analyzing nuclear weapons issues, but
modern gaming techniques offer much promise. They can be interactive on a personal level and iterative. Both are infeasible with commonly used wargaming techniques, which are focused on group decisions and single outcomes. They can be more affordable than wargames, which are traditionally large and require extensive support structures. As nuclear arsenals get smaller and nuclear experience thinner and harder to acquire, gaming provides a viable method to offset a lack of direct experience. “Policy exercises allow people to discover and solve many potential problems without spending large amounts of money, time, and other resource” (Tsuchiya & Tsuchiya, 2000, p. 516).

This research employed a simple version of a policy exercise informed by tenets of Triadic Game Design to collect data, engage players, and produce change. This tailored game construct was specifically designed to facilitate learning about a complex problem with many interdependent factors and provide better data on what and how nuclear weapons experts think. The policy exercise technique could provide all nuclear weapons experts the opportunity to deconstruct or diminish their individual illusion of explanatory depth. My first recommendation is that:

1. The DoD should develop and maintain the capability to create and employ serious games such as the policy exercise and integrate these techniques with legacy methods.

Specifically, the DoD should use a policy exercise similar to the one employed here as part of a long-term effort to improve the insights and intuition of personnel dealing with nuclear weapons issues. This could be accomplished using an initial 90-minute in-person session with a small group of 15 personnel. To ensure diversity in experience of participants, they could be purposefully selected; one deputy assistant secretary, two principal directors, two military flag officers, four O-6 level military officers or civilians, and six mid-level military officers or
civilians. Gameplay should incorporate periods for players to discuss their choices and reflect on the experience. This could be followed with one or two 45-minute individual online sessions using an interactive digital artifact to explore additional aspects of the nuclear weapons problem set. Analysis of data from those sessions should then be used to inform design of wargames and serve as topics for facilitated discussion among larger groups. Such a program would provide experience unlike that available elsewhere.

**Future Research.** This project confirms the general practicality and value of conducting research *through* games. The focus of this research was confined to a narrow aspect of nuclear deterrence. Further research should include other aspects such as the effect of Russian numerical superiority in non-strategic nuclear weapons on Russian decision-making, explicit introduction of new technologies such as missile defense or anti-submarine warfare, implications of alliances, and \( n \)=player situations.

**Misperception of Force Structure Transition Points.** The data revealed a force structure issue requiring further research. Gaming could serve as a major component for that research. As stated above, the data suggest that somewhere between arsenals of 1000 warheads and 500 warheads experts think a transition from the Triad to a Dyad is warranted. Under New START, the arsenal will be limited to 1550 warheads by 2018. From a cursory look at the data, one could infer that analysis of the transition from the Triad is not necessary until a decision to pursue a reduction below 1000 warheads. Such a conclusion would be misguided as it based on data reflecting players' perceptions under *Loose* evaluation criteria.

I established *Strict* evaluation criteria to analyze player force structure choices. Those criteria identify as *nonstandard* the player choices that were either infeasible or contrary to historical rates or values. Applying the strict evaluation criteria to player force structure choices
revealed that players’ perceptions did not match outcomes. Actual force structure choices were predominantly of Dyads, 70% at 1000 warheads, 60% at 500 warheads, and 50% at 300 warheads. Employment of the Triad was only 23%, 18%, and 0 at the same warhead levels. That leads one to suspect the actual expected force structure transition point lies somewhere between the current New START arsenal of 1550 and any lower number, not between 1000 and 500. The President has already stated an ability to further reduce the arsenal by 30% (i.e., transition to a 1000 warhead arsenal), but this research suggests nuclear experts have misperceptions regarding the viability of the Triad at levels above 1000 warheads. This research does not identify that inflection point, therefore my second recommendation is:

2. The DoD should start a multidisciplinary research program to determine force structure transition points across several potential futures.

This should include analysis using nuclear exchange models to assess counterforce targeting aspects, but emphasis should be on the ability of a weapons system to provide attributes such as survivability, responsiveness, and flexibility and perceived value of those attributes should be analyzed across potential futures. Methods to understand the effect various force structures and force postures have on adversary decision-making in different potential futures should also be pursued.

**Nuclear Weapons Policy.** Recommendations for policy emerge from analysis of the misperceptions held by nuclear weapons experts. These misperceptions are internalized, hidden from self-assessment. They inform the intuition of policymakers and affect policy and strategic choices. When based on experience, it is experience with large nuclear arsenals, not small arsenals that is drawn upon.
The Future of Deterrence is not Punishment. The latent threat of retaliation has generally been understood to be the primary method of deterring (Delpech, 2012; Kissinger, 1957; Schelling, 1966). Within the Triad, that retaliation is often associated with the SSBN, which remains hidden at sea to survive an attack and provide the potential second strike. It is true that the cost to attack the SSBN fleet is too high to seriously contemplate, because when they are hidden at sea they cannot be targeted. But, if SSBN locations became known, the cost to attack would drop precipitously. The current ICBM force does not share these characteristics. The ICBM retains a constant high cost to attack by the nature of its deployment; it cannot become "unhidden" and profitable to attack. Thus the SSBN is primarily considered a retaliation capability and the ICBM a warfighting or first strike capability. However, in the context of small nuclear arsenals the ICBM provides increased value in deterring through denial, not threat of punishment. Low arsenal sizes have made the ICBM too costly to attack. The implications of this are underappreciated. Current guidance is to include denial and incentives in our deterrence framework and operational planning (DoD, 2006), but this is inadequate. DoD must go a step further and reprioritize deterrence priorities. My final recommendation is:

3. The DoD should reorient its deterrence strategy and operations to emphasize deterrence by denial over deterrence through threat of punishment for small arsenals.

Summary

This research focused on the preferences of experts regarding a narrow subset of the deterrence problem set. It demonstrated that participation in a tailored policy exercise game could result in a change in their preferences and even their conceptual frameworks. Results reveal that many experts use a misperceived framework when analyzing nuclear weapons issues. They undervalue the ICBM in small arsenals and misidentify the point of suitable transition from
the Triad to a Dyad. The misperceptions of experts have implications to national security & budget priorities.

Based on the conclusions, I recommend DoD adopt the policy exercise methodology for use in addition to its current methods of providing experiential learning and analyzing complex problems. The DoD should also study potential Triad-to-Dyad transition points, which may be higher than previously thought. Additionally, The DoD should emphasize denial over threat of punishment in nuclear deterrence strategy and operations. I also recommend additional research using these methods to explore other aspects of the deterrence problem set and force structure issues at low numbers to further understand how Less is not just less, *Less is Different.*
Endnotes

1 This is an inverse of the concept presented by Anderson (1972) "More is Different." In that article he described how characteristics, indeed natural laws, can emerge from mass and complex diversity. If there can be emergence, then surely those characteristics must dissipate if the mass or complexity which initially created them is removed. Thus, in a world of emergents, less is also different.

2 "Strategic stability should be understood to mean a situation in which no party has an incentive to use nuclear weapons save for vindication of its vital interests in extreme circumstances" (Colby, 2013, p55).

3 In this group I include uniformed and civilian military personnel and civilian government officials with direct responsibility for an aspect of the safety, security, and effectiveness of U.S. nuclear capabilities.

4 The early Cold War years were without advanced computing, satellite, and other capabilities useful in early detection of attack that could minimize the success of a first strike.

5 The current nuclear warhead stockpile is a 78 percent reduction from late 1989 when the Berlin Wall fell.

6 More on Chatham House Rule can be found at: http://www.chathamhouse.org/about/chatham-house-rule#sthash.RxrRjp7u.dpuf

7 Several players disregarded these protections and used their actual names or created user names identifiable by me. None of the participants expressed concern regarding a need for or desire for confidentiality. The subject matter was considered non-threatening.
References


Appendix A: Participant Solicitation emails

Attachment 5: Alternative recruitment email for DCO online session

From: hustus.h@husky.neu.edu

SUBJ: Request for participation in research project on nuclear arsenals

Dear [insert name of adult known contact],

As you know, [As Mr XXX, XXXX, has indicated – for those I send this email to who were recommended by a common colleague] I work on nuclear weapons issues for the U.S. Air Force. I am also pursuing a Doctor of Law and Policy degree from Northeastern University’s College of Professional Studies. My capstone research project aims to discover the perceived value of nuclear weapons delivery systems at various arsenal sizes. This project, as well as this email, is neither an official USAF nor U.S. government activity or correspondence. I am contacting you in a personal capacity.

I’m looking for people who work with nuclear weapons issues to participate in a small-group facilitated session involving survey questions and use of a web-based computer tool to analyze force structures at several nominal arsenal sizes. I’m seeking participation from national government employees, universities, think tanks, contractors, and some organizations outside the United States. All participants must be over 18 years of age.

I’d appreciate your participation and ask that you invite colleagues to participate as well. My goal is to get 20 individuals to participate in a single session lasting approximately 90 minutes. I’d like to hold this session using Defense Connect Online (DCO). During the session, participants need individual access to DCO via a tablet, laptop, or desktop computer. I plan to record the session using DCO capabilities, but will download that data promptly to protect confidentiality. Outside your DCO login, I will not collect personally identifiable information and the session will be conducted under Chatham House Rules (i.e., participants are free to use the information received, but neither the identity nor the affiliation of the speaker(s), nor that of any other participant, may be revealed)

The participation of you and your colleagues is entirely voluntary.

Please let me know if you and you colleagues are interested in participating or would like more information. You can reach me by email or telephone.
Appendix B: Unsigned Consent Form

Attachment 3: Online Consent Form

Northeastern University, Department of: Law and Policy
Name of Investigators: Principal Investigator: Dr Casper Hartevedt
Student Researcher: Hunter Hustus
Title of Project: Nuclear Arsenals at Low Numbers: When Less is Different

Request to Participate in Research

Thank you for your interest in my research. We would like to invite you to participate in a session designed to analyze nuclear force structures at various arsenal sizes. The session includes online responses to survey questions and use of a computer tool. The survey questions should take about 15 minutes to complete and the analysis of nuclear arsenals using the computer tool should take about 50 minutes. The complete session should take about 90 minutes.

I hope you’re participating in this study because you are interested in nuclear weapon policy. Your participation could improve our understanding of how we can maintain strategic deterrence in differing future conditions. You must be at least 18 years old to participate.

The decision to participate in this research project is voluntary. You do not have to participate and you can refuse to answer any question. Even if you begin the web-based online survey, you can stop at any time.

There are no foreseeable risks or discomforts to you for taking part in this study.

There are no direct benefits to you from participating in this study. However, your responses may help us learn more about nuclear weapons force structures at small arsenal sizes.

You will not be paid for your participation in this study.

Your part in this study will be kept confidential. However, because of the nature of web-based activity, it is possible that respondents could be identified by the IP address or other electronic record associated with the response. Neither the researcher nor anyone involved with this survey will be capturing those data. Any reports or publications based on this research will use only group data and will not identify you or any individual as being affiliated with this project.

If you have any questions regarding electronic privacy, please feel free to contact Mark Nardone, NU's Director of Information Security via phone at 617-373-7601, or via email at privacy@neu.edu.

If you have any questions about this study, please feel free to contact Hunter Hustus at 202-701-3318 or hustus.h@husky.neu.edu, the person mainly responsible for the research. You can also contact Dr Casper Hartevedt at 617-373-4027 or at c.hartevedt@neu.edu, the Principal Investigator.

If you have any questions regarding your rights as a research participant, please contact Nan C. Regina, Director, Human Subject Research Protection, 900 Renaissance Park, Northeastern University, Boston, MA 02115. Tel: 617-373-4598. Email: n.regina@neu.edu. You may call anonymously if you wish.

This study has been reviewed and approved by the Northeastern University Institutional Review Board (IRB). [Protocol # will be provided to you by the IRB office].

By clicking on the I Agree button below you are indicating that you consent to participate in this study. Please save or print a copy of this consent form for your records.

Thank you for your time.
Hunter Hustus

Hustus  Cohort VII

APPROVED

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12
Appendix C – Survey Questions

Survey Questions (the second survey was identical with the exception of elimination of Questions 1-4).

First, enter a username (required).

1. What is your age?
   [18 to 24 years, 25 to 34 years, 35 to 44 years, 45 to 54 years, 55 to 64 years, 65 or older]

2. How often do you spend time on issues related to nuclear weapons?
   [Never, Monthly, Weekly, Daily]

3. Which of the following best describes your current position or employment?
   [Federal Government, Contractor, Think Tank, Student, University, Non-Governmental or Internal Organization, Other]

4. Which of the following best describes the national or international affiliation of your position or employment?
   [United States, NATO - other than the United States, ASEAN - other than the United States, OAS - other than the United States, Other]

5. There is a number of nuclear weapons sufficient to deter adversaries, regardless of the number of nuclear weapons they possess. Beyond that number, additional weapons provide little or no additional benefit.
   [Strongly Disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree]

6. To maintain strategic stability, the U.S. nuclear arsenal does not have to be superior in number to Russia’s nuclear arsenal.
   [Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree]

7. To maintain strategic stability, the U.S. nuclear arsenal does not have to be at least equal in number to Russia’s nuclear arsenal.
   [Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree]

8. The number of nuclear weapons possessed by a potential adversary is irrelevant to determining the appropriate size of the U.S. nuclear arsenal.
   [Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree]

9. The submarine-launched ballistic missile fleet (SSBN) is the most survivable of U.S. nuclear forces.
   [Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree]

10. Survivability is the most important attribute for a nuclear weapons system.
    [Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree]
11. The submarine-launched ballistic missile fleet (SSBN) is the **most valuable** component of U.S. nuclear forces.  
[Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree]

12. The value of the land-based intercontinental ballistic missile (ICBM) force **diminishes as arsenal size decreases**.  
[Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree]

13. In the five nuclear arsenals below, U.S. nuclear arsenal strategy should...
Appendix D Additional Data and Analysis

Table D.1. Data from Questions 5-8 at T₁ and T₂ Including Change and Absolute Change

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Table D.4. Paired Samples Test: Questions 9-11 Indicating Lack of Statistical Significance

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Key:

1. "Prioritize SSBN over ICBM", "Consist of a Triad (three delivery systems)", "Retain SSBN", "Retain ICBM", "Retain Bombers"
2. "Prioritize ICBM over SSBN", "Consist of a Triad (three delivery systems)", "Retain SSBN", "Retain ICBM", "Retain Bombers"
3. "Prioritize SSBN over ICBM", "Consist of a Dyad (two delivery systems)", "Retain SSBN", "Retain ICBM"
4. "Prioritize ICBM over SSBN", "Consist of a Dyad (two delivery systems)", "Retain SSBN", "Retain ICBM"
5. "Prioritize SSBN over ICBM", "Consist of a Dyad (two delivery systems)", "Retain SSBN", "Retain Bombers"
6. "Prioritize ICBM over SSBN", "Consist of a Dyad (two delivery systems)", "Retain ICBM", "Retain Bombers"
7. "Prioritize SSBN over ICBM", "Consist of a Monad (one delivery system)", "Retain SSBN"
8. "Prioritize ICBM over SSBN", "Consist of a Monad (one delivery system)", "Retain ICBM"
9. "Consist of a Monad (one delivery system)", "Retain Bombers"
| Player | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 |
|--------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 1000 Loose | 2 | 6 | 2 | 4 | 2 | 2 | 4 | 1 | 3 | 3 | 3 | 1 | 1 | 1 | 2 | 3 | 2 | 2 | 6 | 2 | 2 | 4 | 2 | 2 | 4 | 1 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 2 | 3 | 2 | 2 |
| 1000 Strict | 2 | 6 | 2 | 4 | 4 | 4 | 4 | 6 | 3 | 3 | 3 | 3 | 1 | 3 | 4 | 4 | 2 | 1 | 1 | 4 | 3 | 3 | 3 | 3 | 3 | 8 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 6 | 4 | 3 | 2 | 3 |
| 500 Loose | 2 | 6 | 2 | 4 | 6 | 4 | 8 | 4 | 2 | 3 | 3 | 4 | 3 | 1 | 1 | 3 | 2 | 3 | 1 | 2 | 2 | 6 | 2 | 4 | 6 | 4 | 8 | 4 | 2 | 3 | 3 | 4 | 3 | 1 | 1 | 3 | 2 | 3 | 1 | 2 |
| 500 Strict | 8 | 6 | 2 | 8 | 6 | 8 | 8 | 3 | 8 | 3 | 3 | 3 | 4 | 3 | 3 | 4 | 8 | 6 | 1 | 3 | 3 | 3 | 1 | 7 | 5 | 7 | 7 | 4 | 2 | 2 | 3 | 5 | 2 | 1 | 1 | 3 | 8 | 3 | 1 | 4 |
| 300 Loose | 8 | 4 | 5 | 4 | 8 | 8 | 3 | 3 | 2 | 3 | 3 | 5 | 5 | 5 | 5 | 8 | 1 | 3 | 3 | 4 | 8 | 4 | 5 | 4 | 8 | 8 | 3 | 3 | 2 | 3 | 3 | 5 | 5 | 5 | 3 | 8 | 1 | 3 | 3 | 4 |
| 300 Strict | 8 | 4 | 5 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 4 | 6 | 6 | 5 | 5 | 3 | 7 | 7 | 7 | 6 | 5 | 7 | 8 | 4 | 6 | 3 | 5 | 5 | 5 | 8 | 8 | 4 | 8 | 8 | 4 |

Key:
1. "Prioritize SSBN over ICBM", "Consist of a Triad (three delivery systems)", "Retain SSBN", "Retain ICBM", "Retain Bombers"
2. "Prioritize ICBM over SSBN", "Consist of a Triad (three delivery systems)", "Retain SSBN", "Retain ICBM", "Retain Bombers"
3. "Prioritize SSBN over ICBM", "Consist of a Dyad (two delivery systems)", "Retain SSBN", "Retain ICBM"
4. "Prioritize ICBM over SSBN", "Consist of a Dyad (two delivery systems)", "Retain SSBN", "Retain ICBM"
5. "Prioritize SSBN over ICBM", "Consist of a Dyad (two delivery systems)", "Retain SSBN", "Retain Bombers"
6. "Prioritize ICBM over SSBN", "Consist of a Dyad (two delivery systems)", "Retain ICBM", "Retain Bombers"
7. "Prioritize SSBN over ICBM", "Consist of a Monad (one delivery system)", "Retain SSBN"
8. "Prioritize ICBM over SSBN", "Consist of a Monad (one delivery system)", "Retain ICBM"
9. "Consist of a Monad (one delivery system)", "Retain Bombers"