Gaming Undergoverned Spaces: Emerging Approaches for Complex National Security Policy Problems

Chapter Nineteen

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Games have long been an important part of defense analysis that are used to understand new strategic and operational problems, develop strategies and concepts, and assess the potential shortcomings of plans. The ability of games to help policy professionals explore the key elements of new problems and the relationship between them makes them a highly effective tool to help decisionmakers make sense of undergoverned spaces (UGS). However, existing approaches to games for doing research and analysis tend to fall short, either by exhibiting the same types of pathologies as modeling and simulation efforts or by failing to generate credible information to systematically advance understanding. In this chapter, we explore the potential value of gaming in policymaking for UGS, describe two common failure modes, and offer several approaches for improving games to explore these spaces. We conclude the chapter by offering a vision for a new game concept—a contest arena—which combines advances in several areas that could improve the ability of games to inform adaptive planning in UGS.

Overview of Gaming

The U.S. Department of Defense (DoD) defines a *wargame* as the "representation of conflict or competition in a synthetic environment, in which people make decisions and respond to the consequences of those decisions."[1] In practice, various terms have been used to describe

[1] Joint Publication 5-0, *Joint Planning*, Washington, D.C.: U.S. Joint Chiefs of Staff, 2017, p. V-31.

events that fit this broad definition,[2] and different games for different purposes can look quite different from one another. Yet most games still leverage the same basic elements of *actors* represented by human players making *decisions* in a complex policy *environment* using a set of *rules* to determine what actions they can take and what the impacts of those actions are on themselves, other actors, and the environment. These elements combine to create tools that focus on human decisionmaking, particularly in group settings and in competition with other players over time, which provide a critical opportunity to observe strategic decisionmaking processes and outcomes.

Games are used by a wide variety of policy professionals. Ever since the Prussian army began using wargames for training in the 19th century, gaming has been used by major militaries for military planning, concept development, training, and education.[3] Since at least the 1950s, games used to support defense and national security analysis have examined questions that extend far beyond force-on-force combat and address political, economic, social, information, and infrastructure decisionmaking.[4] Today, games are valued for their ability to foster innovation in the force,[5] support decisionmaking in complex contexts,[6] and bring stakeholders together to work on emerging and contentious issues.[7]

Gaming practitioners use two lenses to explain how games provide value to national security policy. The first lens treats games as an art form that produces an understanding about the stories told by national security professionals.[8] This group of gaming practitioners tends

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2 Common terms are *game*, *wargame*, *serious game*, *peace game, crisis game, crisis simulation, tabletop exercise*, *tabletop simulation*, and just plain *tabletop*.

3 Matthew B. Caffrey, Jr., *On Wargaming: How Wargames Have Shaped History and How They May Shape the Future*, Newport, R.I.: Naval War College Press, 2019, p. 20.

4 For discussion of early "political-military" games, see Elizabeth M. Bartels, *Building Better Games for National Security Policy Analysis: Towards a Social Scientific Approach*, dissertation, Pardee RAND Graduate School, Santa Monica, Calif.: RAND Corporation, RGSD-437, 2020, pp. 139–169; Sharon Ghamari-Tabrizi, "Simulating the Unthinkable: Gaming Future War in the 1950s and 1960s," *Social Studies of Science*, Vol. 30, No. 2, April 2000; and William M. Jones, *On the Adapting of Political-Military Games for Various Purposes*, Santa Monica, Calif.: RAND Corporation, N-2413-AF/A, 1986.

5 Robert Work and Paul Selva, "Revitalizing Wargaming Is Necessary to Be Prepared for Future Wars," *War on the Rocks*, December 8, 2015.

6 See Chapter Twelve (Paul K. Davis, "Toward an Analytic Architecture to Aid Adaptive Strategy for Competing in Undergoverned Spaces," in Aaron B. Frank and Elizabeth M. Bartels, eds., *Adaptive Engagement for Undergoverned Spaces: Concepts, Challenges, and Prospects for New Approaches,* Santa Monica, Calif.: RAND Corporation, RR-A1275-1, 2022).

7 See Chapter Thirteen (Robert J. Lempert, Kelly Klima, and Sara Turner, "Multi-Stakeholder Research and Analysis for Collective Action in Undergoverned Spaces," in Aaron B. Frank and Elizabeth M. Bartels, eds., *Adaptive Engagement for Undergoverned Spaces: Concepts, Challenges, and Prospects for New Approaches,* Santa Monica, Calif.: RAND Corporation, RR-A1275-1, 2022).

8 Ed McGrady, "Getting the Story Right About Wargaming," *War on the Rocks*, November 8, 2019; and Peter P. Perla and Ed McGrady, "Why Wargaming Works," *Naval War College Review*, Vol. 64, No. 3, Summer 2011.

to view games as a different type of research than scientific analysis, pointing to such traditions as artistic research as models for the process and goals of games-based research.[9]

The second lens treats games as a tool for data generation and analysis that is analogous to other forms of social scientific inquiry. Gaming practitioners with this perspective argue that the social sciences offer approaches to analyzing human behavior at the individual and group levels. Advocates for treating games as a science argue that applying social scientific standards from observational and experimental approaches to games helps align them with the approaches used by other national security policy tools. This can make gaming outputs more useful for research by making insights easier to integrate into broader studies using multiple methods and can make findings from a game more digestible to senior policymakers who are not directly involved in the game.[10]

Although the artistic approach to gaming has dominated the field to date (it is no accident that the best-known text in the field is titled *The Art of Wargaming*),[11] the prospect of science and technology investments to support engagements in UGS warrants consideration of how scientific approaches to gaming might be advanced given the prominence, and often uniqueness, of gaming as a research tool.[12]

One helpful way to contextualize the role of games in policy analysis and decision support is to examine how games fit into the broader universe of tools for policy research. Put differently, what types of questions are games well suited to inform? John Hanley has advanced a conceptualization of the relationship between research tool and question as a spectrum from statistical indeterminacy to structural indeterminacy, shown in Figure 19.1.[13] At the low end are problems that can be modeled using statistics because the issue is clearly defined with known measures, thus making precise data available across a large body of observations. At this end of the spectrum, the relationships between different concepts are known, as is the distribution of different conditions in the population. This level of knowledge is typically

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9 Artistic research as a model for the field of gaming is discussed briefly in Peter P. Perla, "The Art and Science of Wargaming to Innovate and Educate in an Era of Strategic Competition," King's College London Wargaming Network Lecture, London, United Kingdom, December 4, 2018; and more extensively in Sawyer Judge, *The Wargaming Guild: How the Nature of a Discipline Impacts Its Craft and Whether It Matters*, dissertation, Washington, D.C.: Georgetown University, 2019.

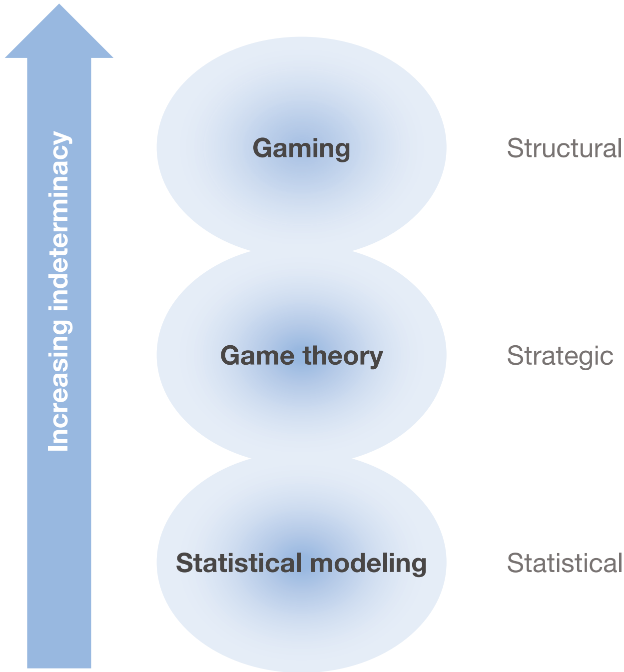
10 Bartels, 2020; and Jon Compton, "The Obstacles on the Road to Better Analytical Wargaming," *War on the Rocks*, October 9, 2019.

11 Peter P. Perla, *Peter Perla's the Art of Wargaming: A Guide for Professionals and Hobbyists*, 2nd ed., John Curry, ed., 2012.

12 See Chapter Five of this report (Gabrielle Tarini and Kelly Elizabeth Eusabi, "Adaptation, Complexity, and Long-Term Competition in UGS: Perspectives from Policymakers and Technologists," in Aaron B. Frank and Elizabeth M. Bartels, eds., *Adaptive Engagement for Undergoverned Spaces: Concepts, Challenges, and Prospects for New Approaches,* Santa Monica, Calif.: RAND Corporation, RR-A1275-1, 2022).

13 John T. Hanley, *On Wargaming*, dissertation, New Haven, Conn.: Yale University, 1991, pp. 14–19.

FIGURE 19.1
Spectrum of Analytical Tools



SOURCE: Adapted from briefings on wargaming by John T. Hanley, Jr. Used with permission.

associated with mathematical models based on empirical data.[14] Farther up the spectrum, problems are characterized by strategic indeterminacy, so game theory can be used.[15] At this point on the spectrum, the structure of the problem is known—the actors, their available choices, and their payoffs—and analysis allows an understanding of how behavior is likely to unfold. At the upper end of the spectrum is structural indeterminacy, which is when the key elements of the policy problem and how they relate to one another are not yet known. This is where games come into play.

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[14] For example, see Chapters Fourteen and Fifteen of this report (Zev Winkelman, "Using Technology to Improve the Agility of Force Generation Processes," in Aaron B. Frank and Elizabeth M. Bartels, eds., *Adaptive Engagement for Undergoverned Spaces: Concepts, Challenges, and Prospects for New Approaches,* Santa Monica, Calif.: RAND Corporation, RR-A1275-1, 2022; and Ben Connable, "Authentically Describing and Forecasting Human Behavior for Policy Analysis: A Review and a Path Forward," in Aaron B. Frank and Elizabeth M. Bartels, eds., *Adaptive Engagement for Undergoverned Spaces: Concepts, Challenges, and Prospects for New Approaches,* Santa Monica, Calif.: RAND Corporation, RR-A1275-1, 2022).

[15] See Chapter Seventeen (Justin Grana, "Difficulties in Analyzing Strategic Interaction: Quantifying Complexity," in Aaron B. Frank and Elizabeth M. Bartels, eds., *Adaptive Engagement for Undergoverned Spaces: Concepts, Challenges, and Prospects for New Approaches,* Santa Monica, Calif.: RAND Corporation, RR-A1275-1, 2022).

Many of the characteristics of UGS exhibit structural indeterminacy and thus are ripe for gaming. Among the most important features of UGS, from the perspective of indeterminacy, is the presence of multiple actors with divergent and often unknown interests, capabilities, and decisionmaking processes.

Traditional kinetic wargames usually feature two sides, who represent opposing militaries and make decisions about the conduct of attrition-based warfare. In turning from purely military problems to UGS, more decision centers are added. For example, the views of political decisionmakers, interagency perspectives from across government functions, the views of other nations, and the views of nongovernmental actors are all identified as key perspectives in UGS, and thus need to be represented in games examining these spaces. At the same time, the ability of these actors to make various decisions that interact and can be combined means that an actor's complete decision space is unknowable. This complexity means that decisions are rarely made with full information, about either the state of the environment or the objectives of different actors. This uncertainty presents theoretical and practical problems to game-theoretic exploration because the interactive structure of the game is not fully evident and the interactive state space cannot be fully explored using computational means.[16] Therefore, when compared with game-theoretic or statistical alternatives, gaming might be the best available tool for providing a broad look at interaction in UGS.

Gaming Undergoverned Spaces

As the frequent use of the term *wargame* suggests, much of the focus on analysis using games has centered on force-on-force kinetic warfare. However, there has also been a long history of games that are focused on UGS. Beginning in the 1950s, the RAND Corporation began experimenting with "political-military" games, work that was later extended by the Massachusetts Institute of Technology, Harvard University, and the Joint Staff's wargaming arm.[17] Many of these games focused on how a crisis might unfold in light of the emergence of nuclear weapons, and the focus of action was on political and psychological decisionmaking, not military attrition.[18] These games generally took the form of free-form or seminar-style games that were focused on expert interactions and shaped by a carefully written scenario.[19] Later itera-

[16] Grana, 2022.

[17] Rex Brynen, "Gaming the Nonkinetic," in Pat Harrigan and Matthew G. Kirschenbaum, eds., *Zones of Control: Perspectives on Wargaming*, Cambridge, Mass.: MIT Press, 2016.

[18] Reid B. C. Pauly, "Would U.S. Leaders Push the Button? Wargames and the Sources of Nuclear Restraint," *International Security*, Vol. 43, No. 2, Fall 2018.

[19] For descriptions of free-form political-military game design and scenario constructions, see H. A. DeWeerd, *A Contextual Approach to Scenario Construction*, Santa Monica, Calif.: RAND Corporation, P-5084, 1973; William M. Jones, *On Free-Form Gaming*, Santa Monica, Calif.: RAND Corporation, N-2322-RC, 1985; and Jones, 1986.

tions of these games focused on issues that are internal to U.S. bureaucratic decisionmaking, such as military command and control, and semicooperative issues, such as arms control.[20]

A second grouping of games focused on *limited wars*—that is, small-scale conflicts between great-power proxies that would play out in the undergoverned regions of postcolonial southeast Asia and war-ravaged eastern Europe. These games often used top-of-the-line computers to help model the conflict for players.[21] Games focused on UGS fell somewhat out of fashion in the aftermath of the Vietnam War, only to see a resurgence in the 1980s and 1990s, with the end of the Cold War and the rise of rogue states,[22] and another in the mid- to late 2000s, as the long wars in Iraq and Afghanistan focused attention on irregular warfare, postconflict reconstruction, and counterterrorism.[23]

In examining this history, two points become clear. The first is DoD's episodic interest in examining both competition in UGS specifically and non-attrition-based conflict more generally. This is a specific manifestation of a more general DoD tendency to treat UGS as marginal, as previously discussed in Chapter Three, by Adam R. Grissom, and Chapter Five, by Gabrielle Tarini and Kelly Elizabeth Eusebi.[24] This has prevented the advancement of gaming as both an art and a science in relation to such complex strategic challenges. Alternating periods of interest and neglect have created a tendency to reinvent the wheel rather than build on previous gaming work. Without a constant stream of work, researchers leave the field, informal documentation is destroyed, and tools are forgotten. When the next wave of interest in UGS appears, the previous generation of expertise and artifacts is difficult to access, and new gamers must progress without the benefit of many past lessons learned. As a result, there has been relatively little progress in how most games are designed, conducted, and analyzed. If a political scientist from 1950 was teleported to a basic research-design seminar today, the differences in fundamental approaches and tools would be immediate and obvious. In contrast, the gamers of the 1950s would generally be right at home in a contemporary game focused on UGS. Recent DoD interest in gaming offers the opportunity for a concerted effort to both build new tools and ensure that they are institutionalized so that future work can build on them.[25]

[20] For a particularly well-known example, see Marc Dean Millot, Roger Molander, and Peter A. Wilson, *"The Day After . . ." Study: Nuclear Proliferation in the Post-Cold War World*, Vol. I, *Summary Report*, Santa Monica, Calif.: RAND Corporation, MR-266-AF, 1993.

[21] Bartels, 2020, pp. 145–154; and Andrew Wilson, *The Bomb and the Computer*, London, United Kingdom: Barrie and Rockliff, 1968.

[22] Bartels, 2020, pp. 159–166.

[23] Brynen, 2016.

[24] Adam R. Grissom, "Undergoverned Spaces and the Challenges of Complex Infinite Competition," in Aaron B. Frank and Elizabeth M. Bartels, eds., *Adaptive Engagement for Undergoverned Spaces: Concepts, Challenges, and Prospects for New Approaches,* Santa Monica, Calif.: RAND Corporation, RR-A1275-1, 2022; and Tarini and Eusebi, 2022.

[25] Yuna Huh Wong and Garrett Heath, "Is the Department of Defense Making Enough Progress in Wargaming?" *War on the Rocks*, February 17, 2021.

The second point is that, when games about UGS are successfully attempted, two basic approaches are evident: one that tries to build formal game adjudication rules based on documented relationships between interacting factors that players can manipulate and a second that relies on the mental models and the expertise of players to supply the understanding of how different aspects of the game environment relate.[26] At least in part, the differences between these modes may be attributed to the researchers—for example, at RAND in the 1950s and 1960s, the model-driven approaches were generated by members of its mathematics and economics department, while the political-military games were generally produced by its social scientists.[27] Regardless of why, each approach has important strengths and limitations when applied to UGS and is worthy of detailed examination.

Approach 1: Games That Leverage Formal Modeling of Undergoverned Spaces

The first approach to game design attempts to build formal models that capture the dynamics of interdependent choices of military, social, economic, or political operations in UGS explicitly. In theory, this model then becomes the "game board" on which players make decisions and experience the modeled consequences of their choices. This approach often takes as its intellectual starting point the geographic maps, technical performance specifications, and detailed combat rule sets based on the standard practices of rigid, rule-based wargaming and seeks to build similar tools to capture social or nonkinetic phenomena (e.g., cyber effects and deception). However, the nature of UGS presents four immediate problems.

No Models Are Available

The structure of problems associated with UGS challenges game designers because many aspects of UGS are not well understood and have not been captured by parsimonious models that commonly form the foundation of physics-based game mechanics. The lack of compelling causal models has been noted as a limitation in games ranging from irregular warfare to operations in the information environment.[28] A common solution is to build models that are based on theory rather than empirical evidence, such as designing game adjudication models that are based on doctrine.[29] Although this approach might be appropriate for educational

[26] These approaches also parallel two 19th-century approaches to wargaming, *rigid kriegspiel* and *free kriegspiel*. See Perla, 2012, pp. 42–45.

[27] John R. Emery, "Moral Choices Without Moral Language: 1950s Political-Military Wargaming at the RAND Corporation," *Texas National Security Review*, Vol. 4, No. 4, Fall 2021.

[28] Brynen, 2016; and Christopher Paul, Yuna Huh Wong, and Elizabeth M. Bartels, *Opportunities for Including the Information Environment in U.S. Marine Corps Wargames*, Santa Monica, Calif.: RAND Corporation, RR-2997-USMC, 2020.

[29] Brynen, 2016.

purposes,[30] for research and analysis, it risks baking in behavioral assumptions that prevent the game from offering useful or new insights.

Available Models Are Too General or Too Specific

The second problem occurs when credible models are available but cannot be easily translated into game mechanics. Kinetic game rule sets are built with the assumption of generalizability. We can develop a probability that a tank unit will destroy an adversary tank unit that might be conditioned by a few simple factors (ratio of forces, terrain, etc.), which can be applied in many circumstances. However, when the types of social actions of interest in UGS are examined, the relevance of different factors, magnitudes, and even directions of effects can change depending on the specific context and might have a fair degree of uncertainty associated with them. For example, the influence of casualties on willingness to fight can be positive (a rally-around-the-flag effect) or negative (war weariness) depending on the specific population and context.[31]

As a result, social science models on UGS topics tend to be either highly general or highly specific to a particular case.[32] In the former situation, models might be too abstract to provide much of a basis for game rules. After all, the fact that casualties might influence the population to some degree and in some direction does not provide particularly helpful guidance in determining game outcomes under specific combinations of conditions. In the latter situation, game rules derived from the model are not very portable; thus, considerable effort is needed to repurpose them between games.[33] For example, a model of the effects of casualties in the United States during World War II is not likely to inform contemporary popular behavior. Projects can opt to spend time developing transferable models by compiling evidence from many cases and developing a generalizable model that is suitable to serve as a basis for game mechanics, but such efforts are a considerable undertaking that might be outside the scope of a gaming effort.[34]

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30 Elizabeth M. Bartels, "Inhabited Models and Irregular Warfare Games: An Approach to Educational and Analytical Gaming at the US Department of Defense," in Pat Harrigan and Matthew G. Kirschenbaum, eds., *Zones of Control: Perspectives on Wargaming*, Cambridge, Mass.: MIT Press, 2016.

31 Michael J. McNerney, Ben Connable, S. Rebecca Zimmerman, Natasha Lander, Marek N. Posard, Jasen J. Castillo, Dan Madden, Ilana Blum, Aaron Frank, Benjamin J. Fernandes, In Hyo Seol, Christopher Paul, and Andrew Parasiliti, *National Will to Fight: Why Some Nations Keep Fighting and Others Don't*, Santa Monica, Calif.: RAND Corporation, RR-2477-A, 2018.

32 For examples, see Ben Connable, Michael J. McNerney, William Marcellino, Aaron Frank, Henry Hargrove, Marek N. Posard, S. Rebecca Zimmerman, Natasha Lander, Jasen J. Castillo, and James Sladden, *Will to Fight: Analyzing, Modeling, and Simulating the Will to Fight of Military Units*, Santa Monica, Calif.: RAND Corporation, RR-2341-A, 2018; and McNerney et al., 2018.

33 Paul K. Davis and Angela O'Mahony, "Improving Social-Behavioral Modeling," in Paul K. Davis, Angela O'Mahony, and Jonathan Pfautz, eds., *Social-Behavioral Modeling for Complex Systems,* Hoboken, N.J.: John Wiley & Sons, 2019.

34 For examples of this approach, see Elizabeth M. Bartels, Christopher S. Chivvis, Adam R. Grissom, and Stacie L. Pettyjohn, *Conceptual Design for a Multiplayer Security Force Assistance Strategy Game*, Santa

There Is High Dimensionality of Interaction and Competition

The third problem with Approach 1 is that expanding from a focus on the military to address political, economic, social, information, and infrastructure concerns means that games for UGS have a dramatically wider scope than traditional wargames.[35] The need to cover multiple, interrelated topics is often referred to as the *problem of dimensionality*. Other chapters in this report have discussed several conceptual and technical challenges that are associated with developing and maintaining high-dimensional models of UGS, such as the demands of high-resolution modeling; disparate data; computational power; and the management of a federated infrastructure of dynamically changing models and submodels.[36]

Beyond the difficulty of managing such models, attempting to use them in support of games adds additional challenges. First, unless models are carefully designed to allow flexibility, it is often difficult to add options for players to take decisions that are not prespecified by the model's designers. If the model cannot be changed to incorporate player knowledge, the game offers few opportunities for the game designers to learn from the players and, thus, is of less value for research.[37] Players might also become frustrated if their desired action is not allowed, disincentivizing player engagement and biasing the results of the game.[38] A second challenge of high dimensionality models is that they often have complicated interfaces that require more time, patience, and expertise to learn than either designers or players possess.[39] Third, it can be difficult to understand how actions generate effects—that is, the underlying causal model can be opaque.[40] The model acts as a black box that produces results that either align with players' expectations—and, thus, are accepted as legitimate without adding to researchers' understanding of the problem—or do not align and are easily dismissed by players who cannot unpack the causal processes that are generating the results. High-dimensional models are difficult to build in the first place, and they are even more dif-

Monica, Calif.: RAND Corporation, RR-2850-AFRICOM, 2019; and Paul, Wong, and Bartels, 2020.

35 Susan Bryant and Tom Nagle, *Wargaming for the New Great Game*, West Point, N.Y.: Modern War Institute, April 30, 2021; and Yuna Huh Wong, "Irregular Warfare: The *Kobayashi Maru* of the Wargaming World," in Pat Harrigan and Matthew G. Kirschenbaum, eds., *Zones of Control: Perspectives on Wargaming*, Cambridge, Mass.: MIT Press, 2016.

36 In this report, see Chapters Twelve, Fourteen, Fifteen, and Sixteen (Davis, 2022; Winkelman, 2022; Connable, 2022; and Robert L. Axtell, "Short-Term Opportunities, Medium-Run Bottlenecks, and Long-Time Barriers to Progress in the Evolution of an Agent-Based Social Science," in Aaron B. Frank and Elizabeth M. Bartels, eds., *Adaptive Engagement for Undergoverned Spaces: Concepts, Challenges, and Prospects for New Approaches,* Santa Monica, Calif.: RAND Corporation, RR-A1275-1, 2022).

37 Such a system might be of more use in an educational context, in which the focus is more on communication flows from the designers to the players than on learning from the players.

38 Rex Brynen, "Virtual Paradox: How Digital War Has Reinvigorated Analogue Wargaming," *Digital War*, Vol. 1, No. 5, December 2020.

39 Christopher Dougherty, "It's Time to Rethink Our Wargames," *Inkstick*, May 13, 2020.

40 Brynen, 2020.

ficult to build in a way that allows meaningful player interaction without placing significant burdens on players and designers.

There Are Practical Limitations to Using Model-Adjudicated Games Successfully

The fourth problem with Approach 1 is the limited record of model-heavy games meeting players or sponsors' expectations. The rise of commercial computer games over the past 30 years has raised the bar of player expectations. The massive scale of commercial games allows studios to invest hundreds of millions of dollars in designing, marketing, and maintaining top-tier titles. Even games that serve as training platforms, which can be broadly used, tend to have budgets that are an order of magnitude smaller than those of top-tier commercial games. Games for research and analysis, which are less reusable, generally have substantially smaller budgets than training games. As a result, games that are built to conduct research and analysis cannot compete with the polish or sophistication of commercial titles. In some cases, such as photorealistic rendering, the gap might not be critical for the usefulness of the game. However, in other areas, such as human-computer interaction (HCI) and computational architecture, the resource gap can affect game design, conduct, and participation in meaningful ways.

Security and classification requirements limit the extent to which developments in commercial spaces can be leveraged in DoD-bespoke gaming products.[41] As a general rule, security concerns associated with national security work will increase the time and costs associated with development compared with an equivalent commercial application. Working through these problems requires time and often introduces considerable uncertainty into work schedules—something that is often unacceptable given the need to answer pressing policy problems in a timely manner. Each of these pitfalls can be mitigated to some extent, but doing so requires investing substantial time and money.

Taken together, model-based games both struggle to represent the true complexity of UGS and tend to decenter human players. This results in games in which the model is too complicated to be tractable, the model lacks empirical grounding, or the model creates barriers to game play.

Approach 2: Mental Models of Complexity with Free-Form Gaming

The alternative approach that is commonly used in games focused on UGS is to minimize the complexity of the game environment and rules by allowing most of the complexity to exist in the minds of players. This style of game, often called *seminar-style* or *free-form* gaming,[42]

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[41] Yuna Huh Wong, Sebastian Joon Bae, Elizabeth M. Bartels, and Benjamin Smith, *Next-Generation Wargaming for the U.S. Marine Corps: Recommended Courses of Action*, Santa Monica, Calif.: RAND Corporation, RR-2227-USMC, 2019, pp. 40–43.

[42] Jones, 1985.

has little in the way of explicit modeling or formal rules and instead depends on scenarios to define the initial context in broad terms. Details about the environment; about the interests, abilities, and available actions of the players; and about how actions affect others are provided by the players or expert adjudicators in the game discussions and actions. Players are free to suggest a wide variety of possible actions, and interactions between players are worked out in discussion between experts. In this approach, the games mostly exist as mental models until a particular relationship or capability becomes relevant to game play, at which point it is revealed through discourse.

This approach solves many of the concerns of Approach 1. By depending on mental models to govern what is and is not allowable, players have nearly infinite flexibility and autonomy—the human is profoundly at the center of this type of game. Additionally, these games tap into the practical knowledge of players to better understand how those with expertise in a given undergoverned space think and apply their insights to the policy problem of interest. That is, there is no need to attempt to shoehorn understanding into generalizable meso-level models. However, this approach raises new problems.

Limited Player Expertise

The expertise of the players is essential for determining the credibility of seminar-style or free-form games. These games rely on synthesizing the mental models of their participants—if participants' mental models are poor, then the results will not be useful to support research. Vetting this type of game requires assessing the expertise of the players and how well their expertise translates into the game's environment, which often pushes into novel, hypothetical, and future strategic conditions. This problem is particularly acute in the adjudication of emerging areas in which what constitutes expertise and experience is unclear—adjudicators profoundly shape the play of the game, but they might be no more expert than the players.[43] The process of evaluating the credibility of a game's findings using the credibility of the players can be subjective and riddled with incomplete information, leaving some games to be dismissed and others to be given more credit than they might deserve on closer examination.

Limited Tools to Communicate Mental Models

A second problem for using seminar-style or free-form games for research is the question of how information is transmitted from the players' mental models to the research team. Research on expert judgment emphasizes that these mental models often take the form of heuristics, which might or might not be explicit in the minds of the players, much less legible to an observing researcher.[44] Although there are approaches from psychology for elic-

[43] Stephen Downes-Martin, "Adjudication: The Diabolus in Machina of War Gaming," *Naval War College Review*, Vol. 66, No. 3, Summer 2013.

[44] Daniel Kahneman and Gary Klein, "Conditions for Intuitive Expertise: A Failure to Disagree," *American Psychologist*, Vol. 64, No. 6, 2009; and Gary Klein, *Sources of Power: How People Make Decisions*, Cambridge, Mass.: MIT Press, 1999.

iting mental models, they are difficult to implement.[45] Moreover, experts cannot always explain the bases of their decisions in ways that are understandable to nonexperts.[46] As the complexity of systems increases, the prospect that experts, especially those with the most-sophisticated mental models, can communicate their premises and conclusions diminishes.

In practice, analysis of free-form games by and large depends on external observers listening to the arguments put forward by players to rationalize their actions and then reporting on those beliefs. In some cases, surveys of individual players are used to supplement these data, but this happens inconsistently enough that there is not a strong body of research on best practices for administering these additional data collection instruments. Put simply, approaches to measuring why players are making their decisions have not systematically improved since the 1950s. What is more, the many dimensions of complexity in UGS (social, economic, political, etc.) remain difficult to conceptualize and measure—the study of such issues as deterrence, gray-zone competition, and insurgency is rife with debates about how these concepts can be operationalized to allow inferences from real-world observations. As a result, gamers cannot count on existing measures for these concepts in the way that they can for physics-based phenomena, for which accepted measures are easily available from past research.

Systemic Complexity

A third problem is that relationships within complex systems and the dynamics that they exhibit exceed the capabilities of boundedly rational humans to observe and manipulate them without assistance.[47] Humans have finite cognitive capabilities that limit their ability to collect, process, and manipulate information in logically consistent ways.[48] Experts use patterns drawn from past experience to develop heuristic judgments that limit the information needed to make a decision. Although these judgments can be strikingly accurate in familiar contexts, these rules of thumb break down in new contexts, and experts are often unaware when such breakdowns occur.[49] As systems become more complex and human capacity remains finite, these shortcuts are also more likely to lose logical consistency.

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45 M. Granger Morgan, Baruch Fischhoff, Ann Bostrom, and Cynthia J. Atman, *Risk Communication: A Mental Models Approach*, Cambridge, United Kingdom: Cambridge University Press, 2002, pp. 19–31.

46 Klein, 1999.

47 Dietrich Dörner, *The Logic of Failure: Recognizing and Avoiding Error in Complex Situations*, trans. Rita Kimber and Robert Kimber, revised ed., Cambridge, Mass.: Perseus Publishing, 1996.

48 Classic works on bounded rationality and heuristics and biases are Dan Ariely, *Predictably Irrational: The Hidden Forces That Shape Our Decisions*, revised ed., New York: Harper Collins, 2009; Daniel Kahneman, *Thinking, Fast and Slow*, New York: Farrar, Straus and Giroux, 2013; Daniel Kahneman and Amos Tversky, "Prospect Theory: An Analysis of Decision Under Risk," *Econometrica*, Vol. 47, No. 2, March 1979; and Herbert A. Simon, "Bounded Rationality in Social Science: Today and Tomorrow," *Mind & Society*, Vol. 1, No. 1, March 1, 2000.

49 For more on expert judgment, see Richard K. Betts, *Enemies of Intelligence: Knowledge and Power in American National Security*, New York: Columbia University Press, 2009; Bent Flyvbjerg, *Making Social Science Matter: Why Social Inquiry Fails and How It Can Succeed Again*, trans. Steven Sampson, Cambridge,

In summation, in this approach, a dependence on players' mental models allows flexibility on the part of the players and the adjudicators, but it can also be limited by a lack of knowledge about the best elicitation processes for (1) communicating mental models, (2) linking mental models with key concepts that relate UGS to national security, and (3) ensuring that mental manipulations are logically consistent.

Moving Beyond the Two Approaches

The previous section laid out two traditional approaches to coping with the complexity of UGS in games—the first based on developing increasingly sophisticated formal models and the second relying on exploiting the mental models of players to drive game play. Both approaches tend to fall short: Rigid approaches tend to lose focus on the human, and free-form approaches lose the transparency and consistency that comes with formal documentation of a model. An ideal approach to gaming UGS would rest on a balance between the two approaches. Our assessment of the state of the art in both approaches identifies active efforts to bridge the divide between them. First, iterative use of both modeling and Approach 2 games can offer a way to bridge the divide. Second, clever game and interface design can maximize flexibility and opportunities for meaningful interaction in Approach 1 games. Third, drawing on social science research methods can add structure and transparency to the process of explicating and communicating mental models, thus improving the internal validity of Approach 2 games.

Moving Between Games and Models

One approach to bridging the gap is to use games and models iteratively.[50] Work begins with constructing a model, which is then used as the basis for an Approach 2 game. Players are then able to provide feedback about the model, both directly (such as by stating that adjudication results do not align with expectations and discussing) and indirectly (such as by suggesting additional actions that could be taken). The initial model provides a degree of structure to the game, which makes it easier to organize new information that comes in from players. Conversely, the flexibility of an Approach 2 game allows new ideas to be discovered and incorporated through game play. These additions are then used to refine the model, which, in turn, can be used as the basis for additional game play. Over time, the

United Kingdom: Cambridge University Press, 2001; Kahneman and Klein, 2009; Klein, 1999; and Philip E. Tetlock, *Expert Political Judgement: How Good Is It? How Can We Know?* Princeton, N.J.: Princeton University Press, 2017.

50 For two different discussions of this approach, see Paul K. Davis, *Illustrating a Model-Game-Model Paradigm for Using Human Wargames in Analysis*, Santa Monica, Calif.: RAND Corporation, WR-1179, 2017; and Peter P. Perla and Ed McGrady, *Systems Thinking and Wargaming*, Arlington, Va.: Center for Naval Analysis, 2009.

model is expanded and refined sufficiently that the game resembles an Approach 1 effort, with a robust model of the problem at the center of the game.

One open question is whether using this approach will break down in the face of increasing detail. The existing literature on iterative use of models and games tends to favor parsimonious models rather than more-detailed digital twins or agent-based models.[51] It is not clear whether the process can be successfully replicated for more-detailed approaches and, if it cannot, what the key factors might be that would prevent progress. For example, it might be that building a model with any substantial degree of detail requires multiple iterations through the cycle, meaning that substantial time and cost must be dedicated to the effort. Time and resources can be particularly difficult to secure in the case of research on UGS, in which senior-level interest—and, thus, resources—can be fleeting. However, it also might be that more-detailed models simply have too many factors and relationships for human players to meaningfully engage with all of them. In this case, there might be some limitation on the approach that cannot be overcome simply by applying more resources.

Using Emerging Technology to Improve Games That Leverage Formal Modeling

Developments in technology have often been seen as key in managing the pitfalls of gaming complex problems. Policy gaming and computers grew up together in the 1950s and 1960s. Many early games were quick to take advantage of the abilities of computers to handle complex and tedious calculations and to build and solve mathematical models that would have been too cumbersome to manage by hand.[52] As early as the late 1960s, time-share computers—a critical step toward the internet—were being used to enable distributed game play over a distance to support Defense Advanced Research Projects Agency research.[53] This work recognized what are seen as key affordances offered by computers today—the ability to handle models that are too large to manage on paper, the ability to perform cumbersome bookkeeping tasks, and the ability to engage with players who are separated by time and space. With each new wave of technology comes the hope for breakthroughs in game design that will allow for improvements to Approach 1 games.

The earlier chapters in this report detailed recent evolutions in computational approaches that offer promise in better modeling UGS, which could translate into improvements in game design. Advances in Agent-Based Modeling show great promise.[54] Because agent-based models and games share a fundamental focus on causal mechanisms, their advancement might naturally complement the needs of Approach 1 games in ways that earlier "toy"

[51] On parsimonious models, see Chapter Twelve (Davis, 2022). On digital twins and agent-based models, see Chapters Fourteen, Fifteen, and Sixteen (Winkelman, 2022; Connable, 2022; and Axtell, 2022).

[52] Wilson, 1968.

[53] Bartels, 2020, pp. 155, 157–158.

[54] See Chapter Sixteen (Axtell, 2022).

agent-based models could not. The digital twin approach would offer highly detailed models that might also prove useful in gaming applications, although much depends on their practical constraints on data and computing power.[55] Additionally, new tools for data collection would support these more ambitious efforts.[56] Investments in all of these areas could produce models with improved potential to support games.

Beyond these efforts to piggyback on more-general improvements in the modeling of UGS, the continuing evolution of commercial games has raised hopes for additional advancements in games that can support policy analysis. First, advances in artificial intelligence (AI) and machine learning suggest the value of these tools in creating decision aids and other types of support to manage complex games. Second, HCI capabilities have changed how players interact with game environments in ways that open up new design options. Although both areas of research are still in the process of maturing sufficiently to offer truly valuable inputs into policy games, clear avenues for research are becoming evident.

Artificial Intelligence and Machine Learning

Recently, the potential role of AI in military games has received increased attention, in part because of its championing by former Deputy Secretary of Defense Robert Work.[57] Advocates of AI for games point to the advances displayed in competitions against highly skilled players in recreational games. Recent achievements show compellingly that it is possible to learn superhuman strategies even in games in which finding Nash equilibria would be computationally expensive or intractable.[58] Go was thought by many to be beyond reach for AI systems until DeepMind's AlphaGo system defeated Lee Sodol, an 18-time world champion, in 2016.[59] Additional advances can be seen in AI systems built for StarCraft II, a popular real-time strategy game with an action space consisting of hundreds of player actions—much larger than that of Go. AlphaStar, a recently introduced AI architecture with a fairly complex modular structure that brings together several advances in deep reinforcement learning, was

[55] See Chapters Fourteen and Fifteen (Winkelman, 2022; Connable, 2022).

[56] See Chapters Eight and Nine (Andrew M. Parker, "The Need to Invest in Social Science Infrastructure to Address Emerging Crises," in Aaron B. Frank and Elizabeth M. Bartels, eds., *Adaptive Engagement for Undergoverned Spaces: Concepts, Challenges, and Prospects for New Approaches,* Santa Monica, Calif.: RAND Corporation, RR-A1275-1, 2022; and Elisa Jayne Bienenstock, "Operationalizing Social Science for National Security," in Aaron B. Frank and Elizabeth M. Bartels, eds., *Adaptive Engagement for Undergoverned Spaces: Concepts, Challenges, and Prospects for New Approaches,* Santa Monica, Calif.: RAND Corporation, RR-A1275-1, 2022).

[57] Andrew Lohn, "What Chess Can Teach Us About the Future of AI and War," *War on the Rocks*, January 3, 2020.

[58] Noam Brown and Tuomas Sandholm, "Superhuman AI for Multiplayer Poker," *Science*, Vol. 365, No. 6456, August 30, 2019.

[59] David Silver, Aja Huang, Chris J. Maddison, Arthur Guez, Laurent Sifre, George van den Driessche, Julian Schrittwieser, Ioannis Antonoglou, Veda Panneershelvam, Marc Lanctot, et al., "Mastering the Game of Go with Deep Neural Networks and Tree Search," *Nature*, Vol. 529, No. 7587, January 28, 2016.

able to beat a world grand master.[60] The recent successes of AI in such games as Go and StarCraft show that achieving superhuman performance in nontrivial games is possible if sufficient training data and a simulation engine for self-play are available.

However, many of the characteristics that have made these efforts successful are generally missing in policy games, particularly in games focused on UGS. Fundamentally, policy games are most helpful before a problem has been fully structured, and UGS are defined by the uncertainty surrounding available actions and causal effects. Even if the action space can be defined, the high dimensionality of UGS problems will require additional training. The use of AI might add to the difficulty of understanding results because explaining the causal logic of the algorithm's reasoning presents a serious research problem in its own right.[61] Neither training data nor the kind of simulation engine used for recreational games is available for policy games, which are generally run only a small number of times. Similarly, the presence of incomplete information will limit the viable types of algorithms and increase training requirements. Few formal verification tools exist in AI; often, the only way to ascertain whether an algorithm will work in practice is to test it on a data set—typically a large one—representative of the data encountered in the real world. An additional complication when applying AI to UGS is the need to manage multiple decisionmaking agents acting at the same time, which makes it difficult for a learning agent to find an optimal policy. All of these problem areas are the focus of ongoing research efforts but remain essentially unsolved today. A practical implication of these limitations for complex UGS games is that determining the suitability of an AI algorithm for employment in games will likely require a lengthy and iterative process of experimentation and model refinement.

These limitations notwithstanding, AI may be deployed in support of a game in at least four ways. The first potential application is in controlling individual agents or groups of agents, particularly adversarial forces. This is the most commonly envisioned application outside the gaming community but is likely one of the hardest to achieve. Using AI as a player or an agent will require addressing three key issues: how to design goals and rewards for the AI to optimize against, how to train the AI on timescales that allow for uninterrupted interaction with human players, and how to validate models to support the credibility of game results. All three issues are difficult to overcome given the limited structure around UGS and the absence of large training sets or simulations.

Second, a game environment might use AI as part of its model to add complexity to the environment. For example, an event recognition algorithm could be developed to identify certain patterns of activities by collective actors, which could trigger certain outcomes in the

[60] Oriol Vinyals, Igor Babuschkin, Wojciech M. Czarnecki, Michaël Mathieu, Andrew Dudzik, Junyoung Chung, David H. Choi, Richard Powell, Timo Ewalds, Petko Georgiev, et al., "Grandmaster Level in StarCraft II Using Multi-Agent Reinforcement Learning," *Nature*, Vol. 575, No. 7782, 2019.

[61] Matt Turek, "Explainable Artificial Intelligence (XAI)," webpage, Defense Advanced Research Projects Agency, undated.

environment. The technical challenges to be solved for this kind of use of AI likely would be lower than those of using AI as a strategic player.

The third and perhaps most promising application of AI in UGS is as a tool that helps a human player make sense of the complex game environment. Rules-based applications have long existed, and machine learning–based solutions have been explored to support multidomain command and control and operations.[62] Key advancements that are needed to support greater integration of AI into games include how to represent uncertainty, how best to integrate human operator preferences, and how to make human-understandable suggestions.[63] Fundamentally, these tasks are required for the AI to provide a human player with suggestions that can be thoughtfully integrated into the player's decision calculus. For example, a tool that provides a recommended course of action without an explanation often leaves a player with a dilemma whereby they must choose between an option that they developed manually and the machine-generated recommendation, the benefits of which might not be apparent. In this model, the players are effectively deciding whether they trust the algorithm more than their own judgment.

Fourth, game evaluators could rely on AI to monitor and assess large-scale games by extracting patterns from unstructured data and offering tentative explanations of causality within game play, such as player motivations. As with many of these other techniques, the need for repeated play to extract useful information might drive the costs of this approach beyond the anticipated benefits of analysis.

Human-Computer Interaction

Emerging HCI capabilities may provide important opportunities to meet three important objectives. First, HCI may facilitate new modes of game play, such as moving game boards into virtual, augmented, and mixed-reality (VAMR) spaces, thus expanding opportunities for player participation and new game designs for persistent and extended games and scenarios. Second, HCI capabilities may enable new ways of collecting information on how players use information, allocate their attention, develop roles and responsibilities within teams, frame problems, and develop and choose between prospective courses of action in games. The ability to operationalize measures from many research fields might be a key to bringing experimental and empirical methods and measures into gaming practice. Third, HCI may enable new ways to examine how computing resources can assist in, or further complicate,

[62] For examples, see Sherrill Lingel, Jeff Hagen, Eric Hastings, Mary Lee, Matthew Sargent, Matthew Walsh, Li Ang Zhang, and David Blancett, *Joint All-Domain Command and Control for Modern Warfare: An Analytic Framework for Identifying and Developing Artificial Intelligence Applications*, Santa Monica, Calif.: RAND Corporation, RR-4408/1-AF, 2020; and Lance Menthe, Dahlia Anne Goldfeld, Abbie Tingstad, Sherrill Lingel, Edward Geist, Donald Brunk, Amanda Wicker, Sarah Soliman, Balys Gintautas, Anne Stickells, and Amado Cordova, *Technology Innovation and the Future of Air Force Intelligence Analysis*, Vol. 1, *Findings and Recommendations*, Santa Monica, Calif.: RAND Corporation, RR-A341-1, 2021.

[63] Turek, undated.

strategic circumstances, by allowing players to interact with AI agents in a decision-support role, or as automated "players."[64]

However, a key limitation of the current wave of HCI tools is that most work to date has been focused on the relationship between a single user and the system rather than a decisionmaking group. These applications have proved useful in such training settings as live, virtual, and constructive simulation-based training systems,[65] but they are less clearly applicable when the game is focused on group decisionmaking, as is the case in most games for research, analysis, and strategic and operational education. Here, more-promising research tends to focus on the creation of displays to facilitate group planning. For example, Simtable has deployed a variety of camera and projector technologies in emergency and incident-response situations to enable physically proximate and remote stakeholders to develop shared situational awareness and courses of action during complex emergencies, such as responses to wildfires and pandemics.[66]

In addition to this tool-focused approach, paying closer attention to HCI can aid in mitigating some of the barriers to centering human players in games with complex models by offering advice on how to facilitate the flow of information between players and computerized tools. HCI fields have produced guides and best practices for design to help decisionmaking.[67] Advice has varied, from using an interactive design process to favoring simple designs with clear cause and effect. The literature also provides guidelines for evaluating the success of design choices and lays out metrics, such as learnability, efficiency, memorability, errors, and satisfaction, that can be applied to game designs.[68]

Using Better Measurement to Improve Free-Form Gaming

As discussed, the typical weakness of free-form gaming is the lack of transparency; that is, both the mental models of players and how they shape cause and effect in the game are often unclear to those outside the game room. Improving this state of affairs requires paying sharper attention to measurement of what happens in the game. Measurement is a process that moves

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[64] Yuna Huh Wong, John M. Yurchak, Robert W. Button, Aaron Frank, Burgess Laird, Osonde A. Osoba, Randall Steeb, Benjamin N. Harris, and Sebastian Joon Bae, *Deterrence in the Age of Thinking Machines*, Santa Monica, Calif.: RAND Corporation, RR-2797-RC, 2020.

[65] Susan G. Straus, Matthew W. Lewis, Kathryn Connor, Rick Eden, Matthew E. Boyer, Timothy Marler, Christopher M. Carson, Geoffrey E. Grimm, and Heather Smigowski, *Collective Simulation-Based Training in the U.S. Army: User Interface Fidelity, Costs, and Training Effectiveness*, Santa Monica, Calif.: RAND Corporation, RR-2250-A, 2019.

[66] Simtable, homepage, undated.

[67] For example, see Christopher D. Wickens, John D. Lee, Yili Liu, and Sallie E. Gordon Becker, *An Introduction to Human Factors Engineering*, 2nd ed., Upper Saddle River, N.J.: Pearson Prentice Hall, 2004, pp. 185–193.

[68] Wilbert O. Galitz, *The Essential Guide to User Interface Design: An Introduction to GUI Design Principles and Techniques*, 3rd ed., Hoboken, N.J.: Wiley, 2007.

from expertly identified constructs (that is, the mental models that are the focus of many games) to the identification and operationalization of potential candidate measures that can be improved with additional iterations.[69] Although in some cases games consider unique constructs for which there is little relevant research, in many cases key ideas are shared with other studies of national security, public policy, individual and group decisionmaking, and learning. In these cases, gamers can accelerate the transition from construct to measurement and align measurements from games more closely by using other tools and leveraging other research to identify and help evaluate candidate measures.

In some cases, the relevant literature might be driven by the topic of games, which will tend to point researchers toward such areas as political science, international relations, sociology, economics, anthropology, and military history. Given the challenges inherent in the issues associated with game assessment, there might not be agreement on measures, but, even in these cases, existing discussions can help gamers map their approaches to those employed in established research from other fields. To take an obvious example, deterrence has long been seen as difficult to measure because it requires demonstrating that something would have happened had the deterrent not been in place. Security studies have long grappled with this problem, so referencing this literature can ensure that games avoid adopting approaches that have been widely critiqued and are sensitive to ongoing debates in the field.

Beyond measures of interest that are based on particular topics, broader areas of study that touch on the purpose and mechanics of games might produce measures that are relevant to evaluating a variety of games. Gaming is a social activity with human decisionmaking and interactions at its core. Understanding the empirical markers of many activities in these fields might allow better understanding and measurement of the interactions and processes that unfold during any game.

First, we can consider approaches centered on the individual. Social cognition—the study of how people make sense of others and themselves through such topics as attention and encoding (transforming an external stimulus into an internal representation), organizing memory, stages of cognitive response, affect, and social intelligence during planning—provides one potentially valuable set of concepts and methods.[70] It appears plausible that such topics as models for learning, factors that affect learning (e.g., environmental and emotional regulation), trainability of human cognitive abilities, and cognitive biases and heuristics also provide a relevant basis for future measures and metrics.[71] Gaming measures and

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[69] For an accessible description of the development of measures in social science, see Geoffrey Maruyama and Carey S. Ryan, *Research Methods in Social Relations*, 8th ed., Chichester, West Sussex, United Kingdom: John Wiley & Sons, 2014, pp. 14–15.

[70] Susan T. Fiske and Shelley E. Taylor, *Social Cognition: From Brains to Culture*, 3rd ed., London, United Kingdom, and Thousand Oaks, Calif.: Sage Publications, 2016, pp. 1, 63, 93, 278, 368, 423; and Ziva Kunda, *Social Cognition: Making Sense of People*, Cambridge, Mass.: MIT Press, 1999.

[71] Lyn Corno and Eric M. Anderman, eds., *Handbook of Educational Psychology*, 3rd ed., New York and London, United Kingdom: Routledge, 2016, pp. 61–72, 82–86, 127–130.

metrics could be further advanced through the assessment of alternative cognitive processes (e.g., remember, understand, apply, analyze, evaluate, create) and the use of different types of knowledge (e.g., factual, conceptual, procedural, metacognitive).[72] Taken together, these tools would better ground how individual actions are understood and evaluated within games.

Because games for policy are generally interested in the interactions of multiple players, group performance is another important research area to bring into evaluating games. It covers such topics as group formation, group influence, group decisionmaking, social motivational losses, and unique groups.[73] For example, work on group decisionmaking in intelligence analysis might be transferable to group decisionmaking in national security games.[74] Communications is another field of interest. For example, recent work leveraging a narrow area within communications—narrative methods—shows the potential for applying narrative analysis in games to better understand what is happening within them and to differentiate between learning by individuals and learning by groups in the game.[75]

For games with an exploratory objective, a potentially relevant research field is creative cognition, which draws on experimental methods from cognitive science. This covers such topics as the specific cognitive processes and structures that result in creativity, schema and mental models, models of generative and exploratory processes, methodological approaches for evaluating creativity, the conditions under which creativity emerges, and organizational creativity.[76] This research can suggest helpful lenses for comparing the relative utility of game designs for specific tasks, such as synthesis or idea generation.

Table 19.1 summarizes prospective areas in which social science research fields might contribute to gaming, particularly to efforts to assess whether games achieve their stated purposes for training, education, research, and analysis.

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[72] Lorin W. Anderson and David R. Krathwohl, eds., *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*, London, United Kingdom: Pearson, 2001.

[73] Craig D. Parks and Lawrence J. Sanna, *Group Performance and Interaction*, Boulder, Colo.: Westview Press, 1999, pp. 10, 21, 45, 79, 181.

[74] Susan G. Straus, Andrew M. Parker, and James B. Bruce, "The Group Matters: A Review of Processes and Outcomes in Intelligence Analysis," *Group Dynamics: Theory, Research and Practice*, Vol. 15, No. 2, 2011.

[75] Catherine Kohler Riessman, *Narrative Methods for the Human Sciences*, Thousand Oaks, Calif.: Sage Publications, 2008. For an example of formal narrative methods applied to wargame analysis, see John DeRosa and Lauren Kinney, "Narrative Analysis of Wargaming," Connections Wargaming Conference, Washington, D.C., 2018.

[76] Ronald A. Finke, Thomas B. Ward, and Steven M. Smith, *Creative Cognition: Theory, Research, and Applications*, Cambridge, Mass.: MIT Press, 1992, pp. 1–3, 8–14, 17, 134–137; and Robert J. Sternberg, ed., *Handbook of Creativity*, Cambridge, United Kingdom: Cambridge University Press, 1999, pp. 35–38, 62, 95–99, 373–389.

TABLE 19.1
Potentially Relevant Fields for Better Understanding and Improving Gaming

Research Field	Sample Research Topics
Social cognition	• Social intelligence • Planning and decisionmaking
Education and educational psychology	• Cognitive processes • Types of knowledge • Factors affecting learning
Group performance	• Group formation • Group decisionmaking • Military groups
Communications	• Narrative methods
Organizational psychology	• Organizational learning
Creativity	• Preconditions for creativity • Evaluating creativity • Organizational creativity

Charting a Middle Path: Introducing the Contest Arena Gaming Concept

The approaches that we have discussed seek to move from the extremes of Approach 1 and Approach 2 gaming to positions closer to the middle. But what if it were possible to borrow from both approaches by depending on high-complexity modeling while still centering human sensemaking and decisionmaking? In this section, we present one such possibility, which we have dubbed a *contest arena*.[77] In many ways, this concept draws on the same types of developments discussed for improving the state of Approach 1 and Approach 2 gaming but goes a step further in seeking a synthesis of the two as a third way to design and conduct games.

Characteristics of a Contest Arena Game

In defining the contest arena concept, we retain the standard elements of a game—the environment, players, and rules that govern the relationships among them. However, we envision technological tools, most prominently agent-based models, that serve as interactive game boards that can evolve and change over time. Players can access and interact with this board through various HCI and VAMR technologies. These technologies digitally capture and facilitate the exchange of information between the human players and the models that make up the game board. Moreover, through the capture of more of the players' cognition,

[77] The authors are grateful to Adam Russell, formerly of the Defense Advanced Research Project Agency's Defense Sciences Office, for his invaluable leadership in the development of this concept.

decisionmaking, and interactions in a digital form, increasingly sophisticated measurement may be performed to get more value from expert participation and more transparency on the experts' strategic calculations and choices. At the same time, the arena would be designed to prioritize player freedom of action to allow novel moves and contributions from player mental models that might not be fully captured in the initial game model. The result is that strong elements of Approach 1 and Approach 2 gaming are hardwired into the arena. We see six elements as key to the contest arena concept.

A Socially Complex and Dynamic Game Environment

Traditionally, the environment of policy games is created through a mix of narrative scenarios, maps of physical terrain or concepts, and modeling that describes the relationships between elements. Our vision calls for leveraging the emerging complex computational models that represent societies to improve on traditional model-based games by generating in simulation high-dimensional, interdependent representations of populations in UGS.

Our initial vision is based on the use of an agent-based model in which the population is represented at the level of the individual with characteristics that influence how individuals will interact with other agents and in response to player actions. The use of an agent-based model may allow populations within the model to be dynamic and adaptive over an open-ended interaction space and, at least with some degree of abstraction, to continue to maintain the properties of a socially complex, internally consistent and plausible society despite novel actions by human players or other agents.[78] These features would allow the arena concept to move away from the traditional design choice between a formalized model and free play by generating traceable models that also can accommodate multidimensional player choice.

Additionally, this approach would allow a much greater degree of complexity, to better mimic society. Meeting this requirement will require using models that address both (1) a stratified social system that is characterized by inequalities resulting from specialization and competition within the society and (2) the characterization of each agent's status in a broad context that includes social, economic, political, military, and environmental properties.[79] Put simply, agents would be differentiated across several characteristics, allowing players to explore how different social segments might interact differently.

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[78] Models of this type are inspired by early works in the field of artificial life and the development of open-ended systems. See Philip W. Anderson, Kenneth J. Arrow, and David Pines, eds., *The Economy as an Evolving Complex System*, Boca Raton, Fla.: CRC Press, 1988; W. Brian Arthur, Steven N. Durlauf, and David A. Lane, eds., *The Economy as an Evolving Complex System II*, Boca Raton, Fla.: CRC Press, 1997; Lawrence E. Blume and Steven N. Durlauf, eds., *The Economy as an Evolving Complex System, III: Current Perspectives and Future Directions*, London, United Kingdom: Oxford University Press, 2005; John H. Holland, *Hidden Order: How Adaptation Builds Complexity*, Heather Mimnaugh, ed., New York: Perseus Publishing, 1996; and Christopher G. Langton, ed., *Artificial Life: An Overview*, Cambridge, Mass.: MIT Press, 1995.

[79] A full representation of a desired arena may be mapped to the Political, Military, Economic, Social, Information, Infrastructure, Physical, and Time (PMESII-PT) dimensions (Field Manual 5-0, *The Operations Process*, Washington, D.C.: Headquarters, Department of the Army, March 2010).

This model would both provide high levels of dimensionality to the arena and the agents on the game board and allow a dynamic environment in which the situation that players face would evolve and change, even without any direct action on the part of the players. Specifically, the central premise of the contest arena would be that the world in which competitors engage has its own endogenous dynamics that must be understood, considered, and, when possible, influenced as part of players' strategies. Such an approach would have far more in common with representations of individuals, organizations, and societies associated with digital twin models than with traditional game models that seek to be as parsimonious as possible.

Multiple, Semicompetitive Actors

Another feature of the contest arena is that it would be explicitly multiplayer, requiring that teams engage beyond simple zero-sum or purely competitive interactions. Instead, a competition arena game would feature many teams, each with different goals, preferences, capabilities, and resources. The result would be that each team would need to consider both competitive and cooperative strategies and discover the goals and motives of multiple teams.

The heterogeneity among player teams could be substantial. For example, teams might represent consolidated states with a global or regional presence, substate actors ranging from insurgents to trade associations, or transnational nonstate actors, such as foreign fighters and international relief organizations. Each organization would have different capabilities, objectives, levels of access to the local population, and knowledge of the environment—all of which would shape how the team would interact with the population—rather than using a one-size-fits-all solution, which can occur in traditional game constructs. The arena would better align with the conditions of infinite games or brawls;[80] the arena would involve many players competing and ultimately succeeding by surviving and continuing to play. An arena that supported infinite game play could be achieved in a different fashion for each player rather than through traditional game victory conditions in which one player's victory is another's defeat.

Flexible Rules

To enable flexible game play, every effort would be made to allow players to generate action not envisioned by the original designers. Overcoming this traditional weakness of Approach 1 games will likely require progress in several areas. First, the game's model will need to include a population that exhibits a variety of complex social interactions and structures, which provides a naturally diverse menu of interactive opportunities that consists of military and nonmilitary actions. Progress in this area will ensure that the model is capable of capturing a wider range of potential actions. Second, advanced HCI might reduce the barriers to manipulating models in unanticipated ways, thus allowing the game to provide a level of openness to

[80] On infinite games, see James P. Carse, *Finite and Infinite Games*, New York: The Free Press, 1986; and Simon Sinek, *The Infinite Game*, New York: Portfolio, 2019. On brawls, see George Skaff Elias, Richard Garfield, and K. Robert Gutschera, *Characteristics of Games*, Cambridge, Mass.: MIT Press, 2012.

the model that more closely resembles the flexibility of current Approach 2 games. For example, speech-to-text capabilities and machine vision might allow users without programming expertise to draw and describe new decision rules for interacting with computational agents in the arena's artificial society—effectively making human players increasingly interpretable to the arena in which they are playing.

Today, such approaches usually require the intervention of both subject-matter experts to interpret player actions and technicians to modify models. This approach is not only costly and time-consuming, but it can also limit the traceability of key sequences of cause and effect because adjudicator mental models are potentially both opaque and not aligned with player mental models. Developing systematic processes and tools that empower players to modify models easily and quickly within games would simultaneously enable greater creativity and more directly capture players' expertise than current practices offer.

Long-Term Play

Traditional games are generally limited to a few hours, days, or weeks at the longest, which can make it difficult for the multitude of small, strategic, and organizational choices that undergird long-term competition to unfold and be examined if events are considered with much granularity. To take advantage of the detailed and dynamic game board, contest arena games would be designed to run for weeks, perhaps even months, by providing a persistent environment. This much longer period of play would allow far more opportunities for adaptive dynamics to appear and influence decisionmaking. This long period of play would also more realistically simulate the reality of day-to-day decisionmaking during long-term competition, in which periods of heightened activity punctuate stretches of time in which other priorities come to the fore.

Transitioning to a digital gaming environment would free games from some of the most mundane yet significant constraints—the availability of appropriate game spaces and the costs of travel to support colocation. A physical game that is backstopped by the digital tracking of physical assets would enable the rapid breakdown and reconstitution of game states or their synchronization across multiple player sites.

Long periods of game play would require new models for player recruitment and sustained participation. This would involve new thinking about compensation, the provision of read-ahead and preplay materials, and the creation of a digital infrastructure to enable participation from the variety of computing environments found in national security–adjacent organizations. When games are played in a matter of hours or days, it is often easy to "borrow" civilian staff, military officers, and outside academics and contractors from their day-to-day routines. Far longer periods of play will likely require new arrangements between games and individual participants, as well as the institutions they represent. One existing model for securing such attention can be found in the U.S. Naval War College's Halsey Alfa games, in which professional military education students participate as part of their coursework every year.[81] Other options are contracted player teams and a dedicated staff function.

Self-Organized Human-Machine Teams

To manage the complexity of the environment, artificial society, multiplayer teams, and long periods of game play, players likely will need various forms of assistance in performing cognitive and operational tasks within the game. For example, monitoring a game environment that changes dynamically around the clock would be difficult for a team working eight-hour shifts without tools for change detection that were able to detect and call attention to important changes in the game environment. This opens the space for a variety of computational capabilities that could run the gamut from information monitoring, dashboards, and alerts to advanced applications of AI for use as decision aids or in task automation. Enabling these capabilities would require a set of predefined, published application program interfaces (APIs) to allow machine-to-machine communication across player teams and the arena and the necessary development time prior to game play to allow teams to enter the arena battle ready.

A contest arena presents new opportunities to study how players and player teams might best employ computational resources. Specifically, how players internally organize as a team and apply computing resources to information collection, sensemaking, decision support, and operational oversight and automation could provide an invaluable window into how AI might ultimately affect military organizations and operations in highly complex, open-ended strategic environments.

Instrumented Game Play

Both the contest arena and the physical and digital spaces in which players deliberate would be instrumented to make data capture as low cost and unobtrusive as possible from the perspectives of players and researchers. This would involve favoring interfaces that serve as passive means of data collection and building in tools to easily add active data-capture instruments that align with best practices in relevant fields. For example, the arena might allow easy randomization of players to support survey experiments as part of game play. The goal would be to enable the contest arena to harness improvements in data collection and measurement as a means for better understanding player sensemaking processes, mental models, and decisionmaking. Assessment functions would work to measure how player teams understand the complex behavior of the artificial society and to trace how this understanding translates into the processes of generating, evaluating, and implementing strategies and operations given the environment and other players.

[81] U.S. Naval War College, "Halsey Alfa Group," webpage, undated.

Potential Gains from a Contest Arena

The contest arena presents four opportunities to advance understanding of decisionmaking in infinite games or long-term competition in UGS. First, it offers an opportunity for various stakeholders to engage directly with both one another and models to provide rich feedback to the research teams. Second, the contest arena allows direct measurement and comparison of how well decisionmakers' mental models of a complex social system align with the causal processes governing the behavior of the artificial society within the arena. Third, the arena offers a setting to study organizational designs for long-term competition, particularly the interface between human and computational principals and agents. Finally, the contest arena may create a virtual "sandbox" for testing policies before they are implemented in the real world.

Engaging Environment for Stakeholders to Interface with Complex Models

Traditional games have long been valued for their ability to engage stakeholders and generate compelling stories about how and why change needs to occur to effectively deal with specific strategic challenges.[82] Approach 2 games in particular are seen as opportunities to bring diverse stakeholders into a space to learn from each other directly. The contest arena concept offers the possibility of reaching a larger population of participants by supporting more player teams without some of the costs of travel that are traditionally associated with games.[83] At the same time, by competing through an artificial population with features that resemble those of real-world UGS, players may be challenged to reason and act within the bounds of an internally consistent, complex representation of an undergoverned space and may simultaneously improve that representation by creating new model inputs. Thus, a contest arena game would enable a type of direct feedback about the model that is often difficult to secure in Approach 1 games, particularly as models become more complex.

Ability to Compare Team Models with "Ground Truth"

The use of causal models in the contest arena enables research teams to directly compare the understanding of cause-and-effect relationships held by players with the underlying model that governs the behavior of the actors that make up the arena. This direct comparability allows researchers to assess the relative and absolute ability of different teams and approaches to correctly understand and model the strategic dynamics of UGS. It also potentially allows researchers to assess the relative predictive power of alternative approaches to strategic assessment and action. Such research would build on prior scientific efforts to understand, predict, and prescribe policy actions within simulated social systems.[84] In particular, the arena would allow researchers to explore an environment in which multiple teams are predicting causal

[82] McGrady, 2019.

[83] However, this benefit might be counterbalanced by the longer timeline of the contest arena game.

[84] Philip Root, "Ground Truth," webpage, Defense Advanced Research Projects Agency, undated.

outcomes and taking action to change the arena simultaneously, allowing for deeper study of interaction effects than research to date.

Studies of Organizational Design for Long-Term Competition

The ability to observe team decisionmaking in UGS in a controlled environment provides an opportunity to better understand the relative successes or failures of organizational designs and processes. Research questions might focus on the value of AI assistance in performing different tasks, differences in communication styles depending on team style and composition, or the openness of decisionmaking processes. Although such studies can be conducted in other settings, games provide greater access to decisionmaking processes, a greater ability to collect data, and more opportunity for organizational experimentation than is often possible in sensitive national security organizations during a real-world crisis. The ability to explore organizations over time as they adapt and evolve in the face of changing facts on the (arena) ground, where the perspectives of all actors are equally accessible, might provide unique analytic opportunities to better understand organizational behavior in UGS and long-term competition.

Low-Risk Policy Experimentation

One common application of games in policy spaces is to act as a test bed for new policies before the costs of implementation are incurred. Although game results are rarely perfectly predictive, games that are focused on implementation can reveal potential reactions and unanticipated consequences of a new approach and can allow policies to be refined and adjusted before implementation is attempted.[85] Such games can also enable controlled comparison, such as A/B testing, between alternatives that might be too expensive, ethically fraught, or practically impossible to attempt in the real world. A contest arena game would provide a forum to test policies in the context of UGS. This approach might be particularly valuable for considering strategic dynamics over substantial periods of time, particularly as multiple actors modify their behavior in response to one another's policy actions. Such changes are central to adaptive planning, but they can be difficult to observe in the field, where data are missing, sparse, or lost, thus making long-term assessment a challenge.

Concluding Thoughts

Gaming remains one important method for researching national security competition and conflict. However, approaches to gaming suffer from their lack of ability to handle complexity, resulting in a push toward either increasingly model-based formal methods of game adjudication that limit player freedom and might not be externally valid (Approach 1) or highly flexible, expertly adjudicated games that might allow highly creative strategies to emerge

[85] For an example of the impact of games for this application in a different context, see Elizabeth M. Bartels, Jeffrey A. Drezner, and Joel B. Predd, *Building a Broader Evidence Base for Defense Acquisition Policymaking*, Santa Monica, Calif.: RAND Corporation, RR-A202-1, 2020.

but might lack internal consistency and validity (Approach 2). Recent efforts have offered incremental improvements to both approaches, but they have failed to offer a genuinely novel approach to gaming that can provide new types of insights on active policy questions.

Emerging technologies could enable a new class of games that might offer a third way of designing and playing games. In this approach, agent-based models serve as game boards in which diverse, socially complex societies represent open-ended, evolving populations over which multiplayer teams compete. Through advancements in AI, HCI, and distributed computing, new models and interfaces can address many of the weaknesses of traditional Approach 1 games while providing the ability for players to modify models in real time that might allow the preservation of the strengths of Approach 2 games. Together, new approaches to game design and conduct might be able to place decisionmakers in increasingly complex and instrumented environments, allowing better insights into organizational and strategic decisionmaking in long-term competition and engagement in UGS.

Collectively, increasingly complex games may both elicit and expose the effects of complexity on strategic and organizational behavior and develop decisionmaking expertise that might not be attainable with traditional games. The contest arena concept that we have proposed draws inspiration from Herbert A. Simon's classic observation that it is the environment, not the decisionmaker, that drives complex behavior:

> We watch an ant make his laborious way across a wind- and wave-molded beach. He moves ahead, angles to the right to ease his climb up a steep dunelet, detours around a pebble, stops for a moment to exchange information with a compatriot. Thus he makes his weaving, halting way back to his home. . . .
>
> Viewed as a geometric figure, the ant's path is irregular, complex, hard to describe. But its complexity is really a complexity in the surface of the beach, not a complexity in the ant. On that same beach another small creature with a home at the same place as the ant might well follow a very similar path.[86]

A contest arena, or other new approaches to designing increasingly complex games, could provide the beaches needed to better understand how to engage in UGS and compete over the long term in infinite games.

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[86] Herbert A. Simon, *The Sciences of the Artificial*, Cambridge, Mass.: MIT Press, 1996, pp. 51–52.

Abbreviations

AI	artificial intelligence
DoD	U.S. Department of Defense
HCI	human-computer interaction
UGS	undergoverned spaces
VAMR	virtual, augmented, and mixed reality

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