Toward an Analytic Architecture to Aid Adaptive Strategy for Competing in Undergoverned Spaces

Chapter Twelve

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CHAPTER TWELVE

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Some aspects of great-power competition are straightforward, but other aspects are more shadowy.[1] Some are overt and well recognized, while others are gradual, less alarming, and perhaps more dangerous. Russia seeks to undermine the processes of governance in other states, while China tries to undermine institutions that regulate international cooperation, to reshape norms in ways consistent with its ambitions,[2] and to undermine legitimacy of the Taiwanese government.[3] The following paragraphs discuss Russia and China in the context of undergoverned spaces (UGS) in slightly more detail.

UGS and Great-Power Competition

Russia in UGS

Russia's interventions in Georgia and Ukraine are well known.[4] More generally, Russia has pursued subversion programs to fragment target states and create UGS.[5] This part of Rus-

[1] Melissa M. Lee, "Subversive Statecraft: The Changing Face of Great-Power Conflict," *Foreign Affairs,* December 4, 2019.

[2] Yanzhong Huang and Joshua Kurlantzick, "China's Approach to Global Governance," *The Diplomat*, 2020.

[3] Michael Schuman, "Keep an Eye on Taiwan," *The Atlantic*, October 10, 2020; and Rush Doshi, "China Steps Up Its Information War in Taiwan," *Foreign Affairs*, January 9, 2020.

[4] Although this work was completed in 2021 before the Russian invasion of Ukraine, we believe many of the issues addressed in this report—e.g., the protection of the international system's laws and norms, Robust Decision Making under uncertainty, understanding the will to fight, the need to increase the complexity of the games employing the national security enterprise—have all demonstrated their relevance by the political and military challenges posed by the conflict.

[5] Lee, 2019.

sian strategy has intellectual roots going back a century.[6] Such activities extend to attacks on developed states, such as in the 1980s when the Soviet Union spread false information claiming that the United States had engineered the AIDS epidemic.[7] More recently, Russia unleashed information warfare against the United States during its 2016 election as described in the report from Special Counsel Robert S. Mueller III.[8]

Information warfare is a central element of today's Russian strategy because Russia is too weak to compete effectively militarily and economically.[9] Russia has used information warfare through social media and other modern cyberspace technology against France and the United States and against vulnerable target regions in Georgia, Ukraine, and elsewhere. A core element of Russian strategy is the effort to weaken target countries *from within*, often by exploiting preexisting social, political, and economic schisms[10] and sowing doubt about leaders and institutions.[11]

It is not the intent here to claim the existence of a new coherent multidimensional Russian doctrine; it is but merely to note the centrality of these matters in modern *political warfare*, an activity defined decades ago by George Kennan:[12]

> Political war is the employment of all the means at a nation's command, short of war, to achieve its national objectives. Such operations are both overt and covert. They range from such overt actions as political alliances, economic measures (as [European Recovery Plan] ERP—the Marshall Plan) . . . and "white propaganda" to such covert operations as clandestine support of "friendly" foreign elements, "black" psychological warfare and even encouragement of underground resistance in hostile states.

Today, hybrid and political warfare dominate the Russian battlefields with other major powers. Interestingly, Russia claims that it has been the victim rather than instigator—a victim, for example, of the color revolutions, of Western efforts to entice Ukraine and other former Soviet states into the North Atlantic Treaty Organization (NATO) and the European

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[6] Thomas Rid, *Active Measures: The Secret History of Disinformation and Political Warfare*, New York: Farrar, Straus and Giroux, 2020, pp. 17–33.

[7] Adam B. Ellick and Adam Westbrook, "Operation Infektion: Russian Disinformation: From Cold War to Kanye, a 3-Part Video Series," *New York Times*, 2018.

[8] U.S. Department of Justice, *Report on the Investigation into Russian Interference in the 2016 Presidential Election*, Vol. I, Washington, D.C., 2019.

[9] Herbert R. McMaster, *Battlegrounds: The Fight to Defend the Free World*, New York: Harper, 2020.

[10] Herbert R. McMaster cites an old Russian joke about a Russian farmer with a single cow. If granted one request by the Russian equivalent of a genie, the farmer's foremost wish is the death of his neighbor's second cow. Tearing others down, then, can be an objective in itself (see McMaster, 2020, p. 40).

[11] Henry Farrell and Bruce Schneier, *Common-Knowledge Attacks on Democracy*, Cambridge, Mass.: Berkman Klein Center, Harvard University, 2018.

[12] George F. Kennan, "Policy Planning Staff Memorandum," Washington, D.C.: U.S. Department of State, No. 269, 1948.

Union, and of efforts to topple regimes it does not like.[13] In any case, Russia has embraced the warfare methods with enthusiasm and has produced structures that suggest systematic study. One has been touted as the Gerasimov Doctrine with new rules of war,[14] although a more realistic view is that Russian doctrine has merely evolved modestly from previous doctrine.[15] The Russian definition of *hybrid war* seems to be as follows:[16]

> Hybrid war: a strategic-level effort to shape the governance and geostrategic orientation of a target state in which all actions, up to and including the use of conventional forces in regional conflicts, are subordinate to an information campaign.

Other definitions appear in more-extensive reports on hybrid warfare and operations in the gray zone by the Center for Strategic & International Studies and the RAND Corporation.[17]

China in UGS

China's views of hybrid warfare are as broad as Russia's but reflect its own history and geographic realities. Ross Babbage has written extensively on Chinese thinking and actions,[18] noting origins as far back as Sun Tzu in 500 BC. Mao Tse-tung's thinking reflected his study of commanders ranging from George Washington in the American colonies to T.E. Lawrence in the Middle East. And, of course, Mao had ample experiences of his own. Mao's thinking preceded cyberwarfare as it is seen now, but he would have embraced it.

As discussed in Babbage's review, China has pursued its strategic ambitions in a long sequence of hybrid warfare operations, which have adhered well to Mao's principles. These involved annexation of Tibet (1950–1951), support for insurgencies in Vietnam and elsewhere

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[13] Dave Johnson, "Review of Speech by General Gerasimov at the Russian Academy of Military Science," NATO Defense College, Russian Studies Series 4/19, March 2, 2019.

[14] Valery Gerasimov, "The Value of Science Is in the Foresight: New Challenges Demand Rethinking the Forms and Methods of Carrying Out Combat Operations," trans. Robert Coalson, *Military Review,* January/February 2016.

[15] Eugene Rumer, *The Primakov (Not Gerasimov) Doctrine in Action*, Washington, D.C.: Carnegie Endowment for International Peace, 2019.

[16] Mason Clark, *Russian Hybrid Warfare*, Washington, D.C.: Institute for the Study of War, 2020.

[17] Melissa Dalton, Kathleen H. Hicks, Lindsey R. Sheppard, Alice Hunt, Michael Matlaga Friend, and Joseph Federici, *By Other Means,* Part II, *Adapting to Compete in the Gray Zone*, Washington, D.C.: Center for Strategic and International Studies, 2019; and Lyle J. Morris, Michael J. Mazarr, Jeffrey W. Hornung, Stephanie Pezard, Anika Binnendijk, and Marta Kepe, *Gaining Competitive Advantage in the Gray Zone: Response Options for Coercive Aggression Below the Threshold of Major War*, Santa Monica, Calif.: RAND Corporation, RR-2942-OSD, 2019.

[18] Ross Babbage, *Stealing a March: Chinese Hybrid Warfare in the Indo-Pacific; Issues and Options for Allied Defense Planners*, Vol. I, Washington, D.C.: Center for Strategic and Budgetary Assessments, 2019a; and Ross Babbage, *Stealing a March: Chinese Hybrid Warfare in the Indo-Pacific; Issues and Options for Allied Defense Planners*, Vol. II, *Case Studies*, Washington, D.C.: Center for Strategic and Budgetary Assessments, 2019b.

(1950–1980), war with Vietnam (1977–1987), the Doklam incident with India in 2018, posturing about the Senkaku Islands, and efforts to dominate the South China Sea. Interestingly, Chinese thinking has embraced all the elements and tactics also discussed in writings about Russia's use of hybrid warfare—for example, such elements as the emphasis of winning the narrative, pursuing intense political warfare, and exploiting political weaknesses in adversary states.

What Is and Is Not Special

Little is new about hybrid and political warfare, and definitions vary. Christopher Paul notes commonality across concepts:[19]

> First, there is a range of conflict and competition short of war, and even when we cross into "war" there is still a spectrum of variation in intensity, capabilities used, and attribution. Competition and conflict across these ranges can involve both conventional and unconventional military forces, as well as capabilities from across the elements of power, including (but not limited to) the diplomatic, informational, military, economic, and legal.
>
> Second, adversaries can pursue these competitions in a gradual or incremental way, creeping or nibbling their way to success, and they can be conducted in a delayed or difficult to attribute manner or seek to remain below thresholds for escalation, creating challenges and dilemmas for the other competitor.

Paul goes on to note what is arguably newer and ominous. In modern times, the United States has been competing with adversaries who are practicing hybrid warfare gradually *while the United States has seemed unaware that it is in a war.* Babbage makes a similar point: China has been engaged in hybrid and political warfare for years, whereas Western decisionmakers still see themselves in a state of peace.[20]

What This Chapter Does

Against this background, this chapter takes first steps toward sketching an analytic architecture to aid development and execution of adaptive strategies for dealing with great-power conflict and competition over UGS, interpreted broadly to refer to hybrid and political warfare and political-economic competition. Achieving an appropriate analytic infrastructure would require a substantial effort because the subject-area knowledge is fragmented, multiple government agencies are involved, and some of the technical-analytic needs pose frontier challenges.

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[19] Christopher Paul, "Confessions of a Hybrid Warfare Skeptic," *Small Wars Journal*, March 3, 2016.

[20] Babbage, 2019a, p. i.

Given this, the remainder of this chapter suggests an initial analytic architecture to inform U.S. planning for competition over UGS, particularly in the form of hybrid and political warfare. An analytic architecture must deal with conflicting objectives, differing policy-level perspectives, and changing contextual realities. Any notion of *optimal strategy* is folly, but much can be done nonetheless.[21] Unfortunately, much of what is needed for a sound analytic contribution lies at the frontiers. The shortcomings start with the science: Hybrid and political warfare have been well studied, but much of the social science is about statistical correlations found in historical data or quarrels about one or another overly simplistic theory. It should be about an integrated causal theory to inform decisions for the future. Doing better is a grand challenge for social science.[22]

Therefore, I present *some* features of an analytic architecture that should help the United States with planning. These features seem valuable and plausible but exceedingly ambitious. They deal with the following:

- strategic planning for adaptiveness
- system thinking
- portfolio analysis methods for conceiving strategies that balance a variety of activities
- qualitative and semi-qualitative methods for integrating fragmented knowledge
- gaming, game-structured simulation, and analysis for discovery, exploration, and insight
- special analytical challenges (e.g., multi-resolution modeling and improved theory-data connections).

There is a logic to this list. Strategic planning should emphasize adaptiveness; it should conceive issues in system frameworks (multiple countries, time spans, dimensions of competition, domains of action); and it should see strategies as portfolios of diverse actions with diverse objectives. Planners should draw on integrated knowledge, much of which will be qualitative and changing. Enhancing that knowledge could be improved with human gaming, game-structured simulation, and exploratory analysis. Although myriad issues exist, some particular challenges merit special attention, notably multi-resolution modeling to connect

[21] See also Chapters Ten and Eleven (Edward Geist, "Why Reasoning Under Uncertainty Is Hard for Both Machines and People—and an Approach to Address the Problem," 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 Steven W. Popper, "Designing a Robust Decision–Based National Security Policy Process: Strategic Choices for Uncertain Times," 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).

[22] 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, pp. 20–24.

knowledge across boundaries and the related issue of how to achieve dynamic, efficient, and effective iteration between theory and data.

Strategic Planning for Adaptiveness

Features of Strategic Planning

Ideal strategic planning takes a long view and a system perspective that addresses multiple objectives, recognizing that some are in tension and that some will change. It may address matters on short-, medium-, and long-term timescales. The options considered are composites of multiple building-block options that address one or more of the many challenges. Although strategic options may be characterized by catchy phrases suggesting one or another focus, all respectable options must address all objectives to a greater or lesser extent.[23] It follows that analysis may be conceived and examined by a *strategic portfolio analysis,* as will be discussed.

Planning for Adaptation

It is perhaps a cliché that planning should be adaptive, but it is less clear how to make that happen. An earlier paper on the subject influenced planning activities in the Office of the Secretary and Office of the Joint Staff.[24] Figure 12.1 shows one of the paper's simple but important constructs. From left to right across the bottom ovals, it acknowledges the need to (1) think about extrapolative strategy, but it then goes on to emphasize the need to (2) develop contingent strategies where branch points are foreseeable, (3) develop broad capabilities to help adapt to surprise shocks, and (4) take actions to shape the environment to improve the odds of desirable developments. This construct addressed planning for several short-, medium-, and long-term timescales.

Thinking on Different Timescales

To pursue such a strategy for adaptiveness, one needs to study the system and its development, monitor the apparent effectiveness of actions, and adjust as necessary. This involves rethinking operational- and strategic-level objectives and strategies as more is learned and the system changes. Even if tactical- and operational-level actions are successful, they may not bring strategic success, as illustrated by the 20-year U.S. experience in Afghanistan. Perhaps this is from not understanding the system or anticipating the side effects of actions; perhaps the system has changed; or perhaps strategic thinking and objectives have changed. In any case, the portfolio of instruments must be adjusted on different timescales (Figure 12.2).

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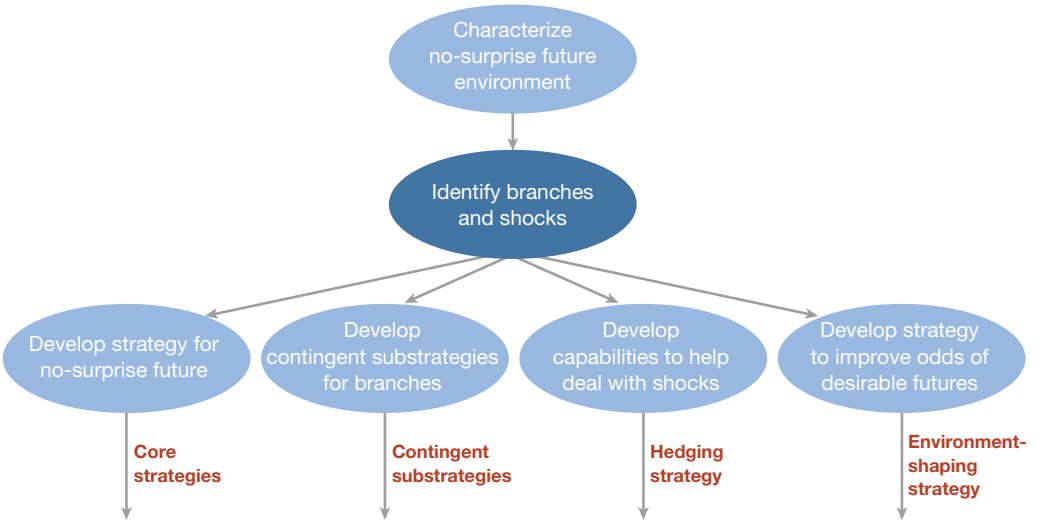
[23] In contrast, organizing around priorities can shortchange anything *not* on the priority list driven by headlines and recent events.

[24] Paul K. Davis, David Gompert, and Richard Kugler, *Adaptiveness in National Defense: The Basis of a New Framework*, Santa Monica, Calif.: RAND Corporation, IP-155, 1996.

FIGURE 12.1
Uncertainty-Sensitive Strategic Planning



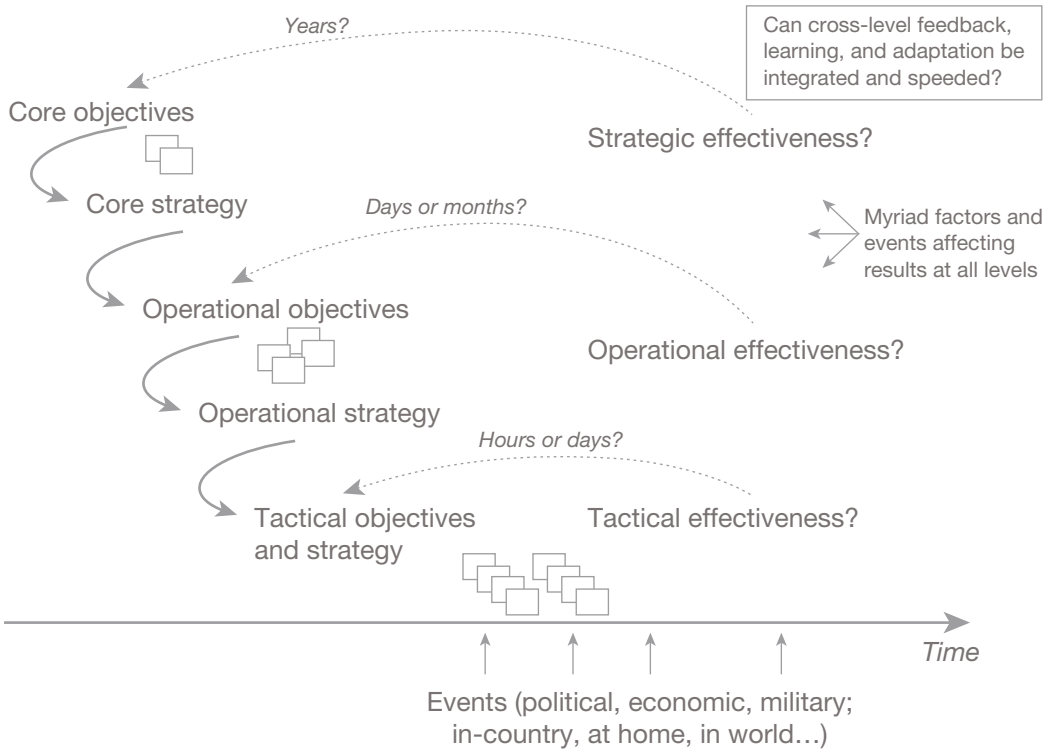
SOURCE: Adapted from Davis, Gompert, and Kugler, 1996.

NOTE: The depiction based on earlier collaboration with Paul Bracken, reflected in Paul K. Davis, *National Security Planning in an Era of Uncertainty*, Santa Monica, Calif.: RAND Corporation, P-7605, 1989; Paul Bracken, *Strategic Planning for National Security: Lessons from Business Experience*, Santa Monica, Calif.: RAND Corporation, N-3005-DAG/USDP, 1990.

This has long been recognized in principle, but the adaptations have often gotten short shrift. Furthermore, planners often see themselves as thinking, deciding, and then moving on to other matters—rather than attending to long-term processes adaptively. A similar attitude afflicts strategic planners and analysts. An important question is whether learning and adaptation can occur faster and more wisely, so that strategic, operational, and tactical adaptations are better synchronized and more effective *over time*.

Addressing this issue would probably require changes in organizational structure and doctrine, education of senior leaders, information systems, incentive structures, and analytic architecture. Such matters are far beyond the scope of this chapter but are quite important. It is relevant that some large corporations have relevant mechanisms as part of succession planning. Also, both civilian government agencies and military organizations are familiar with examples in which new commanders consciously build on their predecessor's work rather than overfocusing on how they can change everything.

FIGURE 12.2
Adapting Tactics and Strategies on Different Timescales



NOTE: The strategic, operational, and tactical levels of warfare correspond roughly with decisionmaking at the top political level, at a high military level, and at the point of execution.

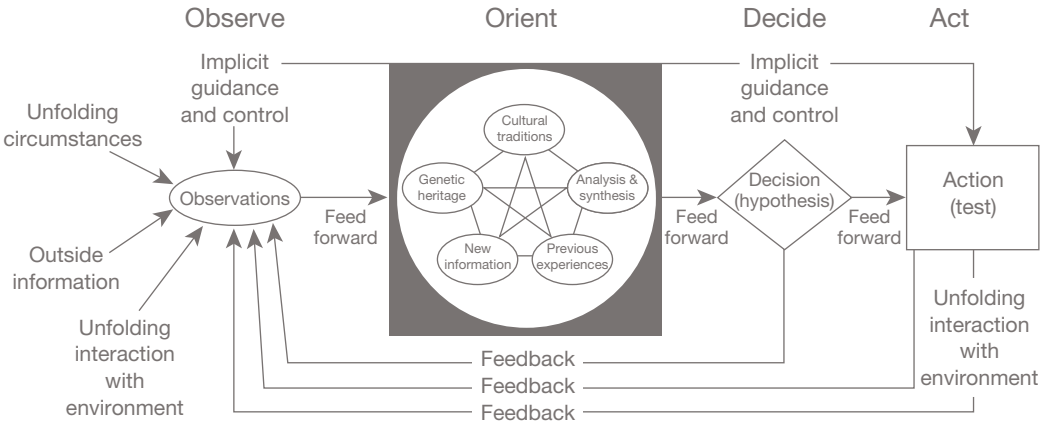
Metaphors for Thinking About Adaptations

Some authors describe adaptation challenges in terms of metaphors, such as John Boyd's Observe, Orient, Decide, Act (OODA) loop[25] (Figure 12.3) or more recently the Act-Sense-Decide-Adapt (ASDA) cycle, first proposed by the Australian Army. The ASDA cycle (Figure 12.4) is merely a variation of the OODA loop, but it has a bias toward action stemming from the belief that it is often necessary to interact strongly with a complex system to understand it. In some settings, doing so could provide valuable feedback on what works.[26] The need to interact applies well to information warfare, as in observing what messages catch on and foster desirable shifts of narrative, perhaps in days rather than months. In

[25] Digital copies of Boyd's famous six-hour briefing "Patterns of Conflict," circa 1986, can be found online. For a discussion applying this concept to the business world, see Chet Richards, *Certain to Win: The Strategy of John Boyd, Applied to Business*, Bloomington, Ind.: Xlibris US, 2004.

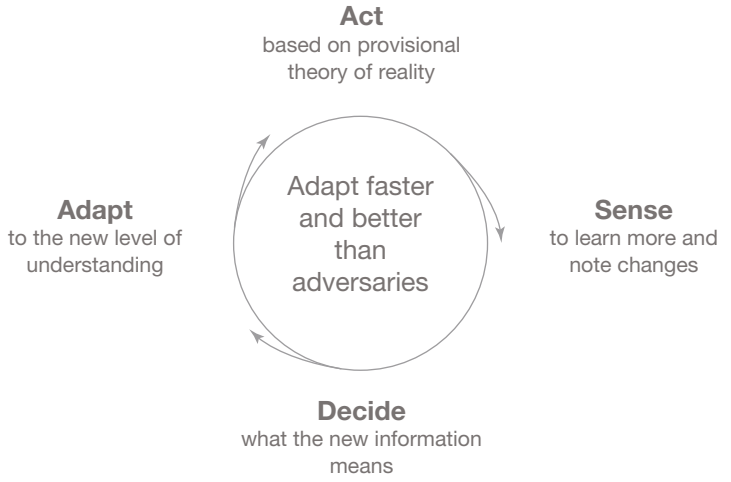
[26] Ron Kohavi and Stefan Theme, "The Surprising Power of Online Experiments," *Harvard Business Review*, October 2017.

FIGURE 12.3
Boyd's OODA Loop



SOURCE: Patrick Edwin Moran, "Diagram of the OODA Loop," Wikipedia, April 19, 2008, CC BY 3.0.

FIGURE 12.4
A Version of the ASDA Cycle



SOURCE: Adapted from Huba Wass de Czege, "Systemic Operational Design: Learning and Adapting in Complex Missions," *Military Review*, February 2009.

other settings, the approach suggests the need for on-the-ground personnel to understand

firsthand local narratives and how they are affected by events and information operations.[27] Again, one might aspire to this occurring within days or weeks, something perhaps possible with insertion of appropriate teams for such sensing, and related technology.

Huba Wass de Czege offers one depiction of the ASDA cycle.[28] Although he had military campaigns in mind, much of his discussion applies more generally. He defines *adaptive campaigning* as "the art of continually making sense of dynamic situations and evolving designs, plans, modes of learning, and actions to keep pace."[29]

One caution about both metaphors is that abbreviated descriptions emphasize the speed with which one can adapt. Clearly, however, the *quality* of the adaptation also matters greatly. An analytic architecture to assist adaptation must strive for *good* and timely adaptations—in part to avoid disruptive small adjustments of little consequence and in part to avoid serious errors.

System Thinking and Influence Diagrams

System thinking is crucial in strategic planning, as discussed in numerous books and papers.[30] Roughly speaking, it refers to framing problems in a way that recognizes *all* the contributors and processes contributing significantly to what is being addressed, such as critical components of machines, processes, and organizations; important interactions with the external environment; and different aspects of what the system does. System thinking contrasts with focusing on only one part of the system because it is the easiest for the organization to address, because it exhibits the most-evident distress signals, or because it is being stressed in

[27] There is need for social science relating to intervention operations that go beyond aloof quantitative analysis of aggregate data and get deeply into the system, as with field work or detailed case studies. For a review pointing toward original literature by Nicholas Sambanis and Stathis Kalyvas, among others, see Paul K. Davis, ed., *Dilemmas of Intervention: Social Science for Stabilization and Reconstruction*, Santa Monica, Calif.: RAND Corporation, MG-1119-OSD, 2011, p. 327.

[28] Wass de Czege, 2009.

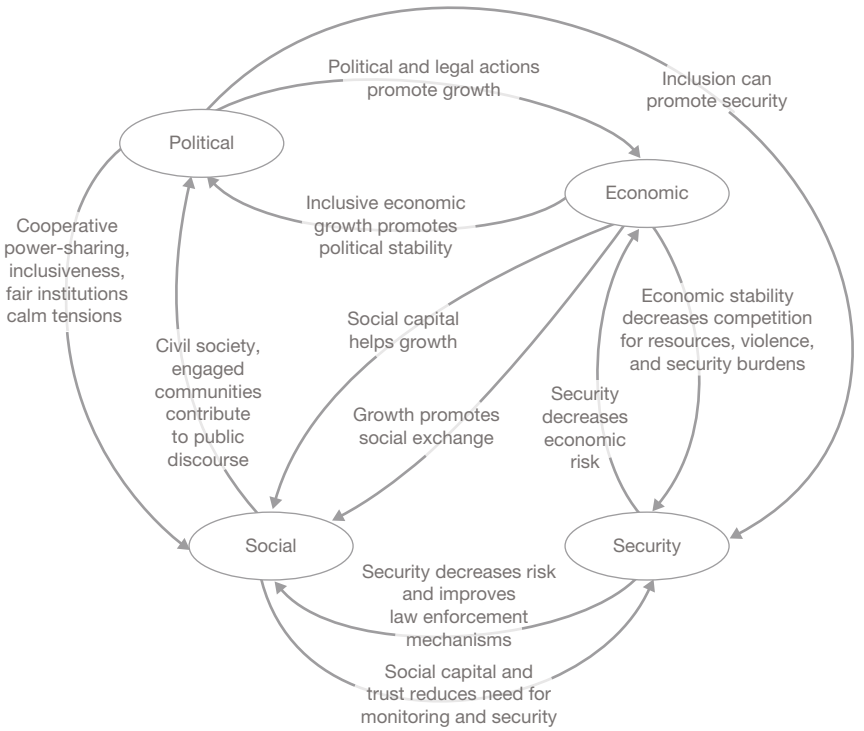
[29] Wass de Czege, 2009, p. 4.

[30] A sampling includes the following: Hugh J. Miser and Edward S. Quade, eds., *Handbook of Systems Analysis*, New York: North Holland Publishing Company, 1988; Russell L. Ackoff, *Ackoff's Best: His Classic Writings on Management*, New York: John Wiley & Sons, 2008; Peter Checkland, *Systems Thinking, Systems Practice (Includes a 30-Year Retrospective)*, Chichester, England: John Wiley & Sons, 1999; John D. Sterman, *Business Dynamics: Systems Thinking and Modeling for a Complex World*, Boston, Mass.: McGraw-Hill, 2000; and Peter M. Senge, *The Fifth Discipline: The Art & Practice of the Learning Organization*, New York: Penguin Random House, 2006. A recent paper discusses the need for policy studies to reembrace system thinking and modernize it for dealing with complex systems (see Paul K. Davis, Tim McDonald, Ann Pendleton-Jullian, Angela O'Mahony, and Osonde Osoba, "Reforming the Teaching and Conducting of Policy Studies to Deal Better with Complex Systems," Santa Monica, Calif.: RAND Corporation, EP-68721, 2021. [Reprinted from *Journal on Policy and Complex Systems*, Vol. 7, No. 1, 2021.])

headlines. It is also in contrast with the common approach of relegating many crucial matters to the set of exogenous factors.

Understanding complex systems is notoriously difficult. Diagrams are powerful ways to make sense of them. These have a variety of forms and names, but the term *influence diagram* conveys the sense of a diagram that shows how elements of the system relate to each other.[31] Figure 12.5 shows an influence diagram about how to establish trust and cooperation after a civil war.[32] It contains no information beyond that of purely textual material, but it summarizes

FIGURE 12.5
An Illustrative Influence Diagram



SOURCE: Wilke, Davis, and Chivvis, 2011.

[31] Related diagrams are referred to as mind maps, causal-loop and stock-and-flow diagrams, relevance diagrams, and system maps. Most are acyclic directed graphs. The term *influence diagram* is used generically here and in the modeling system Analytica®, but has a more specialized meaning in Bayesian networks.

[32] Elizabeth Wilke, Paul K. Davis, and Christopher S. Chivvis, "Establishing Social Conditions of Trust and Cooperation," in Paul K. Davis, ed., *Dilemmas of Intervention: Social Science for Stabilization and Reconstruction*, Santa Monica, Calif.: RAND Corporation, MG-1119-OSD, 2011.

relationships in an easily communicated way. Figure 12.5 is a higher-level depiction. Each bubble could be expanded to show a complicated substructure, perhaps at several layers of hierarchy. For example, the elements and relationships constituting the security component are numerous and complicated. Such layering can avoid system diagrams becoming incomprehensible.[33]

Such hierarchical system maps can summarize a great deal of knowledge about social systems—adding coherence to something that might otherwise seem unboundedly complicated. Doing so, however, is a major undertaking when one goes beyond vague abstractions and generalities. It requires specialized knowledge of the target system, tight reasoning, and a good deal of discussion and debate.

Portfolio Analysis

Portfolio Analysis for Structuring

As mentioned earlier, portfolio analysis is a good mechanism for framing strategic planning in a way that lends itself to periodic review and adaptation.[34] Such analysis does not optimize for some notion about the future; rather, it seeks to find strategy that strikes a sound *balance* across considerations given the tensions, uncertainties, and disagreements among decisionmakers. Some aspects of balance can be informed by historical experience or other empirically based information, but a sound balance also depends on judgments that are difficult to systematize because they involve so many considerations and value issues. No stable utility function exists.

A layered (multi-resolution) portfolio strategy can reflect actual strategy rather than just some one-line bumper sticker or some particularly visible single activity. That is, the initial activities of strategy use a particular mix of military, economic, and political instruments[35] in pursuit of multiple short-term operational objectives consistent as a whole with

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[33] Elisabeth Bumiller, "We Have Met the Enemy and He Is Power Point," *New York Times*, April 27, 2010. The article's depiction of a particular system dynamics diagram is humorous, but its hairball diagram reflected serious work to interpret counterinsurgency doctrine. It was useful to those involved (for more on this diagram, see Brett Pierson, Walter Barge, and Conrad Crane, "The Hairball That Stabilized Iraq: Modeling Fm 3-24," in A. Woodcock, M. Baranick, and A. Sciaretta, eds., *The Human Social Cultural Behavior Modeling Workshop*, Washington, D.C.: National Defense University, 2010) but was not suitable for broad communication.

[34] Davis, Gompert, and Kugler, 1996. The approach was inspired by financial portfolio analysis, as in Harry M. Markowitz, William F. Sharpe, and Merton H. Miller, *The Founders of Modern Finance: Their Prize-Winning Concepts and 1990 Nobel Lectures*, Charlottesville, Va.: Research Foundation of the Institute of Chartered Financial Analysts, 1991. That provided language, constructs, and metaphors. However, national security portfolio analysis must be very different from, for example, a pension fund's investments in stocks, bonds, and real estate. Historical empirical data are not a good basis for national security planning. For more evolved versions of the approach (and earlier references), see Paul K. Davis, *Analysis to Inform Defense Planning Despite Austerity*, Santa Monica, Calif.: RAND Corporation, RR-482-OSD, 2014.

[35] This set should include what others refer to as DIME (diplomatic, informational, military, and economic), DIME-FIL (diplomatic, informational, military, economic, financial, intelligence, and law enforcement),

long-term strategic objectives. Again, the approach is intended from the outset to support *adaptive strategy.*[36]

In the 2000s, the Under Secretary of Defense for Acquisition, Technology, and Logistics asked RAND to extend its strategic portfolio analysis methods to aid him in conducting capability area reviews. After studying the nature of such reviews and having extensive discussions with the Under Secretary, my team and I identified the items in Table 12.1 as requirements for a portfolio analysis tool. These were general and would apply for a portfolio analysis tool aiding strategy formulation for hybrid and political warfare.

The first requirement is to help decisionmakers orient themselves by seeing the multiple strategic objectives and how options address each of them. This means, for example, comparing options in a multi-criteria scorecard rather than just by some aggregate score. The next requirement is to be able to quickly see the basis for the top-level assessments. That is, the tool should allow drill-down or zooming to see at a glance how the options rate at a next level of detail and how that aggregates to the top-level assessment (Figure 12.6). My team and I sought to make this aggregation logic visually intuitive.[37] The next requirement would be the need to confront the ubiquitous *deep uncertainties* facing strategic decisionmakers.[38] This leads to the need to explore option consequences across the entire space of possibilities rather than clinging to the illusion of a meaningful best estimate and then doing token sensitivity analysis around it. This approach to strategic portfolio analysis has been applied in numerous applications.[39]

Table 12.2 illustrates a simplified scoreboard summary for notional strategies with different mixes of military, political, and economic actions. Options appear as rows. Second and sub-

PMESII (political, military, economic, social, information, and infrastructure), and PMESII-PT (political, military, economic, social, information, infrastructure, physical environment, and time).

[36] Davis, Gompert, and Kugler, 1996; Paul K. Davis, *Analytic Architecture for Capabilities-Based Planning, Mission-System Analysis, and Transformation*, Santa Monica, Calif.: RAND Corporation, MR-1513-OSD, 2002. Regrettably, *capabilities-based planning* sometimes has a negative connotation because of poor implementation in the early 2000s (see Appendix B in Davis, 2014).

[37] This is possible if top-level objectives are *critical* components, in which case a threshold level of effectiveness must be achieved for each. Stoplight charts can then quickly convey why a given option failed: Any option with even one failed component (shown in red) fails.

[38] Deep uncertainty exists "when the parties to a decision do not know or do not agree on the system model(s) relating actions to consequences or the prior probability distributions for the key input parameters to those model(s)." See Robert J. Lempert, Steven W. Popper, and Steven C. Bankes, *Shaping the Next One Hundred Years: New Methods for Quantitative Long-Term Policy Analysis*, Santa Monica, Calif.: RAND Corporation, MR-1626-RPC, 2003. This definition is now used internationally (see Chapter Eleven in this report [Popper, 2022]); and Vincent A. W. J. Marchau, Warren E. Walker, Pieter J. T. M. Bloemen, and Steven W. Popper, eds., *Decision Making Under Deep Uncertainty: From Theory to Practice*, Cham, Switzerland: Springer, 2019.

[39] See Davis, 2014. It mentions applications for the Assistant Secretary of Defense (Strategy and Resources) that influenced the first Quadrennial Defense Review in 1997, the Commander of the U.S. Missile Defense Agency in the mid-2000s, the Under Secretary of Defense for Acquisition, Technology, and Logistics from 2007 to 2008, and the Deputy Commander of the Joint Staff's Strategies, Plans, and Policy Recommendations directorate (J-5) in 2008.

TABLE 12.1

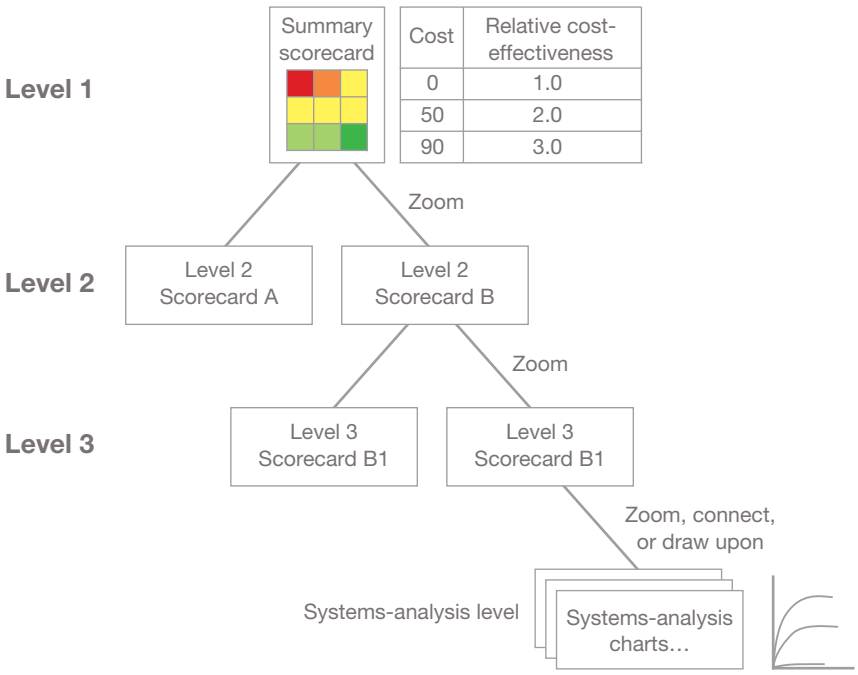
Requirements for Portfolio Analysis Tool for Aiding Strategic Decisionmaking

Requirement	Contrast
Summary multi-objective scoreboards	Ranking options by aggregate score
Drill-down (zooming)	Results without review of reasoning
Multi-resolution modeling and data entry	Single-level analysis, whether simple or detailed
Exploratory analysis across uncertainties and strategic perspectives	Sensitivities around best-estimate scenario; burying of strategic disagreements
Alternative aggregation methods for different purposes (e.g., five-year budgeting versus long-term strategy)	Not applicable

SOURCE: Adapted from Paul K. Davis, Russell D. Shaver, and Justin Beck, *Portfolio-Analysis Methods for Assessing Capability Options*, Santa Monica, Calif.: RAND Corporation, MG-662-OSD, 2008, p. 41.

FIGURE 12.6

Overview of Portfolio Analysis Approach



SOURCE: Davis, 2014, p. 44.

TABLE 12.2
Illustrative Scorecard

Strategy Options	Short-Term Effectiveness	Long-Term Effectiveness	Absence of Risk (after accounting for adaptations)	Net Attractiveness
1. Shows of force, modest sanctions	5	1	9	1
2. Strong economic sanctions, some shows of force	3	5	5	4+
3. Major covert action	5	5	1	1
4. Combination: show of force, sanctions, "white" covert action	5	7	5	6

NOTE: Evaluations account for adaptations, but options vary in how much adaptiveness they permit. Colors and numbers correspond to assessments of very bad (red, 1), bad (orange, 3), marginal (yellow, 5), good (light green, 7) and very good (green, 9).

sequent columns correspond to different evaluation criteria. The far-right column represents the net attractiveness of each option. Colors and numbers correspond to assessments of very bad (red, 1), bad (orange, 3), marginal (yellow, 5), good (light green, 7) and very good (green, 9). Often, various types of cost are shown in columns to the far right, although not in this case.

In this notional analysis, Option 1 is likely to have moderate success in the short term but has no long-term value. It would have very low risk. Because long-term effectiveness is very low (below a threshold of 3), the strategy is rated very poorly overall.

The second strategy is economics oriented and seems better but not impressive. The third focuses on a covert option (e.g., for regime change) and has the potential for great success but is regarded as quite risky. The last strategy is a combination with all instruments, but with a more deniable and less risky covert-action component; it is thought to be adaptive to events. Overall, it is the most attractive. At some future point in time, review of strategy might conclude that the portfolio should put more emphasis on economic sanctions or a different and covert operation. Or it might back away from covert activities because of unexpected negative consequences. Table 12.2 is a top-level assessment.

Table 12.3 is a drill-down or zoom on the last column of Table 12.2, the assessment of each strategy's net attractiveness. Table 12.4 is a drill-down to explain the assessments of worst-case outcomes in Table 12.3.

The evaluations in this layered portfolio analysis (i.e., the colors of the table's cells) might come from wargaming or simulation of test cases. Or they might be entered subjectively by experts familiar with past studies, wargames, and modeling exercises.

Strategic perspectives. An important aspect of strategic portfolio analysis is highlighting alternative *strategic perspectives*. Assessment of strategic-level decisions often depends sensitively on controversial judgments and values. These disagreements can often be highlighted by combining them artfully into two or three alternative perspectives (e.g., optimists versus pessimists, short-term versus long-term emphasis, hawks versus doves, or technology-push

TABLE 12.3
Zoom to Explain Net Attractiveness

Strategy Options	Most Likely Bad Consequences	Best-Case Bad Consequences	Worst-Case Bad Consequences	Net Absence of Risk
1. Shows of force, modest sanctions	9	9	5	9
2. Strong economic sanctions, some shows of force	3	5	5	5
3. Major covert action	5	7	1	1
4. Combination: show of force, sanctions, "white" covert action	5	9	5	5

NOTE: All evaluations allow for adaptations, which will be better in best cases and poorer in worst cases. Some options allow for more adaptiveness than do others. Colors and numbers correspond to assessments of very bad (red, 1), bad (orange, 3), marginal (yellow, 5), good (light green, 7) and very good (green, 9).

TABLE 12.4
Zoom to Explain Worst-Case Bad Consequences

Strategy Options	Operational Consequences, Worst Case	Domestic Blowback, Worst Case	International Blowback, Worst Case	Net Worst-Case Consequences
1. Shows of force, modest sanctions	5	5	5	5
2. Strong economic sanctions, some shows of force	5	5	5	5
3. Major covert action	3	1	3	1
4. Combination: show of force, sanctions, "white" covert action	5	5	5	5

NOTE: Colors and numbers correspond to assessments of very bad (red, 1), bad (orange, 3), marginal (yellow, 5), good (light green, 7) and very good (green, 9). The evaluations account for estimated adaptations.

versus demand-pull). Noting disagreements is often of great interest to policymakers who are distrustful of aggregate scores.

Top-level objectives. Portfolio-analysis work should begin by identifying top-level objectives, which are often in tension, contradictory, or too sensitive to mention.[40] For this chapter, some possible top-level objectives to be considered are

- establishing and enforcing agreed international norms that severely limit interference in internal affairs
- retaining flexibility for covert actions deemed in national interest

[40] As an example, all can agree on the benign objective of deterrence, but the United States also has objectives as nurturing friendly governments and weakening unfriendly ones. To a U.S. adversary, those objectives constitute threats.

- defeating and eradicating violent extremism (including the violent Islamic extremism with which the United States has been at war for two decades)
- reversing trends toward governments hostile to the West
- fostering growth of liberal-democratic governments and reversing trends toward autocracies
- assuring U.S. access to critical resources
- fostering commerce in ways favorable to the United States
- promoting respect for and trust in the United States and its policies.

The tensions among these should be evident.

Different portfolio structures for different purposes. Even strategic planning requires taking diverse perspectives. The paradigm of portfolio analysis with drill-down is widely applicable, but different specializations are needed—for example, for planning on five-year or 20-year horizons, or planning for a mix of operations rather than a mix of experimental probes or planning for a mix of new technologies and tactics. Such matters are illustrated elsewhere.[41]

The Objective of Strategic Portfolio Analysis: FARness

The strategic portfolio analysis, as presented here, is intended to assist in finding strategies (options) that address the sometimes inconsistent objectives that are common in strategic planning. As elaborated elsewhere,[42] the intent should be to find a strategy that is flexible, adaptive, and robust—that is, one that exhibits the elements of "FARness." This might seem obvious. Why would one *not* want such a strategy? In practice, however, this philosophy profoundly affects analysis and decisionmaking. The reality is that the strategy chosen today will affect the ability to deal with events later, but one cannot reliably predict those events or the circumstances in which they will occur. Furthermore, even if consensus exists on the strategy's objectives and constraints, those factors will often change (e.g., how this occurred in the years after the United States invasion of Iraq). It may also be necessary to respond to unanticipated shocks (either adverse or fortuitous). Therefore, one concern is whether the strategy pursued will be able to deal adequately with all of these issues. Will it be flexible enough to allow changes of strategy, will it provide adaptiveness sufficient to cope with new circumstances, and will it be resistant to or resilient (robust) after adverse shock and able to exploit fortuitous developments?

Planning for FARness can be difficult. Often, the tyranny of the best estimate will manifest itself in numerous ways: "We won't need ___ because that scenario simply won't happen; instead, we need to focus on our top priority and put our resources against that!"

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[41] Paul K. Davis, Stuart E. Johnson, Duncan Long, and David C. Gompert, *Developing Resource-Informed Strategic Assessments and Recommendations*, Santa Monica, Calif.: RAND Corporation, MG-703-JS, 2008.

[42] See Davis, 2014, and references therein. This relates closely to Robust Decision Making as discussed in Chapter Eleven of this report (Popper, 2022).

In nonmilitary domains, planning for FARness relates, for example, to governments securing property rights that would *allow* them to expand the width of rivers far beyond that required to deal with forecast sea levels, or to governments developing contracting relationships that would allow them to buy more vaccines as necessary depending on how the coronavirus disease 2019 (COVID-19) pandemic develops.

Although most people understand the virtues of buying insurance for automobile accidents, home fires, or health disasters, these same people—and politicians, governments, and corporations—often seek to cut costs that are thought of as probably unnecessary. That is seriously wrongheaded. How much insurance is enough, of course, is an important question. An important role for portfolio analysis is illustrating ways in which modest investments can buy a great deal of insurance.

Qualitative Modeling for Integrating Knowledge

Where does the knowledge to construct and evaluate options come from? Quantitative analysis is sometimes possible based on empirical data, but an analytic architecture should also make good use of qualitative methods. Fortunately, there is, within social science, increased appreciation for qualitative knowledge. This has come as an antidote to decades of excessive focus on quantitative methods that were once touted, mistakenly, as more objective and scientific. What follows touches lightly on a few types of qualitative modeling that might be valuable in codifying knowledge about great-power competition in hybrid and political warfare, sometimes over UGS.

Factor Trees

Purely Qualitative Versions

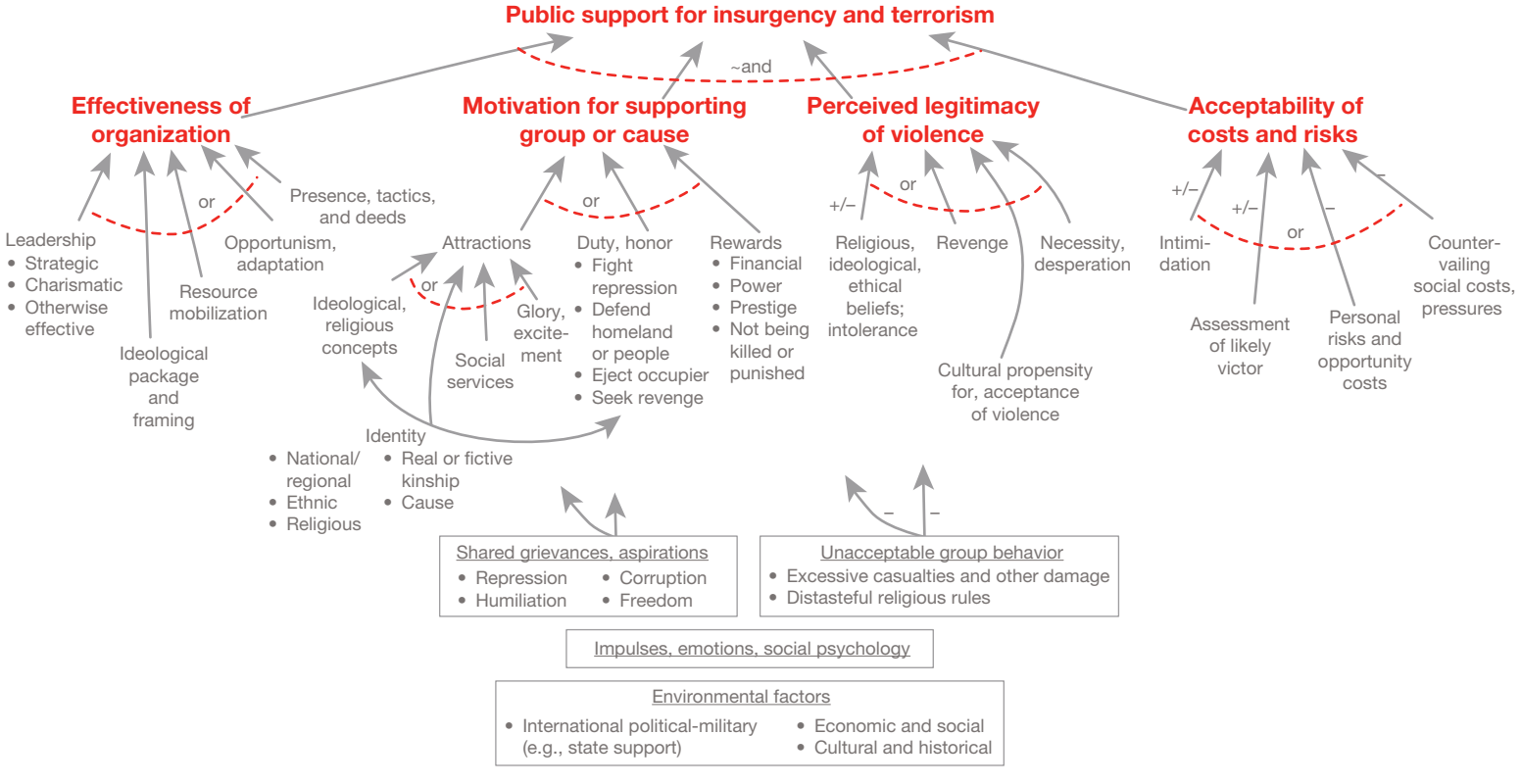
Factor trees are diagrams that have proven suitable for convergent communication, discussion, and classroom instruction. They are similar, in some respects, to system diagrams, but they characterize the primary factors driving an outcome *at a snapshot in time*. They suppress dynamics, particularly feedback loops, and relatively weak interactions. They provide a broad, top-down summary view. First introduced in counterterrorism research, they have been used in a variety of applications.[43] Figure 12.7 is an example and relates to the issue of the strength of public support for insurgency and terrorism (in a particular country at a particular time) and what it depends on.

The factor tree is a layered (multi-resolution) depiction. At the top level of Figure 12.7, four factors are said to determine public support: the effectiveness of the terrorist organization,

[43] Paul K. Davis and Angela O'Mahony, "Representing Qualitative Social Science in Computational Models Under Uncertainty: National Security Examples," *Journal of Defense Modeling and Simulation*, Vol. 14, No. 1, 2017.

FIGURE 12.7

A Factor Tree for Public Support for Insurgency and Terrorism



SOURCE: Davis et al., 2012.

NOTES: Applies at a snapshot in time. Current factor values can affect future values of some or all other factors.

the public's motivation for supporting the organization's cause, the degree to which the public perceives the organization's use of violence as legitimate, and the acceptability to members of the public of the costs and risks associated with support. Each of these factors is determined by one or several layers of more-detailed factors and some global factors (bottom).

Despite being relatively simple and discussable, this factor tree reflects substantial research: a review of relevant scholarly literature,[44] sensitive empirical data from Iraq and Afghanistan, and case studies testing (validating) its initial version.[45]

Substantively, the tree encapsulates a good deal of analytical information. In this case, the factor tree asserts that—to a first approximation—*all* four major factors must be present for public support to be significant (indicated by an "~and"). This suggests, consistent with the literature, that public support for terrorism can collapse for any of several reasons. Moving a level deeper, however, the subfactors are connected in most cases by an "or," which means that they are substitutable: Cutting off one such subfactor might accomplish nothing because other subfactors would be sufficient.[46] The arrows also have valence: Does more of a factor tend to increase or decrease the higher-level effect? Or can the effect be either positive or negative depending on contextual detail?

The factors of a factor tree are intended to be comprehensive, with the tree integrating previously fragmented knowledge and theory. For example, when the report generating Figure 12.7 was written, heated debates existed about the basis for public support (e.g., religious extremism, relative deprivation, oppressive government, or calculations about whether government or insurgency would win). In truth, *all* such factors and others can contribute. The factors' relative salience depends on the time and place, but—as stressed by RAND colleague Eric Larson in our past work—the factor tree displays the repertoire of factors that can be exploited by either government or insurgent leaders to suppress or enhance support.[47]

Computational Versions

In some cases, it can be useful to map a qualitative factor tree into a computational model. This enables broad exploratory analysis to understand what alternative combinations of factors would produce good or bad outcomes. The result is still qualitative in the sense of being approximate, rough, and imprecisely defined, but it can be used for systematic exploratory analysis. Such a mapping is nontrivial, because all the factors must be defined and combin-

[44] Christopher Paul, "How Do Terrorists Generate and Maintain Support?" in Paul K. Davis and Kim Cragin, eds., *Social Science for Counterterrorism: Putting the Pieces Together*, Santa Monica, Calif.: RAND Corporation, MG-849-OSD, 2009.

[45] Paul K. Davis, Eric V. Larson, Zachary Haldeman, Mustafa Oguz, and Yashodhara Rana, *Understanding and Influencing Public Support for Insurgency and Terrorism*, Santa Monica, Calif.: RAND Corporation, MG-1122-OSD, 2012, pp. 113–209.

[46] These relate to what J. L. Mackie called INUS conditions when discussing causality. The acronym stands for *insufficient but nonredundant part of an unnecessary but sufficient condition*. A brief discussion appears in JRank Science & Philosophy, "Causality: Inus Conditions," webpage, undated.

[47] Davis et al., 2012.

ing rules specified at the nodes. As a proof of concept, RAND colleague Angela O'Mahony and I developed and documented such a model for the case of Figure 12.7.[48] Some highlights of that work appear in our contribution to a special issue of the *Journal of Defense Modeling and Simulation* that focuses on representing social science in national security simulation.[49]

Other Qualitative or Semi-Qualitative Methods

Other qualitative methods exist for making sense of social-science phenomena, such as the foundational theory-building methods of Alexander George, which exploit and suggest the structuring of case studies;[50] Bart Kosko's fuzzy cognitive maps;[51] Charles Ragin's Qualitative Comparative Analysis (QCA);[52] and narrative analysis.[53] These and factor-tree meth-

[48] Paul K. Davis and Angela O'Mahony, *A Computational Model of Public Support for Insurgency and Terrorism: A Prototype for More-General Social-Science Modeling*, Santa Monica, Calif.: RAND Corporation, TR-1220-OSD, 2013.

[49] Davis and O'Mahony, 2017. The special issue also contains several other relevant articles: Rouslan Karimov and Luke J. Matthews, "A Simulation Assessment of Methods to Infer Cultural Transmission on Dark Networks," *Journal of Defense Modeling and Simulation*, Vol. 14, No. 1, 2017; Osonde A. Osoba and Bart Kosko, "Fuzzy Cognitive Maps of Public Support for Insurgency and Terrorism," *Journal of Defense Modeling and Simulation*, Vol. 14, No. 1, January 2017, pp. 17–32; Yuna Huh Wong, Michael Bailey, Karen Grattan, C. Steve Stephens, Robert Sheldon, and William Inserra, "The Use of Multiple Methods in the Joint Irregular Warfare Analytic Baseline (JIWAB) Study," *Journal of Defense Modeling & Simulation*, Vol. 14, No. 1, 2017; and Aaron B. Frank, "Toward Computational Net Assessment," *Journal of Defense Modeling and Simulation*, Vol. 14, No. 1, 2017.

[50] Alexander L. George and Andrew Bennett, *Case Studies and Theory Development in the Social Sciences*, Cambridge, Mass.: MIT Press, 2005.

[51] See Osoba and Kosko, 2017; Osonde Osoba and Bart Kosko, "Causal Modeling with Feedback Fuzzy Cognitive Maps," in Paul K. Davis, Angela O'Mahony, and Jonathan Pfautz, eds., *Social and Behavioral Modeling for Complex Systems*, Hoboken, N.J.: John Wiley & Sons, 2019.

[52] Charles C. Ragin, *The Comparative Method: Moving Beyond Qualitative and Quantitative Strategies*, Los Angeles, Calif.: University of California Press, 1989; and Charles C. Ragin, *Fuzzy-Set Social Science*, Chicago, Ill.: University of Chicago Press, 2000. A chapter-length description characterizes QCA and gives its epistemological foundations: Dirk Berg-Schlosser, Giséle De Meur, Benoît Rihoux, and Charles C. Ragin, "Qualitative Comparative Analysis (QCA) as an Approach," in Benoît Rihoux and Charles C. Ragin, eds., *Configurational Comparative Methods: Qualitative Comparative Analysis (QCA) and Related Techniques*, Thousand Oaks, Calif.: Sage, 2020. The method has been applied in an insurgency analysis (see Christopher Paul, Colin P. Clarke, Beth Grill, and Molly Dunigan, *Paths to Victory: Detailed Insurgency Case Studies*, Santa Monica, Calif.: RAND Corporation, RR-291/2-OSD, 2013).

[53] Steven R. N. Corman, "Understanding Sociocultural Systems Through a Narrative Lens," in L. L. Brooks, B. Strong, M. Zbylut, and L. Roan, eds., *A Sociocultural Systems Primer for the Military Thinker: Multidisciplinary Perspectives and Approaches*, Leavenworth, Kan.: U.S. Army Research Institute, 2012; Rita Parhad, Anastasia Norton, Seth Sullivan, Alysha Bedig, and Jordan D'Amato, "Middle East and North African (Mena) Regional Narratives About the Post-Isil Future," in Allison Astorino-Coutois, Sarah Canna, Sam Rhem, and George Popp, eds., *White Paper on SMA Support to SOCCENT: ISIL Influence and Resolve*, Washington, D.C.: NSI for the Strategic Multi-Layer Assessment (SMA), U.S. Department of Defense, September 2015; and Christopher Paul, "Homo Narratus (the Storytelling Species): The Challenge (and Importance) of Modeling Nar-

ods seem potentially well suited to the challenge of planning for adaptiveness in complex adaptive systems (CAS).

Needed: New Qualitative Methods for Rebalancing the Portfolio

Earlier applications of strategic portfolio methods to U.S. Department of Defense (DoD) planning focused primarily on military capabilities. For those purposes, it was appropriate to use suitably chosen warfare-scenario sets as test cases when evaluating strategies. However, for adjusting portfolio strategies that address hybrid warfare threats, new analytical methods will be necessary. Some should be akin to what corporations use when adjusting their portfolios. If the past portfolio provided a mix of business-as-usual investment and more experimental investments (e.g., introducing a new product, entering a new market, or research and development to generate new products), then rebalancing the portfolio should involve killing off investments that are not proving fruitful or promising and putting more money into efforts that are doing so.[54] For investment in hybrid and political warfare, the issues might be as follows:[55]

- What is the likely and possible payoff for the United States in engaging in a particular long-term competition's hybrid and political warfare? What are the risks?
- Which elements of previous strategy are succeeding, not succeeding, or worse? Should some elements be deleted? Should some be better supported and, if so, how? Why would such additional support for existing activities be expected to pay off?
- Are past failures from inadequate coordination across government agencies? If so, what might improve the situation (e.g., more military training of an ally and more economic aid to an ally showing notable economic progress limited by capital? What are the likely and possible payoffs, risks, and costs?

Such questions are merely sensible and normal. However, the analytic means for answering them are not as well developed, much less systematic; nor is there a norm of routine review followed by significant adjustments.

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

[54] This is related to the financial world's *real options theory*. See also Chapter Five (Gabrielle Tarini and Kelly Elizabeth Eusebi, "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).

[55] Anthony Cordesman suggests analogous questions for when a new President's administration thinks about committing to "long engagements rather than long wars" (see Anthony H. Cordesman, *The Biden Transition and Reshaping U.S. Strategy: Long Engagements vs. Long Wars*, commentary, Washington, D.C.: Center for Strategic & International Studies, December 9, 2020).

Gaming and Game-Structured Simulation for Exploration

Another way to collect ideas and create coherent knowledge involves a combination of gaming, game-structured simulation, and model-based analysis.

Gaming

The virtues of human wargaming have been rediscovered in recent years. Books on the subject exist,[56] as do professional conferences.[57] Another chapter in this report is devoted to gaming.[58] The shortcomings of human wargaming are also well known (Table 12.5). My own view is that wargaming, modeling, and analysis should be pursued in an integrated manner,[59]

TABLE 12.5
Gaming, Simulation, and Synthesis

Characteristic	Human Gaming	Normal Modeling and Simulation	Game-Structured Simulation
Decisionmaking	Human teams	Algorithms	Interchangeable: humans or artificial intelligence (AI) agents
Rigorously repeatable	No	Yes	Yes
Quantitative	No	Yes	As appropriate
Realistic about human actions; for example, creative actions trick	Relatively, yes	No; scripted actions	Potentially yes, through use of human teams and AI

NOTE: Considerable rigor of different types can be achieved. A review of human gaming, its "renaissance within political science," and opportunities for researchers can be found in Erik Lin-Greenberg, Reid Pauly, and Jacquelyn Schneider, *Wargaming for Political Science Research*, Rochester, N.Y.: Social Science Research Network, SSRN Scholarly Paper, February 17, 2021. A 2020 dissertation provides structured guidance on how to increase the social-science quality of wargaming as a function of the game's purpose—for example, exploration, innovation, or evaluation (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).

[56] Peter P. Perla, *Peter Perla's the Art of Wargaming: A Guide for Professionals and Hobbyists*, 2nd ed., John Curry, ed., lulu.com, 2012; and Matthew B. Caffrey, *On Wargaming: How Wargames Have Shaped History and How They May Shape the Future*, Newport, R.I.: Naval War College Press, 2019.

[57] Phillip Pournelle, ed., *MORS Wargaming Special Meeting, October 2016: Final Report*, Alexandria, Va.: Military Operations Research Society, 2017.

[58] Elizabeth M. Bartels, Aaron B. Frank, Jasmin Léveillé, Timothy Marler, and Yuna Huh Wong, "Gaming Undergoverned Spaces: Emerging Approaches for Complex National Security Policy Problems," 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.

[59] Paul K. Davis, "An Analysis-Centric View of Wargaming, Modeling, Simulation, and Analysis," in Andreas Tolk, Charles Turnitsa, and Curtis Blais, eds., *Simulation and Wargaming*, Hoboken, N.J.: John Wiley & Sons, 2022.

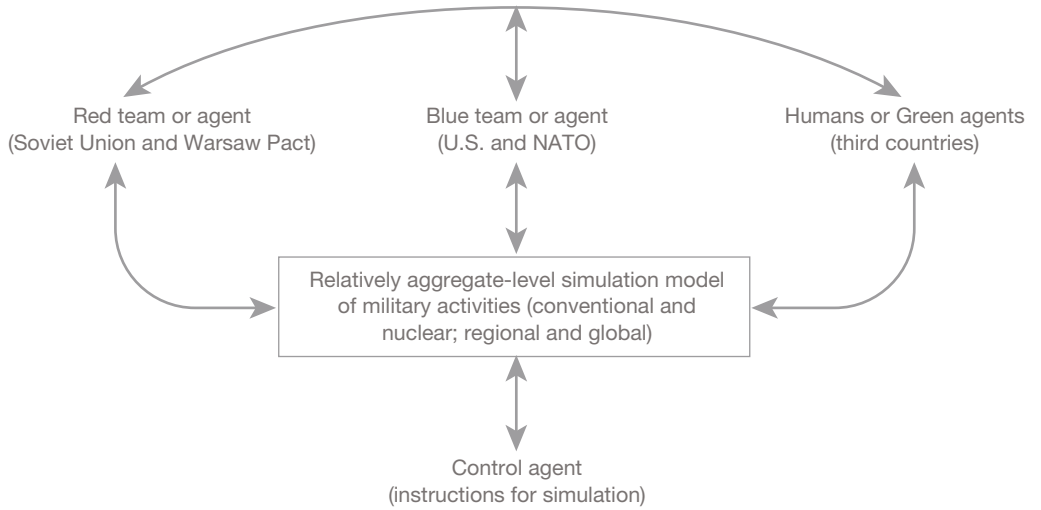
although allowing for and appreciating differences in style and culture across the communities of gamers, modelers, and analysts.

Game-Structured Simulation

Game-structured simulation is when the primary decisionmaking is made by model agents that mirror the human teams of a wargame.

The most historically ambitious effort in game-structured simulation started in 1981 after a decision by the Secretary of Defense and a formal competition of concepts.[60] The origin of the effort was concern about an analysis of the strategic nuclear balance with the Soviet Union, but the ideas about analysis carried over. The winning proposal in the competition suggested that automated wargaming could employ AI agents interchangeably with human teams.[61] After a thinking period before actual development, a substantially modified concept was laid out.[62] It was then implemented as the RAND Strategy Assessment System (RSAS), the architecture for which is shown in Figure 12.8.

FIGURE 12.8
RSAS Architecture



[60] Andrew M. Marshall, "A Program to Improve Analytic Methods Related to Strategic Forces," *Policy Sciences*, Vol. 15, No. 1, 1982.

[61] Morlie H. Graubard and Carl H. Builder, "New Methods for Strategic Analysis: Automating the War-Game," *Policy Sciences*, Vol. 15, 1982.

[62] Paul K. Davis and James A. Winnefeld, *The RAND Strategy Assessment Center: An Overview and Interim Conclusions About Utility and Development Options*, Santa Monica, Calif.: RAND Corporation,

The challenges then and now were very different. The military aspects of the RSAS featured a large simulation of kinetic warfare (the Joint Integrated Contingency Model, which is still used today), whereas this chapter relates more to war in the shadows and cyberspace. The higher-level decisions by the Red and Blue agents of the RSAS were about whether to engage in large-scale conventional warfare, limited nuclear warfare, or general nuclear warfare. The game was largely two-sided, between the Soviet Union–Warsaw Pact and the United States–NATO. The RSAS also used a Green agent, an assemblage of simple models representing the many other countries in play, sometimes with important roles (e.g., Soviet teams or models might be deterred by French nuclear weapons; basing permissions were required and might be delayed). Nonetheless, a richer depiction would be necessary for the work of interest in this chapter.

Notably, the RSAS had multi-resolution features, which enhanced comprehensibility and explainability; it also enabled theretofore impossible uncertainty analysis in many dimensions. As examples of multi-resolution features, the RSAS could use a scripted model for strategic mobility or a more-sophisticated model accounting for details of ship movements, port capacities, and the like. A combat model might reflect logistics with a simple days-of-supply and rate-of-resupply method or something more elaborate. Political models could make decisions based on simple situational assessments or more-sophisticated "look ahead" calculations (running the simulation within itself to estimate the consequences of one or another strategy).

The RSAS could represent actions and adaptations on different timescales: tens of minutes for nuclear missile exchanges; hours for commander decisions about where to send fresh troops; days for theater commanders to make decisions about changes of strategy (often with back-and-forth communication with national leaders); and minutes to days or weeks for national leaders deciding on major changes of strategy, including escalation or de-escalation. There was no attempt to simulate, even speculatively, events over a period of months.[63]

The concept of using game-structured simulation with AI models and teams being interchangeable is apt for the challenge of this chapter. Some admonitions are appropriate, however:

- The AI models needed should be *cognitive models*—models based on the kind of factors and reasoning attempted by high-level decisionmakers (e.g., about adversary intentions

R-2945-DNA, 1983; and Paul K. Davis, "Simple Culture-Informed Models of the Adversary," in Colette Faucher, ed., *Advances in Culturally-Aware Intelligent Systems and in Cross-Cultural Psychological Studies*, Cham, Switzerland: Springer International Publishing, 2018.

[63] DoD was interested in studying protracted nuclear war because the Soviet Union prepared for it, but we failed to find a credible path for doing so with the RSAS. Human gaming would have been more suitable.

and the concrete political, military, and economic risks of various options), not data-driven machine-learning (ML) algorithms.[64] They should be able to reason.[65]

- Such models should be more thoughtfully cognitive than typical Agent-Based Modeling (ABM). They should behave in ways informed by history, human gaming, and political science. Alternative behaviors would be important to consider. Behaviors might be unscrupulous and low-minded actions in single-minded pursuit of narrow national gain or—to the contrary—might be high-minded, as in honoring international rules of the road and reflecting defensive strategy rather than aggression. This would require alternative models along with variable parameters.[66]
- The content of the AI models should be guided by in-depth research rather than by aggregate quantitative political science or superficial elicitations of expert opinion.

Although the 1980s RSAS incorporated a good deal of complexity and its simulations often generated surprising events (i.e., events that might not have been anticipated before the simulation), the RSAS predated many insights that we now associate with the theory of CAS. Furthermore, model-building technology was far more primitive. Moreover, the RSAS was not stochastic, and the rules driving agent behavior were motivated more by top-down theoretical considerations than by bottom-up mechanisms that often produce emergent behaviors in CAS.

A modern version of the RSAS would be better able to generate complex developments, such as realistic emergent behaviors, and to do so with *n*-party game-structured simulation.

It is doubtful that such work would be usefully predictive: The behavior of CAS is famously sensitive to initial conditions and random events along the way. Or to be more careful, CAS are sometimes sensitive to such things, depending on where the CAS is in its state space. A frontier issue in social-behavioral modeling is how to recognize when a real-world CAS is in a portion of its state space that permits reasonably predictable and controllable interventions or whether its state is such that interventions will have highly unpredictable consequences, including some that are seriously counterproductive.

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[64] For a short survey of ML and AI for social-behavioral modeling, see Osonde Osoba and Paul K. Davis, "An Artificial Intelligence/Machine Learning Perspective on Social Simulation: New Data and New Challenges," in Paul K. Davis, Angela O'Mahony, and Jonathan Pfautz, eds., *Social and Behavioral Modeling for Complex Systems*, Hoboken, N.J.: John Wiley & Sons, 2019.

[65] ML and AI can find algorithms that reproduce complex behaviors exhibited in past data, but that is different from AI that can reason about future possibilities. As Judea Pearl has discussed, AI is still not good at cause-effect relations, but it will be. See Kevin Hartnett, "How a Pioneer of Machine Learning Became One of Its Sharpest Critics," *The Atlantic*, May 19, 2018; and Judea Pearl and Dana Mackenzie, *The Book of Why: The New Science of Cause and Effect*, New York: Basic Books, 2018.

[66] The RSAS used alternative Red and Blue agents with different objectives, personalities, and cognitive styles. Each agent made decisions based on context. As a result, "war fighting" models were sometimes eager to de-escalate, while deterrence-emphasizing models were sometimes willing to escalate ruthlessly. See also Paul K. Davis, "Lessons on Decision Aiding for 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, p. 917.

Recent Work Using Computational Gaming

In recent years, considerable research has sought to exploit human gaming through computational methods. Some examples: (1) online games, including massively multiplayer online games, are used in deterrence-related studies;[67] (2) online gaming and game communities are studied as a source of social and cultural data;[68] and (3) new methods of simulation analytics are under development.[69]

Uncertainty-Sensitive Cognitive Modeling

Colleagues and I have recently used a very low-tech version of the RSAS-related ideas in a study of how to influence peer competitors in crisis or conflict.[70] One DoD approach had been to construct adversary models using a host of expert inputs, attach some Bayesian updating features, and use the model itself to predict adversary behavior. We instead suggested an approach that combines human exercises with analytical thinking. Participants in an exercise develop very simple *alternative* models of how the adversary is reasoning (i.e., cognitive models), develop possible strategies for influencing that reasoning under uncertainty, and then adjust the strategies to be more adaptive—adaptive enough to be plausibly effective across many adversary models. The intent is to overcome the "tyranny of the best estimate," avoiding errors at both extremes: villainizing the adversary and assuming war is inevitable or, to the contrary, assuming the best about the adversary and becoming vulnerable to surprises. An analogous approach could be taken when addressing challenges of gray-area conflict and political warfare, including those involving UGS.

Special Challenges for Methods and Tools

Connecting Levels of Analysis

A recurring theme in this chapter has been the need for multi-resolution analysis. Although it is common to imagine that what is needed is a maximally detailed model that can generate

[67] Kiran Lakkaraju, Laura Epifanovskaya, Mallory States, Joshua Letchford, and Jason Reinhardt, "Online Games for Studying Behavior," in Paul K. Davis, Angela O'Mahony, and Jonathan Pfautz, eds., *Social-Behavioral Modeling for Complex Systems*, Hoboken, N.J.: John Wiley & Sons, 2019.

[68] Sean Guarino, Leonard Eusebi, Bethany Bracken, and Michael Jenkins, "Using Sociocultural Data from Online Gaming and Game Communities," in Paul K. Davis, Angela O'Mahony, and Jonathan Pfautz, eds., *Social-Behavioral Modeling for Complex Systems*, Hoboken, N.J.: John Wiley & Sons, 2019.

[69] Samarth Swarup, Achla Marathe, Madhav V. Marathe, and Christopher L. Barrett, "Simulation Analytics for Social and 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.

[70] Paul K. Davis, Angela O'Mahony, Christian Curriden, and Jonathan Lamb, *Influencing Adversary States: Quelling Perfect Storms*, Santa Monica, Calif.: RAND Corporation, RR-A161-1, 2021.

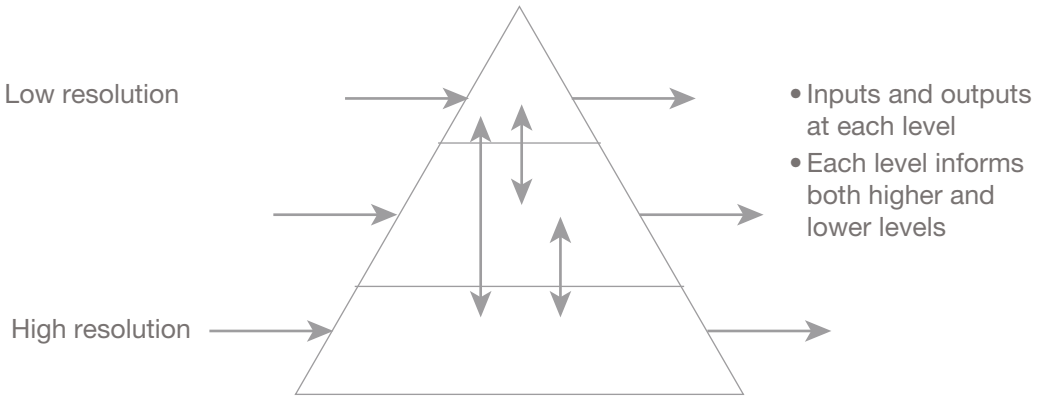
lower-resolution implications by aggregation, the reality is that our knowledge depends on the iterative exchange of information across alternative levels of detail and through alternative lenses, as suggested schematically in Figure 12.9.[71] Often, much of the best information is low-resolution in nature; other times, details matter, and high-resolution thinking and modeling are essential.

The simplicity of many diagrams (e.g., Figure 12.9, the factor tree of Figure 12.7, or the system dynamics diagram of Figure 12.5) gloss over some crucial matters: What happens as the result of the arrows? *How* does information from one level get turned into information at another? *How* do the factors influencing a node of a factor tree combine? The default assumptions usually are that aggregation is simple averaging and that combining is a linear process. This is profoundly wrong, but there is no well-developed theory on how to think about such matters systematically, nor modeling tools for doing so intelligently and efficiently. Instead, modelers develop ad hoc approaches that are sometimes sensible and sometimes quite misleading. Doing better is a frontier topic for social-behavioral modeling and analysis.[72]

To illustrate issues, consider the problem of anticipating the adversary's reaction if the United States takes a particular offensive measure. Should one assume the logical and coordinated reaction of all adversary officers, a distribution of responses from imperfect coordination, or what? Or will the reactions follow rigid doctrine, whether or not logical for the circumstances? Such questions are familiar to commanders but not systematically represented in theories and models.

Such issues arise *routinely* when working across levels of resolution. As a matter of theory, the correct way to aggregate and disaggregate will depend not only on context, but

FIGURE 12.9
The Two-Way Flow of Information Across Levels



[71] Paul K. Davis and James H. Bigelow, *Experiments in Multiresolution Modeling (MRM)*, Santa Monica, Calif.: RAND Corporation, MR-1004-DARPA, 1998.

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

on how the estimates will be used. It should be possible to lay logical and pragmatic foundations on how to deal with such matters and to build software methods and tools to assist in doing so, but for a variety of intellectual and organizational reasons that challenge has not yet been undertaken.

One explanation of this failure has to do with camps within the analytical world. For example, different camps exist for system dynamics method and for ABM. Connections between the two are few. The reasons are in part historical. ABM as we usually think about it in 2020 has largely evolved from developments in the 1980s and 1990s associated with the Sante Fe Institute.[73] Such work is bottom-up in character, with a paradigm of investing individual-level agents with simple rule sets that generate emergent phenomena similar to important phenomena observed in the real world. A substantial literature illustrates how such ABM can relate to topics as diverse as racial segregation and collapse of societies. A textbook for the *NetLogo* language has many examples.[74]

System dynamics work has a more top-down character and represents dynamics in terms of macroscopic stocks, flows, and interactions, including feedback loops. The preeminent textbook has many examples,[75] and the System Dynamics literature (i.e., the particular modeling methodology developed at the Massachusetts Institute of Technology [MIT]) is huge. Even the original books by its pioneer, MIT's Jay Forrester, remain fascinating a half-century later. The famously controversial 1972 book *Limits to Growth* and its 30-year update[76] remain insightful and, as it turns out, prescient.[77]

As noted, however, with few exceptions, these two streams of modeling have proceeded in parallel with minimal interaction.[78]

This situation is in contrast with physics and chemistry, in which students learn about how microscopic and macroscopic phenomena can be related through quantum and classical statistical physics, in both equilibrium and nonequilibrium systems. It is common for theoretical chemists and physicists to move easily between microscopic and macroscopic: A clash

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[73] Mitchell M. Waldrop, *Complexity: The Emerging Science at the Edge of Order and Chaos*, New York: Simon & Schuster, 1992; John H. Holland, *Hidden Order: How Adaptation Builds Complexity*, Heather Mimnaugh, ed., New York: Perseus Publishing, 1996; John H. Holland, *Emergence: From Chaos to Order*, Cambridge, Mass.: Perseus Books, 1998; and Joshua M. Epstein and Robert L. Axtel, *Growing Artificial Societies: Social Science from the Bottom Up*, Cambridge, Mass.: MIT Press, 1996.

[74] Uri Wilensky and William Rand, *An Introduction to Agent-Based Modeling: Modeling Natural, Social, and Engineered Complex Systems with NetLogo*, Cambridge, Mass.: MIT Press, 2015.

[75] Sterman, 2000.

[76] Donella H. Meadows, Jørgen Randers, and Dennis L. Meadows, *The Limits to Growth: The 30-Year Update*, White River Junction, Vt.: Chelsea Green, 2004.

[77] Graham Turner, *A Comparison of the Limits to Growth with Thirty Years of Reality*, Canberra, Australia: CSIORO, 2008.

[78] One exception is Hazhir Rahmandad and John D. Sterman, "Heterogeneity and Network Structure in the Dynamics of Diffusion: Comparing Agent-Based and Differential Equation Models," *Management Science*, Vol. 54, No. 5, 2008.

of cultures is not necessary. In social-behavioral modeling, however, the cultures are often distinct,[79] although economists study both micro and macro, and political scientists may study phenomena at the levels of cities, nations, and the international system.

From the viewpoint of policy analysis, the reasoning that underlies policy choices will typically be macroscopic, but it needs to be consistent with microscopic realities. How can that be accomplished if there is no crosswalk? As an example, suppose that an intervention is contemplated to assist a target government. It might focus at a high level on improving the rate of growth of the gross domestic product or the quality of governance. However, the strategies adopted might fail because the underlying culture rejects the intervention actions in that they disrupt transactional arrangements among factions that are important in making things work.

From a conceptual perspective, what is needed is (1) use of microscopic game-structured system simulations, which will almost necessarily involve agent-based components that generate the emergent phenomena of interest, (2) recognition of macroscopic regularities, and (3) understanding of higher-level laws. However, these laws will often need to recognize bifurcations and other features of CAS, such as complex phase spaces in which system characteristics are markedly different in different phase-space regions. System dynamic depictions, then, may apply in each of these regions, although they may need to be explicitly stochastic.

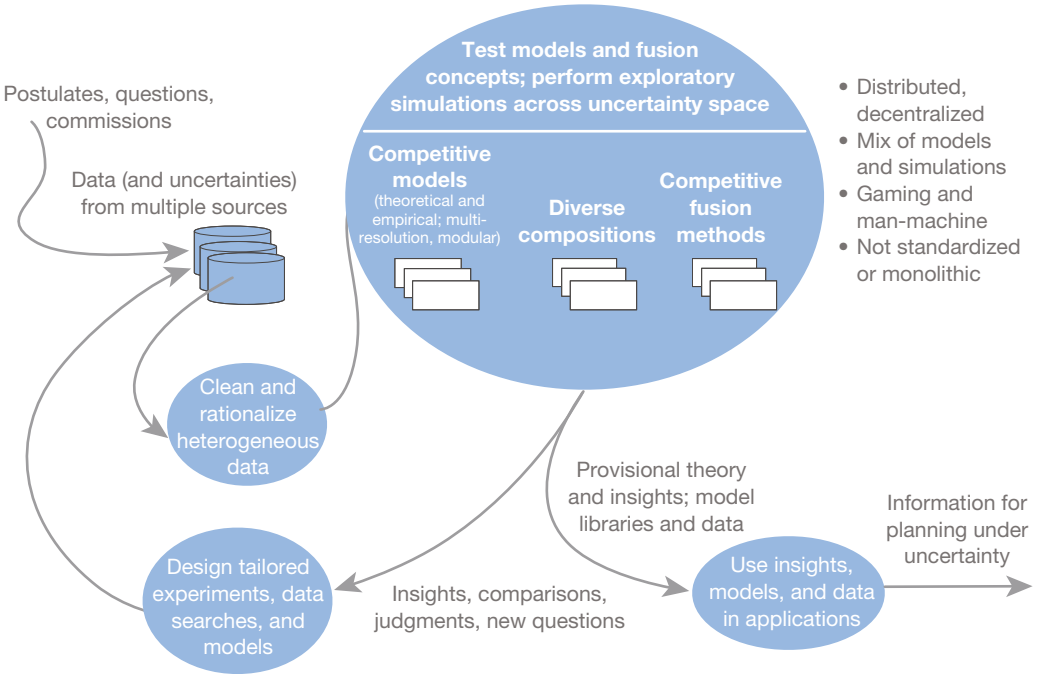
Improving the Theory-Data Relationship

As noted in a recent study for the Defense Advanced Research Projects Agency and a subsequent book reviewing social-behavioral modeling,[80] another frontier challenge is improving the degree to which empirical analysis is informed by good theories and theories are suggested, tested, and improved by data. This is difficult because the empirical data often do not connect well with the parameters of models representing theory. Furthermore, social scientists tend to use data to test hypotheses rather than testing coherent, integrative theories. The study suggested that large research programs consider creating virtual social-behavioral modeling laboratories (SBMLs) to ensure a combination of collaboration and competition among researchers. Figure 12.10 shows the concept schematically. Such a construct might be apt for an ambitious effort to develop analytical methods for, and experience in, strategy-construction for hybrid and political warfare in the gray zone.

[79] An interesting ontological question exists. Physical scientists working at different levels of detail will typically agree on underlying causality, whereas social scientists often disagree about the sequence and directionality of causality. This is because they view different portions and aspects of the overall system. As a familiar example, raising taxes might reduce rather than increase government revenues (superficially puzzling), because it might cause the potential taxpayers to move their financial activities to a different state or country.

[80] Davis, O'Mahony, and Pfautz, 2019.

FIGURE 12.10
An Illustrative Example of the SBML Concept



SOURCE: Paul K. Davis, Angela O'Mahony, Timothy R. Gulden, Osonde A. Osoba, and Katharine Sieck, *Priority Challenges for Social and Behavioral Research and Its Modeling*, Santa Monica, Calif.: RAND Corporation, RR-2208-DARPA, 2018, p. xxvii.

Many advances are being made on better relating theory and data in the modern era of interconnectedness and computation; such advances involve improving inferences about causality,[81] using both theory experiments to study social polarization and influence,[82] and using ABMs and virtual games in connection with laboratory experiments.[83]

[81] Amy Sliva, Scott Neal Really, David Blumstein, and Glenn Peirce, "Combining Data-Driven and Theory-Driven Models for Causality Analysis in Sociocultural Systems," in Paul K. Davis, Angela O'Mahony, and Jonathan Pfautz, eds., *Social-Behavioral Modeling for Complex Systems*, Hoboken, N.J.: John Wiley & Sons, 2019.

[82] Michael Gabbay, "Integrating Experimental and Computational Approaches to Social Influence," in Paul K. Davis, Angela O'Mahony, and Jonathan Pfautz, eds., *Social-Behavioral Modeling for Complex Systems*, Hoboken, N.J.: John Wiley & Sons, 2019.

[83] Lynn Carol Miller, Liyuan Wang, David C. Jeong, and Traci K. Gillig, "Bringing the 'Real World' into the Experimental Lab: Technology-Enabling Transformative Designs," in Paul K. Davis, Angela O'Mahony, and Jonathan Pfautz, eds., *Social-Behavioral Modeling for Complex Systems*, Hoboken, N.J.: John Wiley & Sons, 2019.

Concluding Thoughts

In this chapter, I have discussed some methods that could be brought to bear in improving DoD's ability to understand and develop adaptive strategies for great-power competition involving gray areas and political warfare, including activities involving UGS. My intent has been to suggest some steps toward an analytic architecture. No such architecture exists. I conclude that a new analytic architecture is needed to aid strategic planning for competing with great powers in UGS—which is broadly construed to address hybrid and political warfare and political-economic competition. Such planning must deal with developments in CAS, so the architecture must be conceived accordingly—a radical departure from the past. Analytical tools should help characterize the nature of the system's state and the feasibility (given that state) of influencing developments while controlling risk and evaluate the relative merits of alternative composite strategies for doing so while accounting for the behaviors of adversaries. The strategies should be reflected as portfolios of overt and covert political, military, and economic actions in different domains, levels of detail, and timescales. Some actions will prove successful; some actions will be ineffectual; and some actions, counterproductive. Thus, the architecture should anticipate timely but coherent adaptiveness. Adaptations may involve modest adjustments, significant rebalancing of the portfolio, or major changes with revised objectives. One role of analysis will be to aid in planning for FARness—that is, finding strategies that can be flexible, adaptive, and robust in allowing for, respectively, changes of objective and mission, unexpected circumstances, and either adverse or opportunity-creating shocks. This contrasts with planning on the basis of best-estimate assumptions alone. Another role will be aiding actual strategic adaptations along the way.

Constructing such an architecture, populating it with sound but useful methods and tools, and educating users would require a major effort. It should be heavily influenced by the best subject-area minds and would involve competition of paradigms, methods, and styles. That would not be a project for computer scientists merely seeking a new application for their favored methods.

Abbreviations

ABM	Agent-Based Modeling
AI	artificial intelligence
ASDA	Act-Sense-Decide-Adapt
CAS	complex adaptive systems
DoD	U.S. Department of Defense
ML	machine learning
NATO	North Atlantic Treaty Organization
OODA	Observe, Orient, Decide, Act

QCA	Qualitative Comparative Analysis
RSAS	RAND Strategy Assessment System
SBML	social-behavioral modeling laboratory
UGS	undergoverned spaces

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