

Leveraging Complexity in Great-Power Competition and Warfare: *Volume I*, An Initial Exploration of How Complex Adaptive Systems Thinking Can Frame Opportunities and Challenges

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ISSUE

A key concern for the U.S. Air Force is the ability to leverage multidomain operations (MDOs) to U.S. advantage both in competition and in warfighting. Multidomain actions are viewed as imposing complexity on the adversary's decision process. But what does complexity mean in an Air Force context?

- Currently, we lack understanding of how to impose or exploit complexity to maximize operational effects.
- An informed understanding of the nature and value of complexity as a weapon is necessary—that is, how complexity can be used as a method of attack. How can complexity be employed in an operational setting?
- Science and technology investments are not currently aligned to quantify complexity, measure its operational effects, and determine how to impose complexity and thus shape adversary behavior. How can research on the nature of complexity be used to understand what science and technology efforts might deliver in terms of complexity-informed capabilities?



APPROACH

The RAND Corporation research documented in this report involved a literature review of complexity, graph theory, and complex adaptive system (CAS) to ground the complexity characterization in research relevant to major interstate competition and warfare. The warfighting application of the RAND-developed complexity lens can be applied to four example vignettes, which leverage the emerging MDO concept of operations (CONOP) from recent wargames and a review of historical case studies. The focus on complexity imposition or complexity exploitation in our analysis is on an adversary's decisionmaking because the approach influences the decision calculus to arrive at strategic or operational decisions.



RECOMMENDATIONS

- The Air Force should apply a complexity lens through which to review ongoing and future efforts to best leverage complexity to U.S. decision advantage. The lens should take both offensive (opportunities for attack) and defensive (highlight and address vulnerabilities) looks at systems. The efforts under review should span
 - science and technology needed to leverage complexity
 - planning for MDOs
 - evaluation of MDO effectiveness.
- The Air Force Research Laboratory should conduct game theory–informed wargames to populate probabilities in the mathematical representation of the adversary’s complex decision process.
- The Air Force should conduct workshops in support of Joint All-Domain Operations concepts, leveraging the complexity lens to inform CONOP development.
- Pacific Air Forces and U.S. Air Forces in Europe should integrate complexity lens thinking into their existing tabletop and command post exercises.

FINAL THOUGHTS

- To impose or exploit complexity is to take an action that increases an aspect of the complexity of the environment in a way that makes it more difficult for an adversary to make decisions or to operate, essentially shaping conditions to favor Blue. Thus, to conduct a complexity attack is to take an action that exploits characteristics of CAS in a way that will have a deliberate negative effect on the adversary.
- Applying a CAS lens to warfare is useful to understand how a planner might leverage complexity to U.S. advantage.
- Four general categories of U.S. actions benefit from the CAS nature of the adversary’s decision processes. These are degrading the operational picture, impairing adversary response, spanning organizational boundaries, and exploiting nonlinearities.
- The difference between complexity exploitation and more-traditional actions are that the complexity-based response reshapes an adversary’s decision calculus, while more-traditional options simply lower the probability associated with a given transition from one decision step to the next.
 - There may be cases in which a given course of action exhibits both types of impact.
 - The value of this method is that it provides a useful definitional frame that highlights the unique aspects of complexity-based attacks, and it allows the impacts of different types of Blue actions to be directly compared with one another in terms of their ultimate effects on an adversary’s decisionmaking.
- U.S. actions on the adversary’s decision points in a military vignette can be represented by CAS characteristics that are represented in a Markov chain.
 - Understanding the underlying transition matrix structure (or associated directed graph) tells us some fundamental things about complexity (e.g., the creation of feedback loops).
 - Developing a model with defined probabilities, while challenging, may provide additional insights for warfighting.



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