Reframing Information Warfare Targeting for Complex Adaptive Systems

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Abstract

Conventional Department of Defense analysis and targeting methodologies view the adversary as a mechanical system. Today, the adversary is broadly defined as a faction of related functional components (individuals, organizations, capabilities, and functions) that enable the enemy to operate and succeed in its mission. This traditional approach to targeting has served us well in the more tangible domains of kinetic warfare, where it is essential to understand how neutralizing an enemy's capability is key to attaining tactical, operational, and strategic desired end states. However, this approach is not sufficient to compete with adversaries who seek to challenge U.S. leadership in the 21st century.

This paper examines the growing academic field of complexity science, and considers how it can supplement the existing structure of Joint Targeting doctrine, with a focus on affecting the adversary's cognitive domain. Understanding how complex adaptive systems operate, the nuances of systematic relationships, and how they can be exploited will expand our ability to deliver information warfare effects against complex targets.

Introduction

In *Accelerate Change or Lose*, Chief of Staff of the Air Force General Charles Q. Brown, Jr. directed the United States Air Force (USAF) to adapt and evolve rapidly: "If we are to succeed, we must accelerate the change necessary for us to remain the most dominant and respected Air Force in the world" (Brown 2020). The complexity of the challenges that face the USAF requires the force to be bold. The USAF needs to rapidly reassess and improve the processes that have been cemented in service and joint doctrine, and refresh the status quo with new ideas in order to prepare for tomorrow's fight. In the information warfare domain, complexity science—a young and growing field dedicated to studying complex systems—shows promise. Complexity science, and the study of complex adaptive systems (CAS) provides an abstract foundation of concepts that invites critical thought relevant to an endless number of multidisciplinary sciences and problem sets. In fact, our GPC adversaries, often defined as being comprised of various "system of systems", is better defined as a "complex adaptive system of complex adaptive systems." This nuanced yet critical shift in analytical perspective can open a new dimension in how the USAF thinks about information warfare. To reimagine our current concept of joint target analysis—which focuses on components, capabilities, and function—this paper builds on concepts of CAS as it applies to the information domain in hopes to operationalize this knowledge in the future. The USAF should draw on the insights of complexity science and improve the sophistication of its information warfare targeting strategies, and evolve into a force better postured to shape the cognitive dimension for tomorrow's fight.

A Primer on Complex Adaptive Systems

A complex adaptive system (CAS) is a system of interacting agents that share a common set of characteristics: complexity, or the dynamic and relatively unpredictable nature of interactions between individual agents of the system who operate under local rules, and adaptability, the nature of the agents and the system to react and self-organize in response to external stimuli. By this definition, families, tribes, societies, economies, and nation-states are all examples of CAS with varying levels of complexity and adaptability. These examples illustrate how CAS can be nested within CAS, and how CAS continuously interacts with and adapts to other CAS. Additionally, complexity implies that the behavior of the total system cannot be inferred by the behaviors of the individual agents within the system. One cannot accurately predict the behavior of a nation-state solely by studying the soldier, army, or head of state. Organizational leaders grapple with the tradeoff of adaptability and efficiency. CAS with high levels of dynamic independent behaviors—or complexity—at smaller scales (human-to-human) tend to be more adaptive at larger scales (organization), at the cost of efficiency (Siegenfeld and Bar-Yam 2020). Organizational leaders of CAS attempt to reign in complexity within their teams by incentivizing and disincentivizing individual agent behaviors to meet the desired end state. A practical way to view this concept is through the implementation of rule systems or—hierarchy, protocols, positions, promotions, regulations, customs, and performance reports.

CAS are self-organizing. This is a term in complexity theory that describes how diverse interactions among agents, over time, result in the spontaneous generation of order in a system; this manifests in the system in the form of observable patterns across the whole system. A sociocultural observation of self-organization in a CAS reveals that numerous interactions happen within teams and offices within an organization, and over time, spontaneous but observable patterns and trends emerge across the human system. This concept, known as emergence, may provide insights into a culture of an organization. The concept of emergence can also be observed in the natural world. Flocks of starlings, a species of bird that inhabit a variety of habitats across the globe, create elaborate, complex patterns when traveling and feeding. The flock's patterns emerge naturally through the interactions of independent starling who mimic and adjust their flight behavior relative to the behavior of their nearby starling—or their local agent. This is an example of a pure CAS. Studies suggest that there is no centralized control, or alpha starling in a flock, but self-organization and cohesion emerge from the total interactions of individual agents (Cavagna 2010). See Figure 1 in the appendix section to view an example of a CAS.

Popularized by the Santa Fe Institute in the 1980s, the study of complexity and its various associated frameworks (to include game theory, chaos theory, and network theory), is a revolutionary departure from Isaac Newton's theories on classical mechanics and the scientific study of linear systems, which has dominated physical science discourse for the last three centuries. Four decades later, and even while the study of nonlinear systems and complexity is still in its infancy, this paper is not the first time that the concept of complexity has been pondered for military application.

The late Colonel John Boyd, a titan of United States Air Force (USAF) strategic thinking and the architect of the "OODA Loop", spent the latter part of his years contemplating complexity as it relates to military strategy (Osinga 2014). Boyd immersed himself in various works on the topic, including Alan Beyerchen's article "Clausewitz, Nonlinearity, and the Unpredictability of War." Beyerchen asserts that the unpredictable nature of warfare, caused by the fateful interaction among individual agents of complex systems, results in an observable fact: "a military action produces not a single reaction, but dynamic interactions and anticipations that pose a fundamental problem for any theory" (Osinga 2014). Military action—both kinetic and non-kinetic—imposes complexity on the targeted system, and the target's reaction and ability to adapt in a tactical, operational, and strategic context spans the spectrum of predictability. Boyd stated, "the…strategic aim [is] to diminish the adversary's capacity to adapt while improving our capacity to adapt as an organic whole, so that our adversary cannot cope while we can cope with events/efforts as they unfold" (Boyd 2007). Boyd went on to consider the "essence of moral conflict", where he described a style of warfare that "leverages mistrust and disinformation to sever the bonds within an organization" (Boyd 2007). With a renewed focus on information warfare and given its importance during great power competition, how can the USAF further progress the conversation on moral conflict as it relates to targeting a complex adversary?

Relevance Today

The National Defense Strategy (NDS) of 2018 is a call-to-action that has propelled the largest shift in the Department of Defense's (DoD) strategic priorities since the attack on September 11th, 2001.

Compared to the counterterrorism and counterinsurgency operations which have occupied our attention for the last two decades, the United States is now competing with adversaries that are more sophisticated and whose national interests collide with the post-WWII world order and current ways of life (Mattis 2018). During a moment in time where the United States—and its military services—contemplate how to adapt to the evolving threats on the landscape, Colonel Boyd's controversial thoughts from the 1990s remain prescient.

While acting as a consultant to Department of the Air Force senior leaders, Colonel Boyd presented a strategy for how to impose cost on the adversary by generating effects in the cognitive domain. Boyd proposed a synthesis of kinetic and non-kinetic efforts to "destroy [the] adversary's moral-mental-physical harmony, produce paralysis, and collapse his will to resist" (Osinga 2014). Armed conflict with a peer adversary will drive a paradigm shift in acceptable level of risk and both sides are likely to incur significant losses, increasing the likelihood nation states will turn to the type of efforts in the cognitive domain proposed by Colonel Boyd. Given this context, USAF information warfare Airmen have a duty to accelerate change in this field in order to shape the cognitive battlespace and deter the enemy from engaging in armed conflict with the United States. Joint Doctrine Note (JDN) 1-19, *Competition Continuum*, describes how the joint force should campaign through competition below armed conflict, including a call to "conduct operations in the information environment, to include efforts to counter and undermine the competitor's narrative" (Joint Chiefs of Staff 2019). The following sections will attempt to generate discussion to answer this call, and build on previous studies of CAS to continue Colonel Boyd's discourse on how the USAF can better operationalize information warfare targeting against our adversaries.

The Information Environment and Complex Adaptive Systems

Joint Publication (JP) 3-13, *Information Operations*, describes the information environment as the "aggregate of individuals, organizations, and systems that collect, process, disseminate, or act on information" and consists of "three interrelated dimensions […] the physical, informational, and cognitive" (Joint Chiefs of Staff 2014). The fundamental concepts of CAS theory—dynamic interactions between agents and self-organization—integrates seamlessly with the description above. Individuals, organizations, and systems themselves are agents within a CAS, and the collection, processing, and dissemination of information relates to the dynamic interactions of the agents following local rules, or complexity. Rewritten in the vernacular of the CAS field, the information environment could be defined as "a complex ecosystem—of agents, their behaviors, relationships, and rule systems—which react and adapt to information as it interacts with the physical, informational, and cognitive dimensions of the system."

Complex Adaptive Systems Analysis

The joint target development process follows a largest-to-smallest scale progressive targeting taxonomy, starting at the adversary, then the target system, followed by the target system components, the target itself, and finally the target element (Joint Chiefs of Staff 2018). A complex adaptive system analysis (CASA), or a conceptualization of the target through the lens of a CAS, can be conducted at each level of this targeting taxonomy.

In a notional example where USAF information warfare airmen are tasked with targeting an adversary's air capability, the adversary may be defined as the country's military forces, the target system as its various military service's air components, the target system components as the military service's various operational sub-organizations, the target as the various squadron-level organizations that generate airpower, and the target element as the various offices and individuals responsible for decision-making. At the target system level, if one were to conduct CASA of an adversary's air combat organization similar to a USAF wing-level organization, one might categorize the various wing-level organizations, groups, and squadrons as individual agents within that system (see Figure 2). Interactions between these agents may be observed in the form of exercises, requests for information or support, inspections, or orders between echelons. At this scale, the complexity of the system is relatively low. In other words, there is a comparatively low number of possible behaviors the individual agents can exhibit as unit behaviors are constrained by control mechanisms such as law and regulation, historic expectations, and higher echelon guidance within the wing. In comparison, a more microscopic CASA conducted with detailed resolution at the enemy's squadron-level would reveal multiple offices (agents) within the organization exhibiting both independent behaviors and coordinated behaviors with other offices (agents) in, and outside of the organization. The complexity is greater at this scope even though the scenario remains the same. The complexity profile described above may differ, however, for a substantially different target system. A notional ideologically-driven terrorist network operating in Europe may have a looser set of rule systems that guide system-wide behavior towards the organization's larger objective (Ilachinski 2005). An analyst conducting CASA on this network may encounter a flatter, more loosely defined, and more dispersed hierarchical structure consisting of the geographically separated financier, explosive experts, planners, and operatives as the agents of the CAS (see Figure 3). If this terrorist network operates in a decentralized fashion and coordinates under the loose guidance of the organization leader's social media calls-to-action, the analyst may encounter high levels of complexity (at the expense of effective coordination) at the macro-agent level of the terrorist network. At the most granular level of this terrorist network, the subordinate explosive experts, planners, and operatives reach out to or await contact by their leads. They may also follow a more predictable set of behaviors in order to adapt to the complexity of unpredictable environmental factors. This distinction in observed complexity across multiple scales is important when considering the overall complexity profile of the adversary.

In the introduction, I alluded to various rule systems that organizations leverage to regulate the complexity at various levels of an organization. We can consider a notional command and control (C2) scenario using the previous example of a USAF wing. In a tightly controlled C2 relationship where all decision-making authority rests with the wing commander, the overall complexity of the wing from the macroscopic level is limited to the complexity of the single wing commander. This is just to say that every action by a squadron commander, and every action from a subordinate squadron member would follow the behavior complexity of the wing commander, a single person. This wing would fail catastrophically as the complexity and adaptability of the entire system and subordinate systems would be no match for the complexity of the environment affecting it. If, however, the wing followed a C2 structure (or lack thereof) mirroring anarchy, where each squadron, commander, and Airman made decisions and behaved as they wished, exhibiting complex behaviors from the microscopic to macroscopic scale, it is also doomed to fail. Organizational leaders seeking to design a healthy and productive organization do so by allocating proper decision-making authority at the appropriate level, securing organizational maneuver space and increasing complexity to contend with the complexity of issues (environmental factors) that may face the organization at varying levels. Thus, the effectiveness, productivity, and survival of an organizational CAS relies on maintaining complexity balance across each echelon of the system. Utilizing CASA when conducting target development of an enemy organization, analyzing the adversary's agents, interactions, and rule systems, and identifying opportunities to offset the complexity balance in the target may prove highly effective in creating chaos in an enemy organization.

Complexity science and its various concepts are in continuous development; the application of this science is continually evolving across multiple disciplines as different fields understand the interconnected nature, the complexity, and adaptability of the systems they study. How can the USAF practically apply the concepts of CASA to the target systems that are analyzed?

Intelligence analysts and targeting analysts have analyzed CAS since the inception of the joint targeting cycle used today. CASA is not a brand-new analytical technique or process that should totally supplant all of the cumulative success of current joint targeting tools, techniques, and procedures. CASA is simply a reframing of systems analysis, with particular attention paid to complex behavior, the interrelationships of system components, and how it can describe the total behavior of the greater system itself. In fact, a CAS-approach to analyzing target systems can be integrated seamlessly with today's standard joint targeting processes.

Target systems analysis (TSA) as it relates to the joint targeting process is defined as the "all-source examination of potential target systems to determine relevance to stated objectives, military importance, and priority of attack" (Joint Chiefs of Staff 2018). Having a detailed understanding of the target's composition is a necessary precursor to properly identifying functional dependencies and opportunities for exploitation. Using an earlier analogy, understanding the behavior of a single starling is still critical in understanding the dynamic behaviors and agent relationships that manifest into the exquisite flock patterns when they fly. CASA can assist in filling current gaps on how the target system behaves, so in the process of building a TSA, analysts should consider the following: identify the agents within the CAS, determine the behavior of the agents, understand the relationships that agents maintain with other agents, and understand the rule systems that govern the individual agents and the system itself. As analysts conduct CASA, target system centers-of-gravity in the cognitive dimension can emerge more clearly. Across various levels of the targeting taxonomy e.g., through analyzing a target system, its components, and individual targets, agent behaviors at each level are better understood through the wholistic view of how individual behavior affects organizational behavior, and how those behaviors affect system-wide behavior. Analysts conducting CASA should appreciate the power of visualizations by building a complexity link analysis diagram of these different behaviors and relationships (see Figure 2 and figure 3 for examples); this format could provide additional value in properly assessing the overall complexity of the target system as well as opportunities to exploit the target. When creating a complexity link analysis diagram, it is not critical (nor is it feasible without better computation) to accurately build out the entire behavior snapshot of every agent. The primary utility of the diagram is to aid the analyst in better understanding the relative complexity of the agents across the system. Which rule systems dominate the CAS? Which agents are influential in managing the rule system within the CAS? Which agent interactions are critical to mission success for the adversary? Are there opportunities to introduce—or force a reduction in—complexity for the target system? What are the second and third order effects of influencing the rule systems, behaviors, and complexity of a target system at a certain echelon? Will influential agents within the CAS modify the rule system to respond to the change in complexity, and at what level will these changes be implemented? Can influencing the complexity profile of the organization introduce bureaucracy into the target organization? Does the increase in bureaucracy affect the agility and overall effectiveness of the adversary?

Conclusion and Future Recommendations

Complex adaptive systems exist all around us and within us. We are agents within multiple parallel and intersecting CAS, exhibiting our individual behaviors and dynamic interactions with other agents, bound by rule systems and constantly adapting to the complexity of the environment that affect us. Complexity as it applies to analysis and joint targeting is not intended to threaten the status quo of how the USAF conducts business in the information warfare realm, but should be an additional tool to expand our understanding of the adversary so the force can be positioned to affect it. CASA is novel in its approach to how it can impact the adversary; it refocuses the analysis on the relationships between agents, so while effects may be targeted towards the agents themselves, the larger objective should be to affect relationships between those agents and scale the consequences across the target system.

The complexity concepts and analytical questions discussed through this paper should ultimately be tied to the desired effect on the adversary's CAS. As countless past examples show, kinetic effects during armed conflict can have considerable effects against a CAS. Rapidly destroying (external stimulus) the adversary's ability to command-and-control their air defense system and defend their air space is a substantial shock to the adversary CAS, and these dilemmas force considerable adaptation in rule systems, behaviors, and interactions of agents within the system. However, in competition below armed conflict, the USAF and joint force at large must begin to consider how it can conduct non-kinetic actions in the information warfare domain to create multiple micro-dilemmas within the adversary's complex and adaptive ecosystem. With CAS in mind, how can the USAF erode the adversary's organizational structures and functioning through sophisticated information warfare campaigns? Preventing armed conflict and shaping the cognitive battlespace to the United States' advantage, could hinge on exploring fresh concepts and perspectives to defeat the adversary from within.

For future research, I recommend case studies that analyze previous geopolitical events through the lens of CASA. What can the community learn from the Arab Spring, the Hong Kong demonstrations, and historical events such as the Cultural Revolution in China during the 1960s? How have agents within CAS initiated and influenced behavior within their local systems, and how did the effects of those activities cascade through multiple other complex systems? Those insights would add tremendous value, not only for the greater understanding of the dynamics at work that have shaped the course of human history, but also as a means to expand USAF information warfare capabilities so we can continue to adapt to the threats that face us.

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Appendix: Diagrams

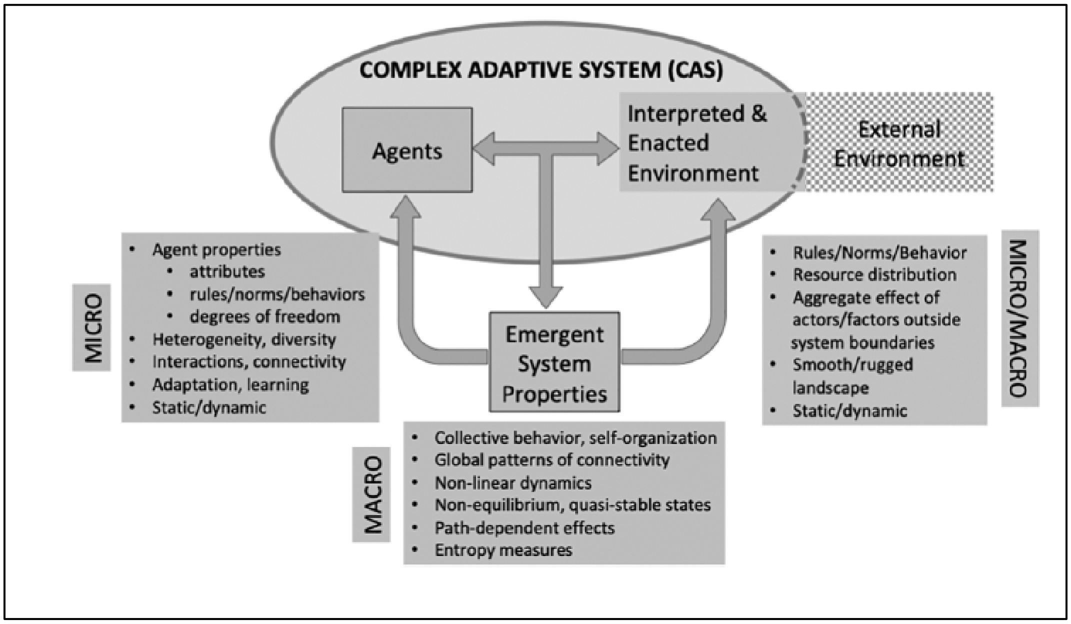

Figure 1. Example of a CAS Model.

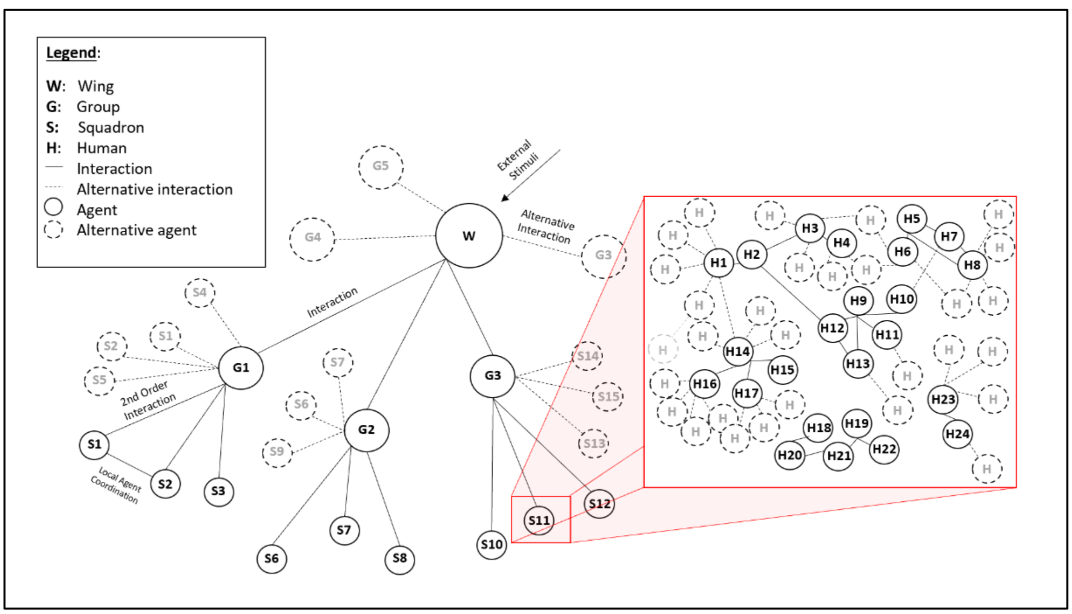

Figure 2. Complexity Link Analysis of a Notional Military Organization. This visualization shows a notional top-down directive within a military organization starting at the wing-equivalent level, issued to solve (and adapt to) a problem presented by the external stimuli (top-right). The dashed lines and circles represent alternative behaviors and interactions (within the bounds of the rule system) which could have occurred but did not in this scenario. For simplicity, not all possible behaviors are reflected in this figure. The zoomed in portion of the figure depicts how the observed complexity increases as detail increases.

Appendix: Diagrams (cont.)

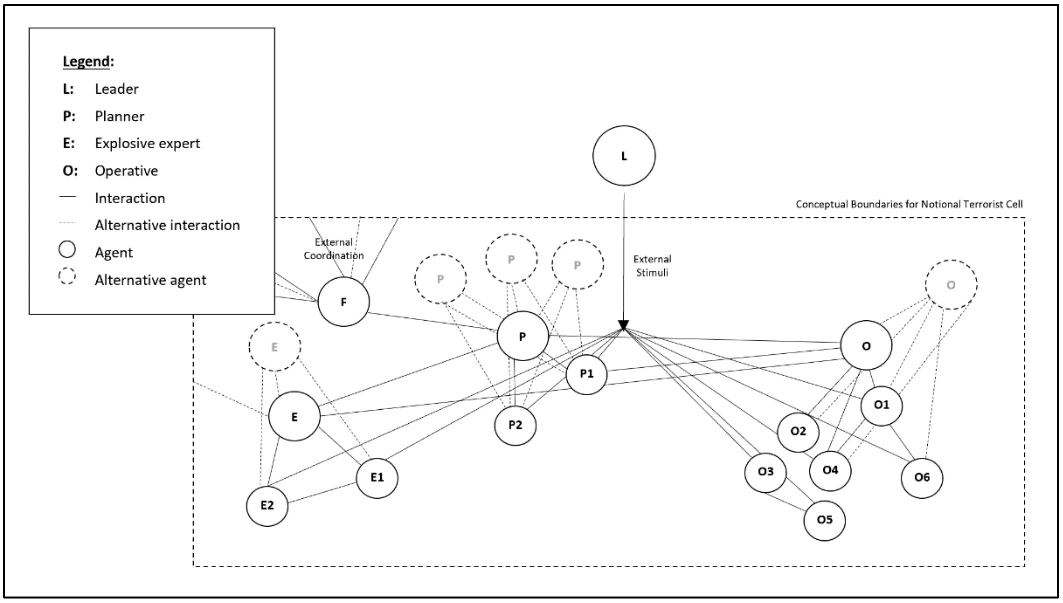

Figure 3. Complexity Link Analysis of a Notional Terrorist Cell. This terrorist cell activates when issued a public call-to-arms by the terrorist organization's leader. While this visualization looks complex, note that a rule system of "listen and obey" for the numbered subordinates result in relatively low complexity, while the functional leaders exhibit more complexity as they determine various courses of action for their attack.