Coping with Complexity: Analyzing Unified Land Operations Through the Lens of Complex Adaptive Systems Theory

A Monograph

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2019

REPORT DOCUMENTATION PAGE

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1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
23-05-2019	SAMS Monograph	July 2018-May 2019

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Coping with Complexity: Analyzing Unified Land Operations Through the Lens of Complex Adaptive Systems Theory	
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)	5d. PROJECT NUMBER
MAJ Alan P. Hastings, USA	
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
U.S. Army Command and General Staff College ATTN: ATZL-SWD-GD Fort Leavenworth, KS 66027-2301	

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
Advanced Operational Arts Studies Fellowship, Advanced Military Studies Program.	
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for Public Release; Distribution is Unlimited

13. SUPPLEMENTARY NOTES

In 2017, the United States Army published the latest version of Field Manual 3-0, *Operations*. The publication emphasized that victory during large-scale combat operations resulted from the destruction or defeat of an adversary's conventional capability and will to resist. However, the concepts articulated in the US Army's current operating concept, Unified Land Operations, do not provide clear guidance on the employment of combat power during large-scale combat operations to defeat or destroy an enemy force. Thus, on the surface, the US Army operating concept appears to lack a coherent basis in sound, clearly communicated theory. Complexity science offers a theoretical foundation for the development of a clearly articulated doctrine for fighting and winning in a complex operational environment. A study of complexity science concepts and a comparison to military theory and US Army doctrine suggests a need to restore the centrality of the concept of positions of relative advantage to the current operating concept, to emphasize the limitations of anticipation during planning and the requirement for adaptation in execution, and to reframe current conceptualizations of mission command in order to increase an organization's adaptive capacity

15. SUBJECT TERMS

Large Scale Combat Operations (LSCO), Unified Land Operations (ULO), Complex Adaptive Systems (CAS), Complexity, Adaptation, Mission Command

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			MAJ Alan P. Hastings
(U)	(U)	(U)	(U)	61	19b. TELEPHONE NUMBER *(Include area code)*

Monograph Approval Page

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Abstract

In 2017, the United States Army published the latest version of *Field Manual (FM) 3-0*, *Operations*. The publication emphasized that victory during large-scale combat operations resulted from the destruction or defeat of an adversary's conventional capability and will to resist. However, the concepts articulated in the US Army's current operating concept, Unified Land Operations, do not provide clear guidance on the employment of combat power during large-scale combat operations to defeat or destroy an enemy force. Thus, on the surface, the US Army operating concept appears to lack a coherent basis in sound, clearly communicated theory. Complexity science offers a theoretical foundation for the development of a clearly articulated doctrine for fighting and winning in a complex operational environment. A study of complexity science concepts and a comparison to military theory and US Army doctrine suggests a need to restore the centrality of the concept of positions of relative advantage to the current operating concept, to emphasize the limitations of anticipation during planning and the requirement for adaptation in execution, and to reframe current conceptualizations of mission command in order to increase an organization's adaptive capacity.

Contents

Acknowledgements

Acronyms

ADP	Army Doctrine Publication
ADRP	Army Doctrine Reference Publication
CAS	Complex Adaptive System
FM	Field Manual
IAF	Israeli Air Force
IDF	Israeli Defense Force
LSCO	Large-scale Combat Operations
OE	Operational Environment

Illustrations

Introduction

In 2017, the United States Army published the latest version of *Field Manual (FM) 3-0*, *Operations*. The publication sought to change the culture of the Army and orient Army leaders on the conduct of large-scale combat operations, to improve the Army's readiness to fight and win our nation's wars against peer and near-peer adversaries in an increasingly complex operational environment, and to focus further intellectual thought and discussion on how the Army, operating as part of the Joint Force, operates to overcome the challenges associated with defeating a peer- or near-pear adversary who may enjoy positions of advantage relative to friendly forces at the onset of a future conflict.[1] It highlights the Army's role as part of the Joint Force, asserting that the Army shapes the operational environment, prevents conflict, conducts large-scale ground combat, and consolidates gains. The publication emphasizes that victory during large-scale combat operations resulted from the destruction or defeat of an adversary's conventional capability and will to resist.

FM 3-0, *Operations* asserts that "unified land operations" is the US Army's operational approach. *Army Doctrinal Publication 3-0*, *Operations*, defines the US Army operational concept, *unified land operations*, as:

> "Simultaneous offensive, defensive, and stability or defense support of civil authorities' tasks to seize, retain, and exploit the initiative to shape the operational environment, prevent conflict, consolidate gains, and win our Nation's wars as part of a unified action."[2]

The causal connection between the conduct of decisive action and the resulting defeat or destruction of an adversary in large-scale combat operations is ambiguous. Similarly, the causal connection between a military force seizing, retaining, and exploiting the initiative and the defeat

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[1] Mike Lundy and Rich Creed, "The Return of US Army Field Manual 3-0 Operations," *Military Review* (December 2017).

[2] US Department of the Army, *Army Doctrinal Publication (ADP) 3-0, Operations* (Washington, DC: Government Printing Office, 2017), 6.

or destruction of an enemy force appears ambiguous. That is, the act of seizing, retaining, and exploiting the initiative by itself does not explain military victory. Further examination of this concept in FM 3-0, *Operations,* yields insights that help to bridge this conceptual gap, but the US Army's underlying theory of victory in large-scale combat operations against peer competitors remains generally unclear.

The concepts articulated in United States Army doctrine do not appear to provide clear guidance on the employment of combat power during large-scale combat operations to defeat or destroy an enemy force. In *A Primer on Theory Construction,* Paul Reynolds asserts that scientific knowledge should provide a sense of understanding and that "a sense of understanding is provided only when the causal mechanisms that link changes in one or more concepts with changes in other concepts have been fully described."[3] US Army doctrine's description of how US Army forces, operating in accordance with the operating concept, will defeat a peer competitor does not satisfy this requirement. Here, too, one encounters only ambiguous and vague linkages. Thus, on the surface, the US Army operating concept appears to lack a coherent basis in sound, clearly communicated theory.

As the following argument demonstrates, complexity science offers a theoretical foundation for the development of a clearly articulated doctrine for fighting and winning in a complex operational environment. This monograph describes a topology of concepts from complexity science and assesses their potential usefulness for developing a greater understanding of large-scale combat operations in a multi-domain environment. Though several authors have written on the application of complexity science to military operations, this monograph aims to

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[3] Paul D. Reynolds, *A Primer in Theory Construction*, Allyn and Bacon Classics ed., Allyn and Bacon classics (Boston: Pearson/AandB, 1971), 5.

supply a topology that is accessible to the average military practitioner. As such, it will not and cannot be exhaustive in its scope.[4]

As this work will explain, military organizations are complex adaptive systems. As such, many of the complexity science concepts supplied align neatly with important military concepts already in existence within US Army doctrine. Understanding complex adaptive systems theory thus provides deeper insights into how military forces interact with the operational environment and each other and allows military practitioners to develop a more holistic theory of warfare. Armed with this deeper understanding, military practitioners can develop more coherent and clearly articulated theories of action and operating concepts.

Methodology

This monograph explores potential applications of complex adaptive systems theory to determine whether useful applications exist to inform how US Army formations should fight and win in large-scale combat operations with a peer- or near-peer adversary. To do so, it defines key concepts from complexity science, illustrates their application in military operations using historical vignettes from three Arab-Israeli wars between 1956 and 1973, assesses the implications for military operations, compares these implications to existing US Army doctrine, and provides recommendations for future iterations US Army doctrinal publications. Section 1 supplies a topology of complexity concepts to include emergence, self-organization, fitness, and anticipation, adaptation, and evolution in complex adaptive systems and explores their applicability to military operations. Section 2 summarizes the findings of the preceding section and connects these concepts into a coherent theory of phenomena of warfare and theory of action for the conduct of large-scale combat operations to defeat or destroy an adversary's system. Section 3 compares the theory provided in the previous section with a review of the US Army's operating concept, Unified Land Operations, highlighting similarities and differences between the

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[4] Ibid., 3.

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findings of this paper and doctrinal publications. Section 4 provides recommendations on how best to reconcile differences articulated in the preceding chapter, namely by offering potential refinements and modifications to existing operational concepts. This monograph focuses its findings on restoring the centrality of the concept of positions of relative advantage, acknowledging the limitations of anticipation during planning and the requirement for adaptation in execution, and suggesting a need to reframe current conceptualizations of mission command to increase an organization's adaptive capacity

Complex Adaptive Systems and Large-Scale Combat Operations

"We should take a long, hard look at what combat – fighting - is like. It appears to be vastly complex... To understand complexity, one needs a grasp of the basics of complexity theory and the fundamentals of General Systems Theory. If we arm ourselves with such tools, we can better understand battlefield phenomena."

Jim Storr, *The Human Face of War*

Complexity science offers a framework with which to develop a for the conduct of military operations in large-scale combat operations. Simply put, complexity science is the study of complex systems. Complex systems are systems consisting of many interconnected elements interacting with one another such that changes in some elements or their relationships generates changes in other parts of the system.[5] Often, these interactions are non-linear in nature. The distinction between linear and nonlinear dynamics in the interactions between components of a system is critical and merits further explanation prior to exploration of complex adaptive systems.

In *Coping with the Bounds: A Neo-Clausewitzean Primer,* Thomas Czerwinski lists the features of linear dynamics: proportionality, additivity, replication, and demonstrability of cause and effect. In proportional cause-and-effect relationships, one should expect that small inputs to result in small outputs while large inputs generate larger outs. In additive relationships between elements, the whole equals the sum of its constituent parts. Because of the properties above, the

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[5] Robert Jervis, *System Effects: Complexity in Political and Social Life* (Princeton, N.J: Princeton University Press, 1997), 6.

behavior of a system with linear interactions between elements should be replicable. That is, one should expect the same results or outcomes from any action that begins under the same conditions. As such, causes and their associated effects are demonstrable in such systems.[6]

In contrast, nonlinear dynamics are disproportionate and non-additive in nature. Behavior on a small scale may generate disproportionately large outcomes as the result of synergistic interactions between elements. This means an observer cannot understand the system through summation of its constituent parts.[7] Therefore, the non-linear nature of complex systems makes observation of the cause-and-effect relationships of interactions of its elements and, thus, predictions of their overall behavior exceedingly challenging.

Military formations are complex systems, consisting of many subordinate units, that are themselves complex systems. For example, during large-scale combat operations US Army corps conduct operations while exercising operational control over two or more US Army divisions and supporting brigades, as well as tactical control over multinational units and United States Marine Corps units. Similarly, US Army divisions fight in large-scale combat operations as a formation consisting of multiple Brigade Combat Teams (BCTs), functional brigades, and multi-functional brigades.[8] While the vast number of agents and systems associated with military formations contribute to the organization's structural complexity, it is the nature of their interactions that contribute to its interactive complexity. The degree of integration and synchronization in the operations of these various subordinate formations affects the ability of the greater formation's ability to fight on a larger scale. Description of the tensions between scale and complexity in a

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[6] Thomas J. Czerwinski, *Coping with the Bounds: Speculations on Non-Linearity in Military Affairs* (Washington, D.C: National Defense University, 1998), 8–9.

[7] Alan Beyerchen, "Clausewitz, Nonlinearity, and the Unpredictablity of War," *International Security* 17, no. 3 (1992): 64.

[8] US Department of the Army, *Field Manual (FM) 3-0, Operations* (Washington, DC, 2017), 69.

system's behavior appears below; for now, it must suffice to consider how dynamics between formations can generate synergistic as well as dissipative effects.

Different military formations enjoy varying degrees of autonomy with respect to the time, location, and method in which they employ combat power and achieve effects. Coordinating the actions of two or more components within a system can achieve effects at a greater scale. For example, the uncoordinated operations of completely autonomous and independent brigade combat teams (BCTs) may prove unlikely to achieve effects greater than the sum of their individual actions. However, synchronization or coordination of their operations, combined with the integration of functional- and multi-functional formations creates the capacity for division-level combined-arms maneuver. In the context of complexity science, one might refer to this newly-created capacity for combined-arms maneuver as an *emergent* capability, or behavior derived from the aggregate actions of the constituent subordinate formations. The relationships and interactions of the system's components give rise to the system's overall behavior.

Emergent Capabilities:
- BDE-level Attack
  - Movement to Contact
  - Attack
  - Exploitation
  - Pursuit
- BDE-level Defense
  - Area Defense
  - Retrograde
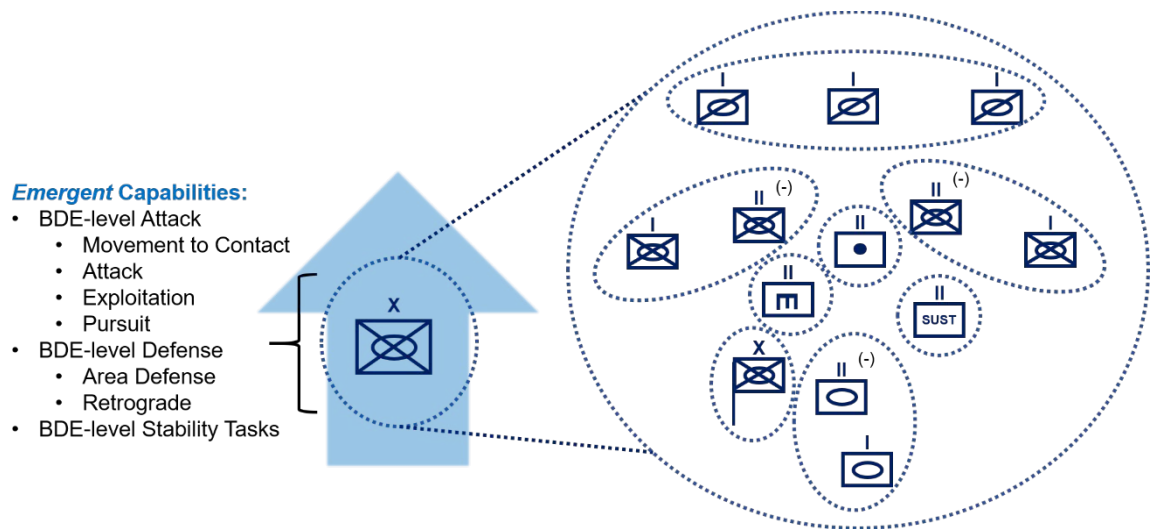- BDE-level Stability Tasks

Figure 1. Emergence in Military Organizations. *Source:* Author.

Components of combat power exist across all warfighting functions and possess their own inherent strengths and weaknesses. When the various arms and branches are joined in a common aim and are in possession of similar internal models regarding their collective behavior,

integration provides the greater system the potential for overcoming challenges within the operational environment that a single arm or branch either could not overcome independently or, due to its distinct qualities, would struggle to overcome. Further, the various arms and branches provide mutual support to compensate for each other's vulnerabilities or complement each other's strengths.[9] Thus, the integration and coordination of various forms of combat power towards a specified aim yield combined arms and joint military operations that amount to more than the sum of their parts.

Yet, not all interactions between components within a system provide for synergistic effect that result in the combined contributions of the parts being greater than the sum. Political scientist Robert Jervis modified this idea of non-additivity in his book *System Effects*, arguing that "the whole is *different from*, not greater than, the sum of the parts."[10] Carl von Clausewitz's concept of friction seems especially relevant here. In *On War*, Clausewitz described the nature of friction: "Countless minor incidents—the kind you can never really foresee—combine to lower the general level of performance…we should bear in mind that none of the components is of one piece; each part is composed of individuals, every one of whom retains his potential of friction."[11] Clausewitz's concept of friction illustrates how the actions of one unit depend on another unit's ability to achieve a specific effect at a particular time or location. This increases the potential for systemic failure and the combined output may prove, in some ways, less than the sum of its parts. As Jervis pointed out, "interconnections can defeat purposive behavior."[12]

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[9] Shimon Naveh, *In Pursuit of Military Excellence: The Evolution of Operational Theory*, The Cummings Center series 7 (Portland, OR: Frank Cass, 1997), 21.

[10] Jervis, *System Effects*, 13.

[11] Carl von Clausewitz, *On War*, eds. and trans. Michael Eliot Howard and Peter Paret (Princeton, NJ: Princeton University Press, 1989), 138.

[12] Jervis, *System Effects*, 18.

Thus, military formations are complex systems because they consist of many interdependent elements. Further, they are not only complex systems: because of their inherent capacity for adaptation, one can also describe military organizations as complex adaptive systems (CAS). Despite the inherent unpredictability of complex systems, the structure, properties, and mechanisms of the behavior of complex adaptive systems provide a framework with which to develop a greater understanding of these non-linear dynamics. Understanding CAS potentially supplies insights into warfare as a phenomenon, as warfare is a clash between opposing CAS.

Adaptive Agents and Complex Adaptive Systems

CAS are adaptive with respect to the opportunities and challenges posed by their environment and other CAS within it. To understand how CAS adapt to their environment, one must explore the structure of CAS and describe three fundamental processes common in all adaptive agents: the performance system, credit assignment process, and rule discovery process.

Internal Models and Performance, Credit Assignment, and Rule Discovery Systems

CAS consist of adaptive agents. Adaptive agents behave in accordance with an internal model, a set of stimulus-response rules for interacting with their environment.[13] Many of these stimulus-response rules remain below the surface of human cognition. Often, adaptive agents do not fully understand and might not even know that rules and subroutines exist which form the internal models that guide their behavior. Yet, it is from these internal models that organized behavior of the agent emerges.[14]

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[13] John Henry Holland, *Hidden Order: How Adaptation Builds Complexity* (Cambridge, MA: Perseus Books, 2003), 43.

[14] Ibid., 33.
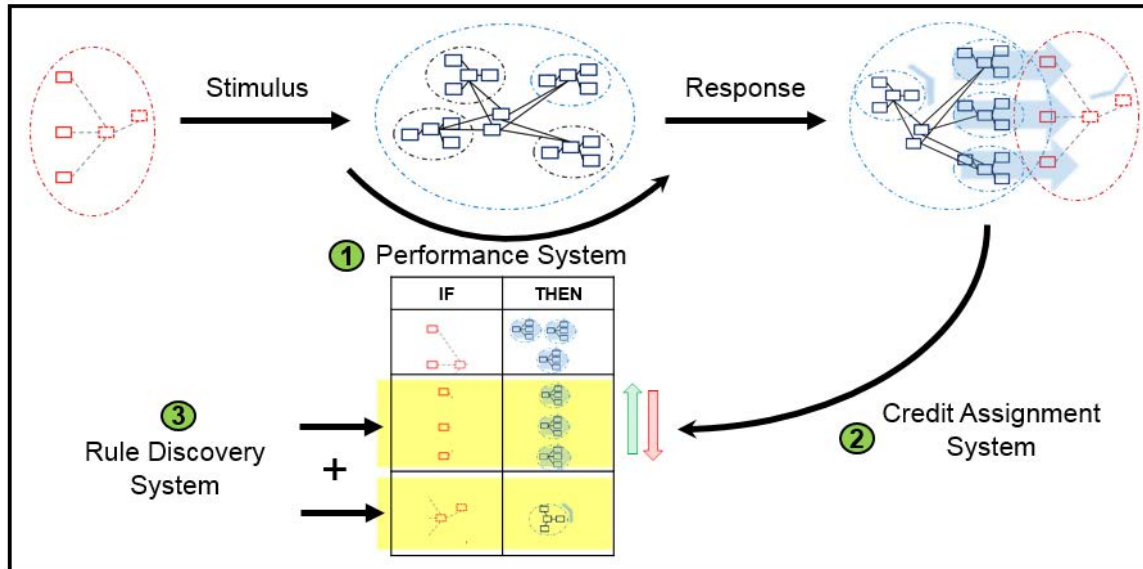
Figure 2. Performance, Credit Assignment, and Rule Discovery Systems in Adaptive Agents. *Source*: Author.

The internal models of agents are not static. All adaptive agents leverage a credit assignment system to refine and update their internal models in a continuous effort to improve their fitness level with the environment around them. An agent's or system's interactions with the environment generate feedback. Behavior that results in a favorable outcome results in the strengthening of the collection of stimulus-response rules enacted during the interaction. Behavior that results in a negative outcome leads to the weakening of the relevant stimulus-response rules.[15]

Adaptive agents respond to novel stimuli and low fitness levels relative to their environment through a rule discovery process. Seeking to respond to novel stimuli within their environment, agents employ combinations of historically successful behaviors, or building blocks, which might plausibly result in a favorable outcome.[16] Thus, an agent's or system's credit

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[15] Ibid., 53.

[16] Ibid., 61.

assignment and rule discovery process serves as the driver for refining internal models and enacting adaptive and evolutionary change.

Humans and the various organizations they create are adaptive agents and possess such performance, credit assignment, and rule discovery systems. Individuals possess structural knowledge and mental models about how the world works and the relationships between actors and variables within their environment. When making decisions, they leverage this structural knowledge to guide their actions in pursuit of their goals. As they interact with their environment, they learn about the cause-and-effect relationships that exist within that environment and, through learning, refine their mental models.

Clausewitz's description of *coup d'oeil* provides an insight into how military decision-makers leverage well-refined internal models. He argued that the concept of *coup d'oeil* "refers to the quick recognition of a truth that the mind would ordinarily miss or would perceive only after long study and reflection."[17] In "Conditions for Expert Intuition: A Failure to Disagree," psychologists Gary Klein and Daniel Kahneman asserted that the development of expert intuition requires two things: dynamic interactions between complex adaptive systems within the environment must behave in accordance with observable cause-and-effect relationships, and; the decision-maker must have adequate opportunity to learn the cause-and-effect relationships that govern dynamics within that particular environment.[18] They describe a process for the development of expert intuition that shares many commonalities with the way in which an adaptive agent's performance, credit assignment, and rule discovery systems work.[19]

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[17] Clausewitz, Howard, and Paret, *On War*, 118.

[18] Daniel Kahneman and Gary Klein, "Conditions for Intuitive Expertise: A Failure to Disagree," *American Psychologist* 64, no. 6 (October 2009): 524.

[19] These processes, common to all adaptive agents, also bear many similarities to John Boyd's observe, orient, decide, and act, or OODA, decision cycle.

Significantly, the non-linear dynamics within a complex environment can frustrate the credit assignment process. Due to their non-additive and non-proportional characteristics, they present a significant challenge to the agent attempting to determine cause-and-effect relationships. In chaotic systems, variables within the environment may be anything from extremely sensitive to indifferent to the actions taken by a system or agent to interact with it in some manner. The dynamics in such situations are often neither additive nor proportional. Further, the temporal relationship between condition-action-result may be such that the cause-and-effect relationship is difficult for the agent or system to discern.[20] Thus, disparities between an agent's structural knowledge and the objective reality concerning the 'true' relationship and interactions between variables inevitably arise. As a result, no adaptive agent can possess full rationality, or the ability to act based on full knowledge of the future consequences of its actions, to include the responses of other agents to those actions. Instead, such agents act based on bounded rationality by leveraging the credit assignment and rule discovery processes. Though imperfect, these processes, common to all adaptive agents, work much more efficiently than adaptation by random trial and error.[21]

Finally, these processes of adaptation through the credit assignment and rule discovery process promote diversity among constituent agents within a system. Previously homogeneous adaptive agents exposed to different local environments, or niches, will formulate different stimulus-response rules and, thus, structural knowledge about the world around them. Heterogeneity, or diversity, is the result of a bifurcation in the trajectory of homogeneous adaptive agents caused by varied responses to the environment. Further, adaptive agents co-adapt as the result of their interactions with each other, driving further diversity.[22] As described above,

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[20] Holland, *Hidden Order*, 54.

[21] Ibid., 61.

[22] John H. Holland, *Complexity: A Very Short Introduction*, 392 (New York: Oxford University Press, 2014), 25.

coordination between adaptive agents that possess complementary qualities can produce synergistic effects. CAS form and dissolve based on the levels of cooperation and competition between diverse groups of adaptive agents.

From Adaptive Agents to Complex Adaptive Systems

Adaptive agents can interact and cooperate with other agents in their local environment to achieve higher fitness levels to shared challenges or opportunities within the environment. Such interactions that have a favorable outcome strengthen in the cooperating agents' internal models, encouraging future cooperation. Boundaries begin to emerge around these cooperating agents as organization emerges - a system is formed. Agents occupy niches within the system based on their roles in past interactions. Thus, self-organized behavior between individual agents results in emergent higher-level, collective behavior.

In a process of co-adaptation and co-evolution, cooperation that produces unfavorable outcomes suffers penalties in the rank ordering of IF/THEN-type stimulus/response rules that comprise the agents' internal models, discouraging future similar interactions. If boundaries containing these agents previously existed, they deteriorate as the relationships and interactions between the agents weaken over time.[23]

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[23] Holland, *Hidden Order*, p. 89.
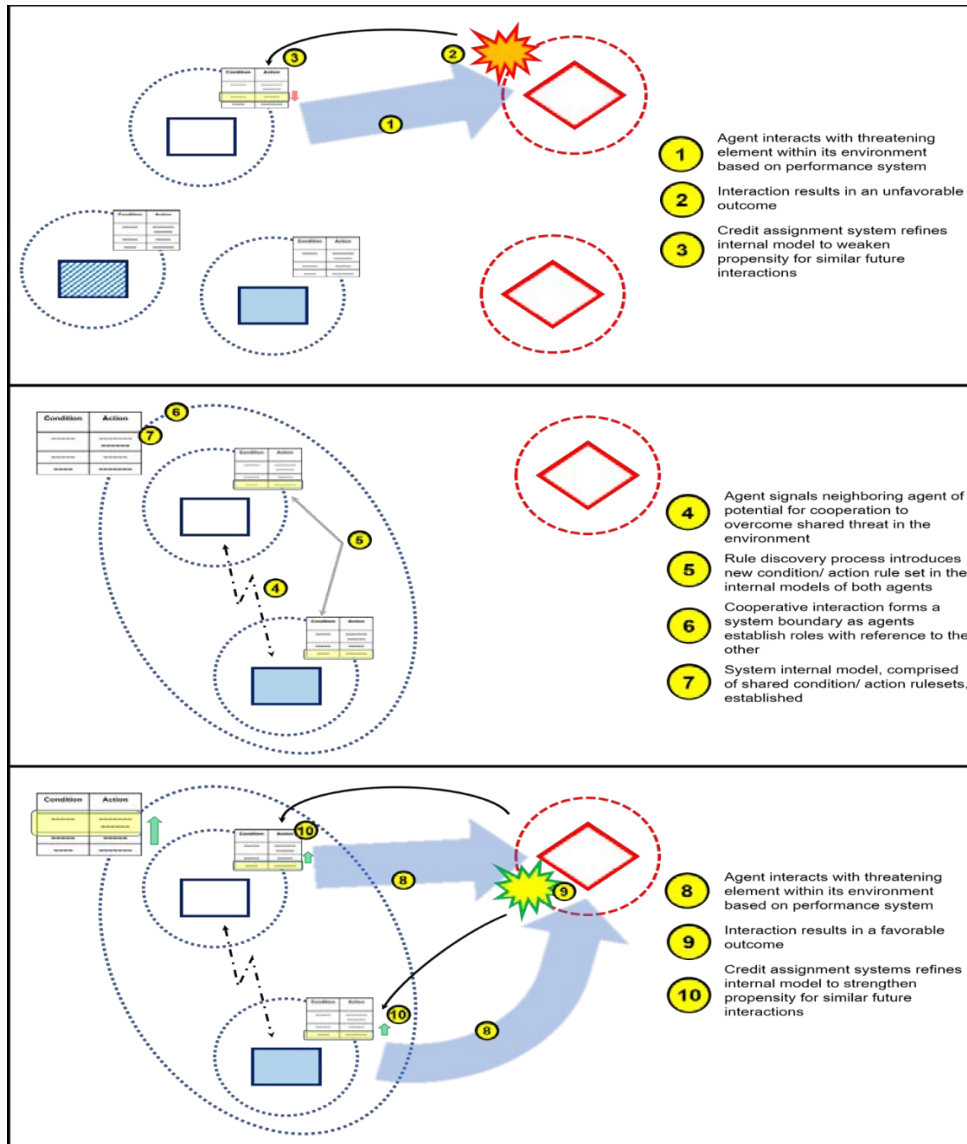
Figure 3. Complex Adaptive System Behavior as the Aggregate of Adaptive Agent Behavior. *Source*: Author.

Diverse types of relationships can exist between adaptive agents based on whether the outcomes of interaction result in favorable or unfavorable feedback for each of the agents involved. Thus, feedback loops create a set of relationships between an agent and the other agents, elements, systems, and subsystems within its environment. The regime of behavior can be further strengthened or modified by interactions of other types and strengths, further defining the relationship or regime of behavior. Through the pull and push of feedback loops, agents or elements become 'coupled' in a pattern of collective behavior. Coupling results necessarily in

reduced autonomy for both agents and an increased level of interdependence in their future shared interactions with the environment. One can see an example of the resulting process of CAS formation through the self-organization of local adaptive agents in the operations of the Israeli Defense Force on the Golan Heights during the confused, often chaotic fighting that took place in the 1973 Yom Kippur War.

CAS Dissolution and Formation through Self-Organization on the Golan Heights

In the early afternoon of October 6th, 1973, the Syrian 7th, 9th, and 5th Mechanized Divisions attacked across the Syrian-Israeli border intent on seizing and reclaiming the Golan Heights—territory lost to the Israelis six years earlier, during the 1967 Six Day War. Opposing them and outnumbered by over five-to-one, the Israeli Northern Command consisted of the Golani Brigade of Israeli paratroop infantry, the Fiftieth Paratroop Battalion, General Ben-Shoham's 188th Tank Brigade, and General Ben Gal's 7th Tank Brigade. The Syrians intended to stretch the thinly-manned Israeli defenses, penetrate the defensive positions, and commit the 1st and 3rd Armored Divisions to complete the seizure of the Heights prior to an expected UN ceasefire agreement.[24]

Though the Israelis fought tenaciously across the entire front, the Syrian 7th and 9th Divisions managed to push the defenders back more than ten kilometers in the north and center. In the south, however, the Syrian 5th Division fought and bypassed thinly spread elements of Ben Shoham's brigade, achieving multiple penetrations across its thirty-five-kilometer frontage and threatening the Jordan and Huleh Valleys west and south of the Golan Heights. Elements of the 188th Brigade continued to fight on valiantly, forming company- and platoon-sized pockets of resistance but accomplishing little to block the Syrian advance. Any coherent, large-scale Israeli defense along the southern Golan Heights had dissolved.

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[24] Trevor N. Dupuy, *Elusive Victory: The Arab-Israeli Wars, 1947-1974* (Fairfax, Va.: Hero Books, 1984).

General Hoffi, the commander of the Israeli Northern Command, ordered the mobilization of reserve units and authorized their piecemeal deployment into theater without waiting to consolidate as battalion or brigade-size formations—anything to stem the tide of Syrian forces and prevent them from flowing into the Israeli homeland below. Uncertain about the enemy forces' composition and disposition on the southern Golan Heights, desperate Israeli commanders dispatched understrength forces to halt the Syrian advance. These disparate company and platoon-sized reserve forces found themselves thrust into a swirling maelstrom of repeated Syrian thrusts of massed armor and hastily assembled Israeli jabs and counterthrusts. Remnants of Ben Shoham's 188th Brigade, detached formations of Ben Gal's 7th Armored, the famous 'Force Zvika', and elements of both Major General Dan Laner's and Major General Moshe Peled's reserve divisions fought tenaciously and gradually coalesced around the town of Nafakh. Through lateral coordination and collaboration, the scattered Israeli forces converged around Nafakh and conducted a successful defense of the town, soundly defeating the lead brigade of the Syrian 1st Armored Division and halting the Syrian advance.[25]

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[25] Abraham Rabinovich, *The Yom Kippur War: The Epic Encounter That Transformed the Middle East* (New York: Schocken Books, 2017), 227.

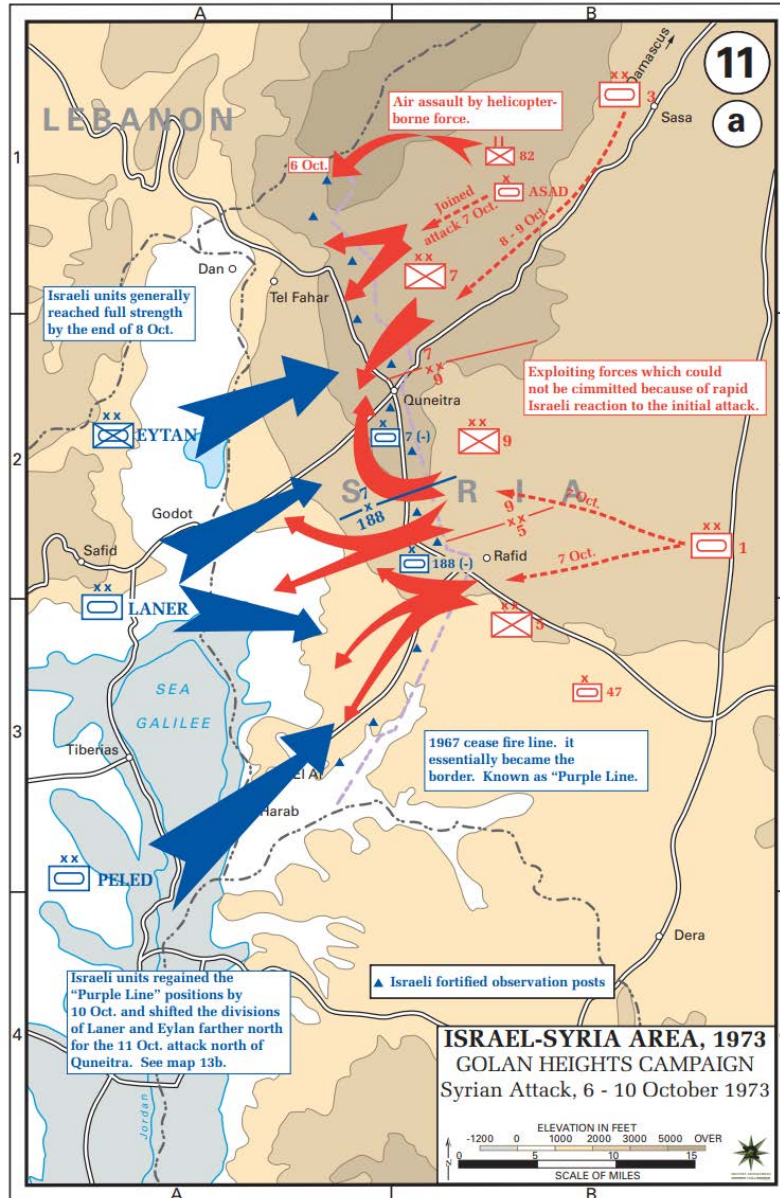Figure 4. Initial Phases of the Golan Heights Campaign, 1973. *Source*: United States Military Academy Academics Department

The Israeli experience on the Golan Heights in the first several days of the 1973 Arab-Israeli war demonstrates how adaptive agents, when confronted with a shared challenge, can collaborate and coordinate their actions to achieve effects greater than the sum of their individual efforts.

Fitness

Complexity science offers the concept of fitness to assess the ability of a complex adaptive system to survive, or 'fit,' within its current environment.[26] Multi-scale systems often have different levels of fitness at the varying levels on which they interact with their environment. The influence of varying levels of fitness at different scales—global, regional, and local—provides for interesting dynamics. A high level of fitness at one scale may enable achieving a high level of fitness at another at some subsequent point in time. On the other hand, high levels of fitness at one level may be offset by the disadvantages caused by low levels of fitness at another.

In a military context, the complexity concept of fitness aligns neatly with the concepts of combined-arms maneuver and positions of relative advantage. In *Fighting by Minutes*, American military theorist Robert Leonard argued that combined arms tactics aim "at employing friendly systems in terrain and under conditions which maximize their advantages while at the same time engaging enemy systems that are at a disadvantage in those conditions."[27] Military forces that achieve and sustain a position of advantage relative to an opposing force and its operational environment enjoy greater odds of achieving decisive effects against those systems. Military forces that suffer from low levels of fitness relative to their operational environment are likely to suffer disproportionate losses in combat power over time, either through destructive or disintegrating effects. When no side can achieve a high level of fitness relative to the other, attrition and protraction ensues, illustrating the close relationship between the concepts of attrition and annihilation and the complexity concept of fitness. Decisive results may stem from one system reaching a high level of fitness at one or more levels so rapidly that it achieves the desired effect on the adversary's system—such as causing its disintegration, destruction, or

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[26] Stefan Thurner, *Introduction to the Theory of Complex Systems* (New York: Oxford University Press, 2018), 246.

[27] Robert R. Leonhard, *Fighting by Minutes: Time and the Art of War* (Westport, Conn: Praeger, 1994), 44.

compelling its submission—before the adversary system can achieve parity. Conversely, attrition may result from failing to achieve a sufficiently high level of fitness at one or more levels quickly enough to overcome the enemy system's robustness or resilience.
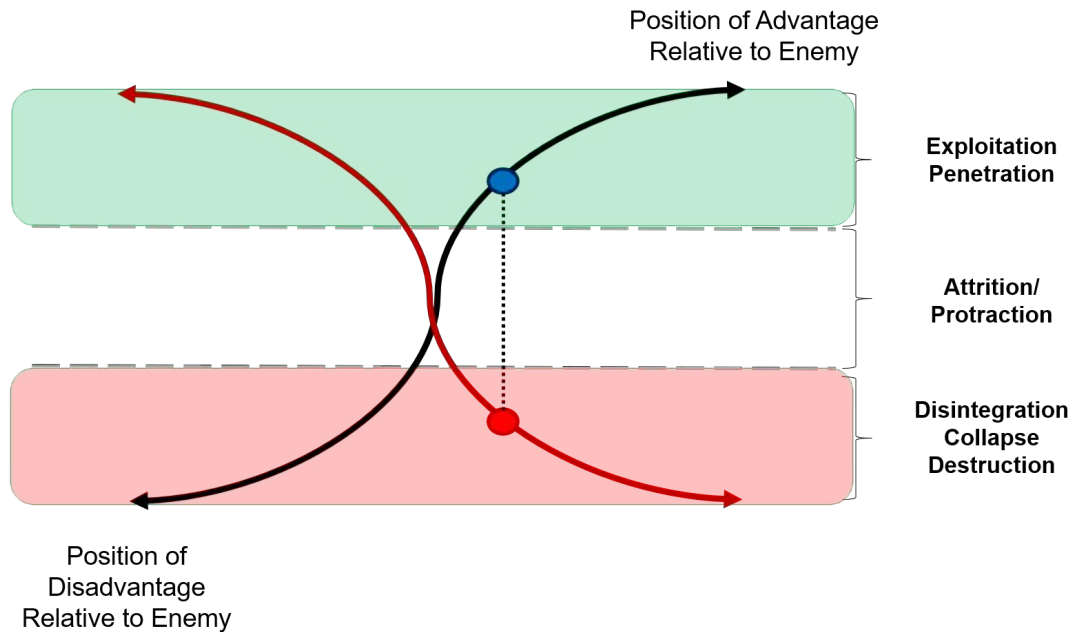
Figure 5. Fitness between Opposing Forces during Military Operations. *Source*: Author.

Positions of relative advantage at higher levels of war offer the potential to achieve increasingly decisive results within the context of a conflict. Positions of advantage at the strategic and operational levels confer potentially war-winning advantages for the remaining duration of the conflict, such as when the Israeli Air Force decimated the Egyptian Air Forces at the onset of the Six Day War in 1967, and thereby achieved air superiority from the onset. Similarly, high fitness levels at the operational and tactical levels can underpin campaign and battle-winning advantages, respectively. The Egyptian crossing of the Suez Canal during the 1973 Yom Kippur War's Operation Badr provides an excellent example of one military system achieving a very high level of fitness against an opposing military system.

Fitness and Operation Badr

In the afternoon of October 6th 1973, the Egyptian Second and Third armies began an assault across the Suez Canal and attacked into the Israeli-held Sinai Peninsula, initiating the fourth Arab-Israeli conflict. The Egyptian Armed Forces had meticulously planned and rehearsed the crossing in the months and weeks prior. Operation Badr proved a masterful demonstration of well-synchronized joint military and combined arms operations by exploiting vulnerabilities inherent in the anticipated Israeli response. Egyptian aircraft and artillery suppressed the Israeli positions along the thinly held Bar-Lev line as infantry and engineers crossed the Suez Canal in multiple waves of assault boats and pontoons. Engineers rapidly constructed pontoon bridges and reduced obstacles on the eastern embankment as tanks and mechanized vehicles made their way across on ferries. By nightfall, nearly 80,000 Egyptian soldiers and their equipment had reached the eastern embankment.[28]

The attack took the Israeli Defense Forces of Southern Command by complete surprise. Still, they responded rapidly and committed to Operation Dovecote, the Israeli plan for an initial defense along the eastern bank of the Suez Canal and subsequent counterattack by armored forces to push the attackers back into the canal. Expecting General Mendler's armored division and Israeli forces defending along the Bar-Lev line to defeat the Egyptian offensive, the Israelis mobilized two reserve armored divisions under General Ariel Sharon and Avraham Adnan. These armored forces, the Israelis believed, would wrest the initiative back from the Egyptian forces in a counter offensive to the west across the Suez and deep into Egypt. Senior Israeli leaders expected the Israeli Air Force to achieve air superiority quickly and support the IDF's counterattack as a form of 'flying artillery.'[29]

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[28] Dupuy, *Elusive Victory*, 411–414.

[29] Rabinovich, *The Yom Kippur War*, 19, 40.

Yet, the Egyptians proved well prepared for this response, having learned valuable lessons about the Israelis' preferred methods of fighting during the 1967 Six Day War. Upon reaching the eastern banks of the Suez, the initial waves of Egyptian infantry quickly dug in and repulsed General Mendler's armored counterattacks with a dense phalanx of anti-tank weaponry, most notably RPG-7 rocket launchers and SAGGER anti-tank missiles. By the early morning of October 7th, General Mendler's division had lost over half of its initial combat strength. A robust Egyptian air defense system similarly frustrated the efforts of the Israeli Air Force to beat back the attacking Egyptian armies. A dense, interconnected air defense umbrella consisting of SA-2s, SA-3s, SA-6s, SA-7 Strellas, and ZSU-23-4s decimated the Israeli Air Force's response, shooting down nearly half of the Israeli aircraft committed on the first day.[30]

Subsequent Israeli armored counterattacks by Generals Adnan and Sharon on the morning of October 8th fared little better. A lack of understanding about the Egyptian forces' dispositions and composition, combined with confusion and disagreement between General Gonen, commander of Southern Command, and his subordinate commanders (Mendler, Adnan, and Sharon) led to costly, piece-meal counterattacks that failed to wrest the initiative back from the Egyptians attackers.

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[30] Dupuy, *Elusive Victory*, 418.
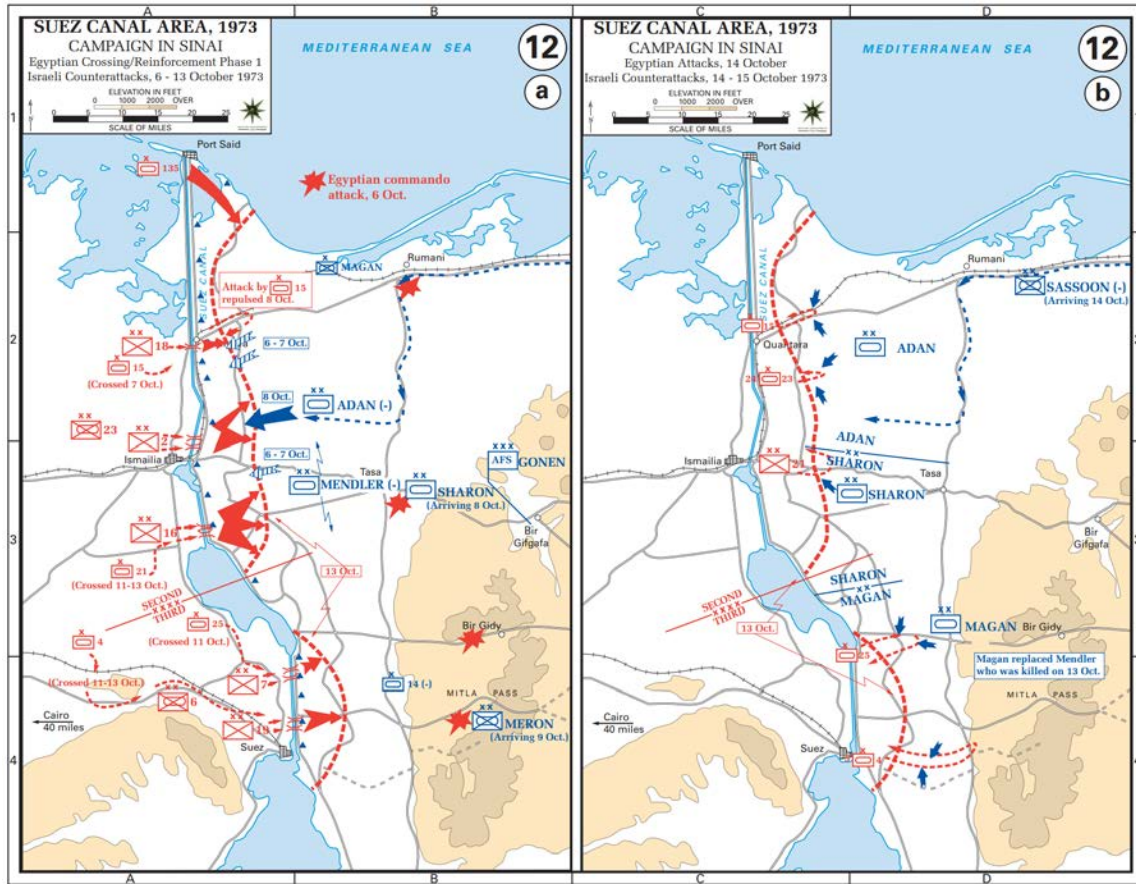
Figure 6. Initial Phases of the Campaign in the Sinai, 1973. *Source*: United States Military Academy Academics Department.

This historical example further illustrates the benefits derived from achieving functional, temporal, and psychological positions of advantage relative to an adversary's military system at the tactical level. Tactical action enabled by high fitness at that level may contribute to an increase in fitness at the operational level and strategic levels. For example, between October 16th and 18th the Israelis conducted several armored task force raids into the Egyptian rear area in conjunction with their crossing of the Suez Canal. These raids resulted in the destruction of six SAM sites and the displacement of another.[31] These actions contributed greatly to the eventual collapse of the Egyptian's formidable integrated air defense umbrella by October 20th, finally

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[31] Ibid., 515.

allowing the Israeli Air Force to provide effective close air support to Southern Command's ground forces.[32]
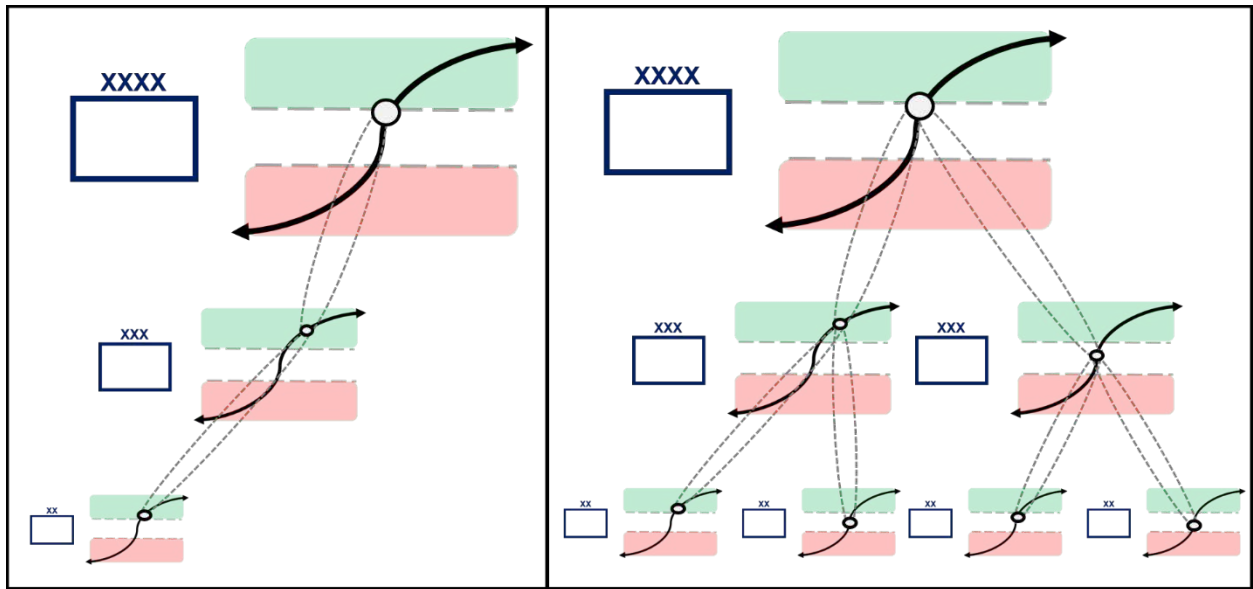
Figure 7. Interdependency of Positions of Relative Advantage and the Levels of War. *Source*: Author.

As a military organization interacts with its operational environment and adversary systems, one can expect that it will suffer the loss of various elements or the disruption or even severing of linkages between elements. Efforts throughout the organization to reestablish communications, reconstitute or substitute for a lost capability, or otherwise adapt its methods necessarily alter the structure of the system and, thus, its corresponding fitness level. Simultaneously, the adversaries' systems and the operational environment also adapt to the dynamic interactions with one another. In this way, the various systems on the battlefield co-adapt and co-evolve.

Achieving and maintaining a high level of fitness relative to the environment is thus essential for the survival and success of a CAS. To achieve a high level of fitness, CAS must array themselves to align with the challenges or opportunities existing within their environment.

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[32] Ibid., 524.

Such articulation of the system requires maintaining a balance between scale and complexity in its interactions with its surroundings.

Scale and Complexity of System Behavior

Amid the interwoven and interdependent tangle of relationships between elements, adaptive agents, and CAS within an environment—itself a CAS—exist lever points, which, if acted upon, offer the potential to change the aggregate behavior of the system's constituent agents, thus altering the system's dynamics and steering it away from its current trajectory.[33] It is against these lever points, or driver nodes, that CAS must direct their actions to drive aspects of their surroundings towards a more favorable state or configuration.[34]

In the system's interactions with its environment, the variously interacting elements, adaptive agents, and subsystems can combine in many ways to act on and achieve effects against the lever points and driver nodes existing within their environment.[35] Some of these lever points or driver nodes may require the application of a large-scale effort through the coordination of a great many of the system's components to achieve a desired effect. Others may require only the actions of a single or a very few components to affect an intended change.

An acting system, consisting of a finite number of components, can only perform a finite number of actions within that environment at any given time. This number, the product of all possible actions by each component, establishes a range of behaviors available to the acting system. As complexity scientist Yaneer Bar Yam points out, "A behavior does not correspond to a particular state of the system, but rather to a particular scheme of coordination of the parts."[36]

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[33] Holland, *Complexity*, 25.

[34] Yang-Yu Liu, Jean-Jacques Slotine Slotine, and Albert Laszlo Barbasi, "Controllability of Complex Networks," *Nature* 473 (May 12, 2011): 167.

[35] Yaneer Bar-Yam, "Multi-Scale Variety in Complex Systems," *Complexity* 9 (2004): 37.

[36] Ibid., 38.

Thus, the extent to which components either are bound by their interdependencies or enjoy autonomy serves to delineate the ends of a range of behaviors available to a CAS.

At one end of this range of behaviors, the components of the system are completely homogeneous and able to perfectly synchronize their actions in time and space to maximize the synergistic effects provided by the interdependent relationships, thereby exhibiting behavior on a large scale. However, coordination within such tightly coupled systems is usually highly centralized and rigid, while the resulting behavior is often simple and easily predictable. The high degree of interdependence inherent in tightly-coupled systems creates a risk of cascading system failure, which can result when a single component fails to deliver the intended effect at a specific time and location upon which other actions are dependent. On the opposite extreme end of the spectrum, the components of the system interact with their environment with complete autonomy, exhibiting a completely disordered and diffuse behavior. The uncoordinated nature of such actions prevents the system from achieving the necessary scale against some driver nodes and leverage points.

Between these two extremes lies a finite number of states or configurations of the system in which the levels of interdependence and autonomy between the components varies. As one moves along the spectrum from system configurations characterized by large scale behavior towards more disordered and diffuse states, the system's behavior become increasingly more complex. In between the two extremes, loosely coupled systems—characterized by the decentralized actions of the system's agents—exhibit a balance between interdependence and autonomy in component behavior. They prove more flexible than tightly coupled systems because the relationships between agents are not rigid and the ways in which they coordinate their actions are less fixed. Thus, they enjoy wide variety in the combinations available with which the system

may approach problems, improving the system's ability to achieve combined effects of greater scale than disordered systems.[37]
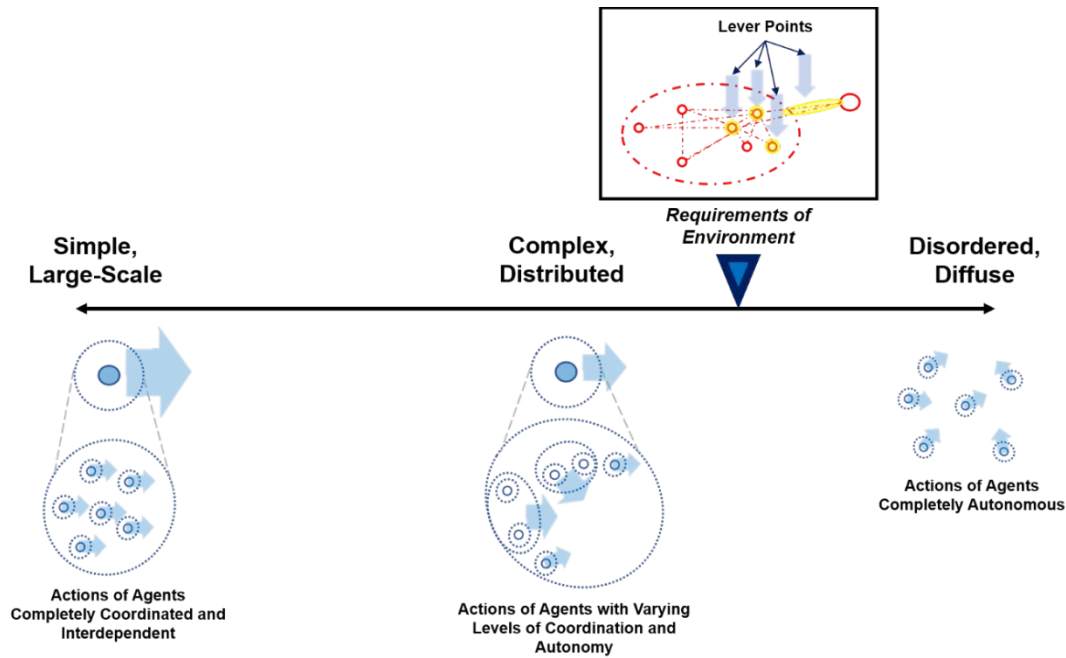
Figure 8. Scale and Complexity in CAS Behavior. *Source*: Author.

CAS must thus strike a balance between the scale and the complexity of its behavior to successfully affect change within its environment. In introducing his "Multiscale Law of Requisite Variety", Yaneer Bar-Yam asserted that, at each scale, the number of possible configurations of the acting system exceed the number of lever points or driver nodes within the environment at that scale.[38] Or, simply put, in order to achieve increasingly higher levels of fitness relative to its environment, a CAS must exhibit behavior of both sufficient complexity and scale to act effectively on the aspects of its environment that it seeks to manipulate.

In the context of military operations, risk exists in both tight coupling and loose coupling of a military system. Tight coupling in military systems can be fraught with organizational risk,

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[37] Czerwinski, *Coping with the Bounds*, 146.

[38] Bar-Yam, "Multi-Scale Variety in Complex Systems," 38.

or the risk of agent failure in the execution of an intended action. The resulting friction will then limit the formation's actions due to the rigid interdependence between subordinate unit action. The synchronization needed for successful action taxes coordination mechanisms within the system. Conversely, loosely-coupled military systems face increased combat risk, or risk of exposure to the enemy's strength, as individual units shed the protection associated with mutually supportive relationships in favor of greater autonomy. In doing so, they become more reliant on the combat power intrinsically available and unmask inherent vulnerabilities that the enemy may exploit.[39] A comparison of Israeli division-level attacks against Egyptian defensive positions near Abu Agiela during the 1956 Sinai Campaign and then in 1967 Six Day war allows for a deeper appreciation of the tension that exists between the requirements for scale and complexity during the conduct of military operations.

Contrasting Scale and Complexity at Abu Ageila in 1956 and 1967

On July 23rd 1956, Egyptian President Gamal Abdel Nasser unilaterally nationalized the Suez Canal, prompting Britain and France to enter into a secret agreement for joint military action with Israel to force the Egyptians to reverse their decision. The Sevres Agreement called for an Israeli invasion of the Sinai to serve as a pretext for British and French intervention and allow them to secure the Suez Canal.[40] A subsequent combined British and French airborne and amphibious operation, Operation Musketeer, would then take place to seize the Suez Canal, occupy the canal zone, and ultimately wrest control of the important waterway from Egypt for international use.

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[39] Edward Luttwak, *Strategy: The Logic of War and Peace*, Rev. and enl. ed. (Cambridge, Mass: Belknap Press of Harvard University Press, 2001), 8–9.

[40] George Gawrych, Key to the Sinai: The Battles for Abu Ageila in the 1956 and 1967 Arab-Israeli Wars, CSI Research Series 7 (Fort Leavenworth, Kansas: United States Army Command and General Staff College, Combat Studies Institute, n.d.), 19.

In the early morning of October 29th, Israeli paratroopers seized the Mitla Pass deep within Egyptian territory on the Sinai Peninsula, opening the second Arab-Israeli war. On the following day, the 77th and 38th Ugdahs, or division-sized Task Groups, of the Israeli Defense Force thrust into the Sinai along the northern and central approaches, respectively, to penetrate the Egyptian Army 3rd Division's defensive positions and thenseize terrain in the vicinity of the Suez Canal. In conjunction with operations to seize Sharm-el-Sheik, these offensive operations aimed to collapse the Egyptian Armed Forces defending along the Sinai, break the Egyptian blockade of the Strait of Tiran, and threaten the Suez Canal to provide legitimacy to Musketeer.[41]
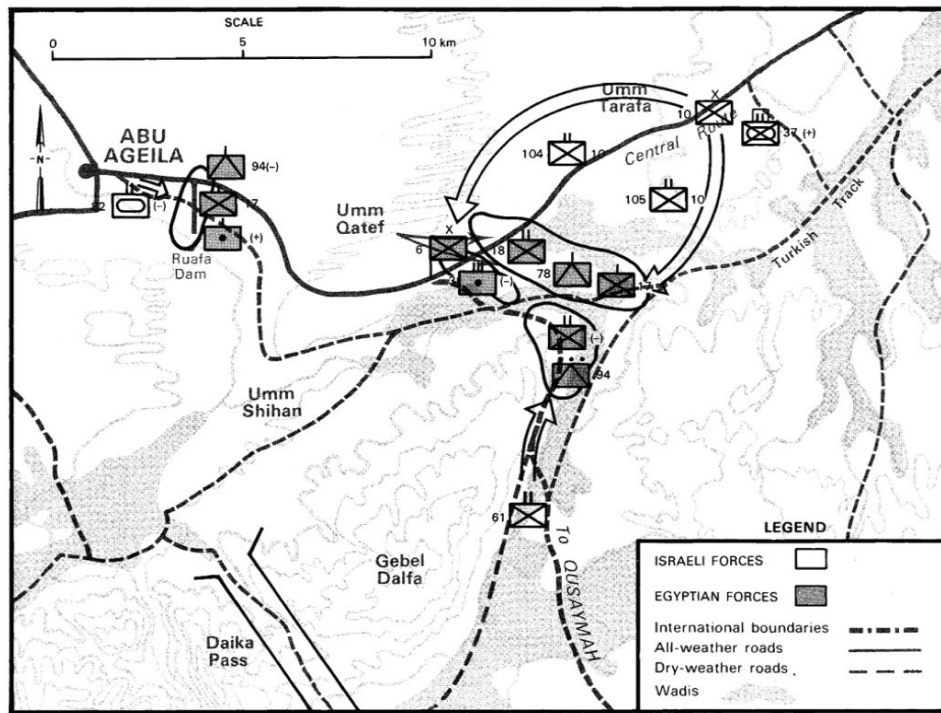
Figure 9. Israeli Plan of Attack on Abu Ageila, 1956. *Source*: Gawrych, *Key to the Sinai: The Battles for Abu Ageila in the 1956 and 1967 Arab-Israeli Wars.*

Though Operation Kadesh enjoyed initial success as the Israeli 202d Paratroop Brigade rapidly seized the Mitla Pass and its approaches from the southeast, the mechanized thrusts by the 38th and 77th Task Groups on October 30th and 31st proved hastily-planned, dyssynchronous

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[41] Ibid., 32.

affairs with disappointing results. The Egyptian 3rd Division's 6th Brigade repeatedly repulsed and counterattacked the 38th Task Group's disjointed attacks near Abu Ageila, eventually prompting the commitment of the Israeli Southern Command's reserve mechanized brigade. Between October 30th and November 1st, elements of the 38th Task Group conducted a series of battalion- and brigade-level assaults without success and with significant casualties. The Israeli Command, unable to control operations and coordinate a combined-arms effort of sufficient scale to unhinge the Egyptian defensive positions, suspended further offensive operations around Abu Ageila.[42] Though the IDF would ultimately prove victorious, the challenges they experienced at the tactical and operational level of war became the focus its evolution during the ten years that followed.

On April 7th 1967, a confrontation between Israeli and Syrian Air Forces occurred, resulting in the destruction of six Syrian fighters.[43] The incident set in motion a series of escalations between Israel and its Arab neighbors that eventually led to the third Arab-Israeli war, known in Israel as the Six Day War. On June 4th, Israeli leaders committed to launch a preemptive attack on a growing military threat along its borders. The Israeli Southern Command's operational concept consisted of four phases: penetration of the initial line of Egyptian defenses along the Rafah-El Arish coastal axis and at Abu Ageila, penetration of the second defensive line near Jebel Libni, seizure of key mountain passes in the central Sinai, and an advance to the Suez Canal.[44]

At 7:45 am on June 5th, Israeli aircraft conducted a three-hour attack, striking airfields across Egypt. The attack resulted in the destruction of over 300 Egyptian planes, 23 radar installations, and many anti-aircraft sites, crippling the Egyptian air forces from the very onset of

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[42] Dupuy, *Elusive Victory*, 165.

[43] Gawrych, *Key to the Sinai: The Battles for Abu Ageila in the 1956 and 1967 Arab-Israeli Wars*, 74.

[44] Dupuy, *Elusive Victory*, 243.

the war. At 8:15 a.m., General Tal's *Ugdah* commenced an attack along the northern coastal axis. Tal's tank-heavy formation's surprised and rapidly overran the defensive positions held by the 20th Palestinian Liberation Army and the Egyptian 7th Division, In the center, General Ariel Sharon's division conducted a meticulously planned and well-synchronized combined-arms division-level attack against the formidable Abu Ageila defensive positions held by Egypt's 2nd Infantry Division, forcing the latter's withdrawal in less than 12 hours. The first phase of the Israeli offensive against Egypt proved immensely successful.
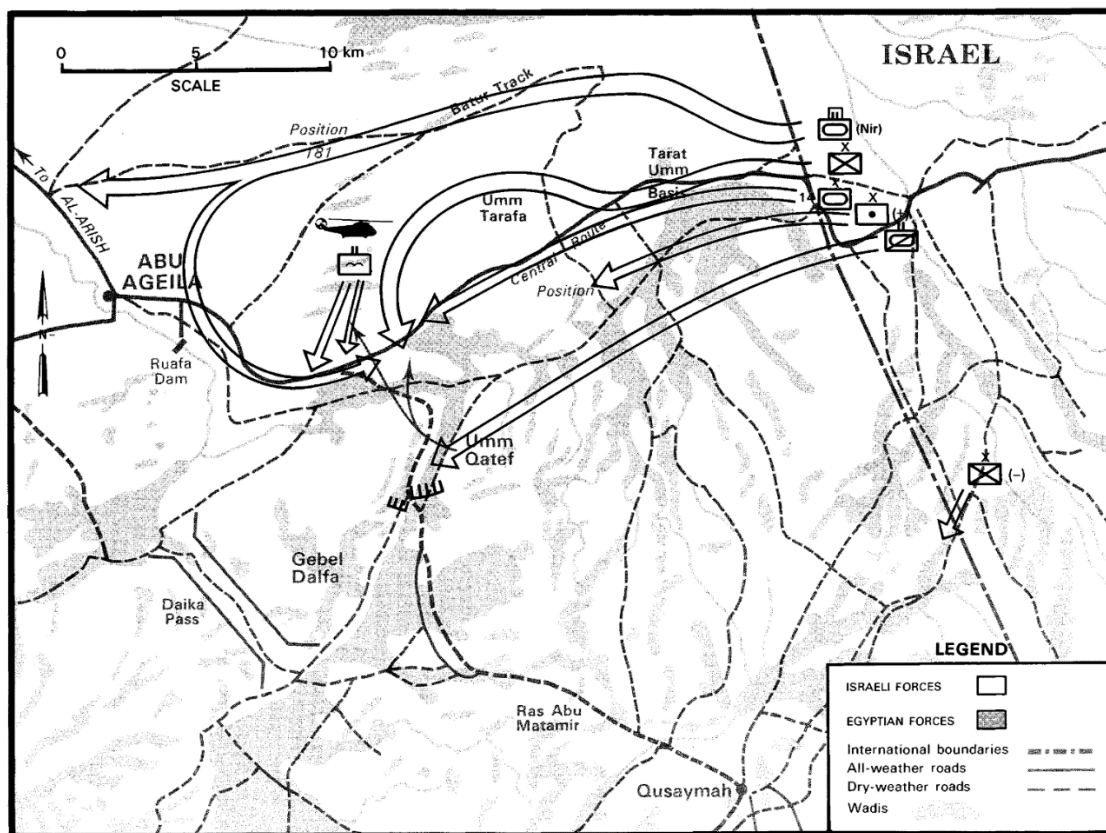
Figure 10. Israeli Plan of Attack on Abu Ageila, 1967. *Source*: Gawrych, *Key to the Sinai: The Battles for Abu Ageila in the 1956 and 1967 Arab-Israeli Wars*, 74

Dumbfounded by the destruction of the Egyptian Air Forces, panicked by the rapid penetration of the Israeli forces in the Sinai, and fearing the potential for a US invasion of the Suez Canal and Nile Delta, Egyptian General Ali Amer ordered the withdrawal of all Egyptian forces in the Sinai west across the Suez Canal. Unlike the well-executed withdrawal of 1956, the

Egyptian operational system collapsed and lost all coherence. Though Egyptian divisions fought valiant, if costly, rear-guard actions to preserve their forces, Egyptian command and control above the division-level disintegrated.

This contrasting historical vignettes illustrate the tension between scale and complexity in a system's behavior. In 1957, Israeli subordinate commanders enjoyed too much autonomy and were too inexperienced in the conduct of combined arms manuever to sufficiently coordinate and achieve the desired effect against the Egyptian defenders. The Israelis rectified this problem in 1967 and, though tightly-coupled, achieved decisve effects in their force employment against a well-prepared Egyptian position. The Israelis would prove capable of operating as a loosely coupled system during the subsequent exploitation and pursuit, accepting risk of not being able to achieve effects at a greater scale in order to increase operational tempo.

Anticipation, Adaptation, and Evolution

This work's topology of complexity concepts concludes with the three processes through which complex adaptive systems behave: anticipation, adaptation, and evolution.[45]

CAS anticipate their future interactions with their environment and the complex adaptive systems that reside within it. CAS leverage detectors to collect information about its environment and processes that information through their performance system. Based on the output of this performance system, CAS arrange and coordinate the actions of effector agents to interact with the environment in ways that anticipate favorable outcomes in accordance with internal goals.[46]

Military planning processes exemplify this process of anticipation. Military decision-makers seek to understand the operational environment and the adversary systems operating within it prior to dividing the formation's objective into a series of tasks and missions for execution by subordinate formations.

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[45] John H. Holland, "Complex Adaptive Systems," *Daedalus* 121, no. 1 (1992): 18.

[46] Ibid., 25.

CAS also adapt to the changing conditions of interactions with their environment. As discussed previously, the internal models of agents are not static. All adaptive agents receive feedback regarding the effectiveness of their actions and employ a credit assignment system to refine and update their internal models in a continuous effort to improve their fitness level with the environment around them. Behavior that results in a favorable outcome results in the strengthening of the collection of stimulus-response rules that directed behavior underlying the interaction. Behavior that results in a negative outcome results in the weakening of the relevant stimulus-response rules.[47]

Military decision-makers frequently rely on more rapid planning or reframing processes to plan and direct adjustments to the behavior of the system based on assessments during the execution of operations. Additionally, CAS can also adapt to their environment through the aggregate behavior of the system's agents. Each of the interdependent elements of the system operates in accordance with its own internal model, adapting to its local environment.[48] As described above, individual agents can self-organize with other agents, producing emergent collective behavior in ways that achieve a higher level of collective fitness with the environment. Through the process of self-organization or self-synchronization, the system can adapt to its environment from the bottom up as well as from the top down.

Adaptation through the self-organization of subordinate units is not an aspect of military organizational behavior often addressed in military doctrine. Self-organization through coordination between subordinate elements requires not only initiative by subordinate military leaders to respond to local opportunities and challenges, but also a shared understanding of which combinations of coordinated behavior are likely to succeed in a given environment. Thus, a common internal model serves as the coordination mechanism for self-organized adaptive

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[47] Holland, *Hidden Order*, 53.

[48] Holland, "Complex Adaptive Systems," 18.

behavior. In highly centralized, or tightly coupled, military organizations, the headquarters directs the synchronization between subordinate units, limiting the potential for adaptive behavior through self-organization.

Finally, CAS evolve. As the CAS interacts with its environment, a credit assignment process enables evolution to occur by evaluating the effectiveness of its behavior in achieving desired outcomes. Responses to stimuli resulting in favorable outcomes strengthen and become building blocks for future behaviors while those resulting in less than favorable outcomes weaken. A rule discovery process continuously seeks to refine the internal model of the system, exploring new ways with which to interact with the environment. This rule discovery system supplies plausible rules from novel combinations of existing tested rules. In subsequent actions, the CAS experiments with these hypotheses, adopting those that produce favorable outcomes and abandoning those that produce undesirable outcomes.[49]

Complexity and Military Operations

Warfare is undeniably complex. Large-scale combat operations involve thousands, if not tens of thousands of agents engaged in a maelstrom of interdependent interactions of varying scale and complexity. Military organizations and actors, seeking to cope with their environment, co-adapt and co-evolve over time. On both sides of a conflict, adversaries modify their behaviors, abandoning actions that result in unfavorable outcomes and experimenting with new combinations of behavior in an ongoing effort to gain a competitive advantage in future interactions with each other as well as the operational environment, itself continuously adapting and evolving to the activities of the opposing forces operating within it. Further, interactions occur across scales—military organizations and individual actors interact with others above, below, and parallel with themselves in organizational hierarchies and modify their behavior based on the behaviors of those with whom they interact. Despite this complexity, CAS theory offers

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[49] Ibid., 23.

insights into the patterns that exist amid this seeming randomness. Understanding the structure, properties, and mechanisms of CAS provides insights into the nature and behavior of military organizations and their conduct of military operations.

Because CAS must achieve a high level of fitness relative to their environment to survive and thrive, it is essential for military organizations to gain and exploit positions of relative advantage over an enemy force in large-scale combat operations. Yet, a well-trained and competent enemy force will be careful to protect their inherent vulnerabilities and act to deny friendly forces the ability to achieve a position of relative advantage. Indeed, peer and near-peer-adversaries possess modern military systems, which military theorist Stephen Biddle describes as "a tightly interrelated complex of cover, concealment, dispersion, suppression, small-unit independent maneuver, and combined arms at the tactical level, and depth, reserves, and differential concentration at the operational level of war."[50]

Indeed, in contemporary operating environments enemy anti-access area-denial systems (A2AD) prevent joint military forces from employing combat power against the entire depth of the enemy system. Integrated fires systems and the threat of weapons of mass destruction serve to frustrate the Joint Force's efforts to project combat power forward. In the context of previously discussed complexity science concepts, there is no easily discernable path to achieving a high level of fitness. Modern military systems will struggle to articulate themselves against opposing systems in a way that achieve decisive effects in a single series of interactions. The fight to achieve an initial position of advantage between modern military systems could very well prove costly and without guarantee of degenerating into a protracted conflict of attrition.

Not only will an enemy anticipate a friendly force's actions and take measures to protect its system's critical vulnerabilities, but it will also react to unanticipated threats through

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[50] Stephen D. Biddle, *Military Power: Explaining Victory and Defeat in Modern Battle* (Princeton, NJ: Princeton Univ. Press, 2004), 3.

adaptation and evolution. Modern military systems enjoy a resilience and robustness that that makes the probability of system collapse or failure resulting from a single series of blows unlikely. A capable enemy system will eventually adapt and evolve to friendly military actions, eroding the military value extracted from impermanent positions of relative advantage. Therefore, one should expect the duration of a conflict between two opposing modern military systems to extend beyond a single series of interactions or a decisive 'first battle,' as the opposing systems act and react to one another's attempts to achieve positions of advantage in a process of co-adaptation and co-evolution. As much as military practitioners should develop doctrinal concepts that avoid iteration and defeat and seek to defeat or destroy an adversary's system in a single series of acts, they should prepare for the very real possibility of iteration in warfare.[51]
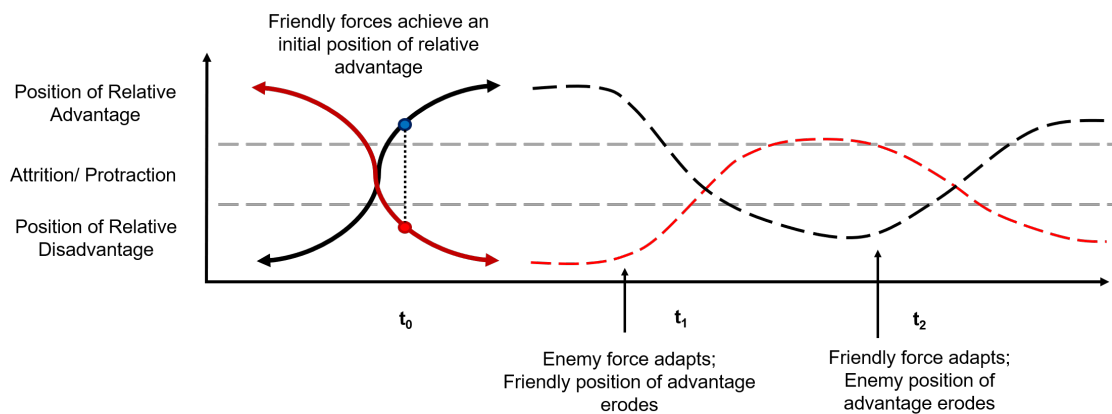
Figure 11. Adaptation in Warfare. *Source*: Author.

Further, the higher the level of warfare, the more value positions of relative advantages may yield towards achieving the military aim. Yet positions of advantage at lower levels, if exploited, can create opportunities to achieve positions of advantage at higher levels. As result, military systems should endeavor to anticipate and seize opportunities to achieve a position of

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[51] Jim Storr, *The Human Face of War* (New York: Continuum, 2009), 54; Naveh, *In Pursuit of Military Excellence*.

advantage in not only the traditional top-down manner but also through adaptation and self-organization from the bottom up.
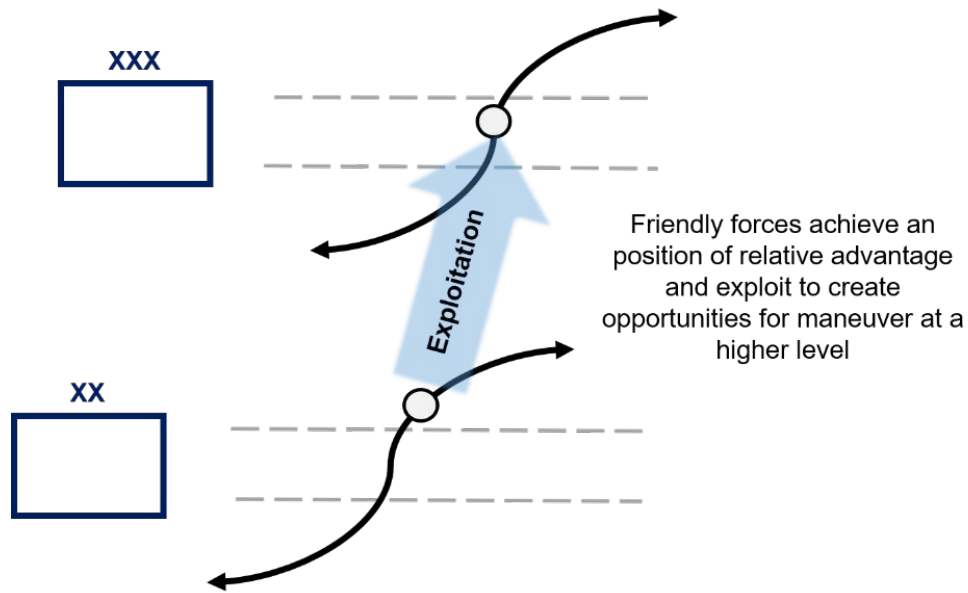
Figure 12. Exploitation of Positions of Relative Advantage to Achieve Opportunities at Higher Levels. *Source*: Author.

Loose coupling, or decentralization, provides flexibility that allows for adaptation in the face of uncertainty. Tightly coupled, or highly centralized, military systems develop highly optimized plans, efficient and exacting in their employment of combat power with an anticipation of delivering decisive effects on the enemy system. Yet, because uncertainty surrounds the enemy system's behavior, the possibility exists that friendly forces will array themselves in a way fails to achieve a position of relative advantage. Even in those instances wherein the friendly system's actions do achieve an initial relative position of advantage, windows for exploitation against adaptive enemies are fleeting and that the value of that advantage erodes over time.

Understanding this, military planners and decision-makers consider the full range of potential outcomes resulting from a clash of opposing systems, developing decision points, branch plans, and sequels, increasing the complexity of and organizational risk associated with its plans. These are critical processes to developing a better understanding of an operational environment and the adversary systems that operate within and essential to taking informed

action on the battlefield. Yet, no amount of planning or anticipation can overcome the inherent uncertainty surrounding the possible outcomes of interactions between opposing complex adaptive systems.

To address unanticipated challenges or seize unforeseen opportunities, military formations require depth and breadth in the variety of responses to the challenges likely to confront them. With proper task-organization, dispersed groups of semi-autonomous, self-contained forces capable of self-organizing with adjacent units offer such adaptive capacity, eschewing efficiency in favor of increased resilience and robustness. Indeed, in his "Patterns of Conflict," theorist John Boyd asserted that success on the battlefield requires "a variety of responses that can applied rapidly, harmonizing the activities of the elements of the organism."[52] Thus, loosely-coupled organizations seem best suited to operating within complex environments characterized by perpetual novelty.

This deduction generates two additional implications for military practitioners. First, a shift from traditional top-down control to bottom-up collaboration and self-organization requires a change in the coordination mechanisms that direct cooperative interactions and provide the system its coherence. Shared internal models guiding the collaborative interactions of decentralized actors can replace centralized control by an organizational headquarters, but command remains essential for providing the military aim through which the system maintains its coherence.[53] Second, a focus on self-organization or collaborative maneuver requires military commanders to shift the orientation of their coordination efforts from 'down-and-in' to 'up-and-out.' Traditionally, commanders and staffs have sought to reduce organizational risk generated by friction by coordinating the interactions between subordinate units. Boyd asserts that this process of top-down control generates internal cognitive dissonance and erodes the quality of the

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[52] John Boyd, "Patterns of Conflict" (Unpublished presentation, 1986).

[53] Naveh, *In Pursuit of Military Excellence*, 6.

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decision-making that directs the system's actions over time.[54] CAS theory offers a solution. The concept of self-synchronization suggests that commanders should place greater emphasis on coordinating their actions with the activities of other components of the larger system of which they are a part.

In conclusion, warfare consists of a series of violent interactions between opposing CAS. Success comes from the attainment and exploitation of positions of relative advantage that destroy or defeat the adversary's system – the higher the level of war at which this occurs, the better. However, war is adversarial. A capable and well-prepared enemy not only seeks to achieve a position of advantage relative to the friendly system, but also determinedly protects against the achievement of such an advantage against themselves. Further, a single act or series of offensive actions may prove incapable of collapsing or destroying sufficiently resilient, robust, or adaptive enemy systems. Under these circumstances, friendly forces must employ a combination of aggressive reconnaissance and military deception to identify and create, and then - through decisive offensive action - seize and exploit positions of relative advantage that generate opportunities for maneuver at progressively higher levels. Positions of relative advantage that, when exploited, do not yield higher level opportunities provide significantly less value.

The military forces most capable of operating in this manner are distributed, self-contained, semi-autonomous combined arms, joint, or multi-domain formations operating at supporting distances or ranges of one another, demonstrating an emergent capacity for higher-level maneuver through self-organized behavior characterized by collaborative coordination towards the achievement of a common military aim. The following section applies this conclusion to Unified Land Operations—the US Army's operational concept—to determine what similarities and differences exist. The concluding section offers possible solutions with which to reconcile any differences that may exist.

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[54] John Boyd, "Destruction and Creation" (Unpublished presentation, 1976).

Reviewing US Army Doctrine

FM 3-0 frames the US Army's role in the conduct of large-scale combat operations, stating: "During large-scale combat operations, Army forces focus on the defeat and destruction of enemy ground forces as part of the joint team."[55] Yet, US Army doctrine seems to offer a topology of implicitly related concepts rather than an explicit and coherent conceptual framework for how US Army forces achieve the destruction or defeat of a modern enemy system. Causal connections exist rather than explicit ones, creating conceptual gaps or seams in the US Army operational concept and future operating concept. As this chapter will argue, the complexity concepts of fitness, adaptation, and self-organization provide concepts and metaphors that might serve to bridge these conceptual gaps and seams.

US Army Doctrine and Fitness

FM 3-0 states: "It is the exploitation of positions of advantage through maneuver which deters, defeats, or destroys an enemy."[56] US Army doctrinal publications describe how positions of relative advantage exist in all domains and at every level of war. For example, military forces strive to achieve air, maritime, space, and cyberspace superiority, exploiting those positions with cross-domain maneuver. At the tactical level, military forces can achieve positional relative advantage by threatening or striking the flank or rear of an opposing force. Quantitative or qualitative superiority can provide favorable combat power ratios, which themselves can serve as positions of relative advantage. In addition to these physical positions of relative advantage, military forces can achieve temporal or psychological positions of relative advantage which they might exploit and dominate an enemy force.

FM 3-0 places heavy emphasis on seizing the initiative as a primary means of gaining a position of relative advantage, asserting that Army forces "seize, retain, and exploit the

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[55] US Department of the Army, *Field Manual (FM) 3-0, Operations*. p. 1-15

[56] Ibid., p. 1-19.

initiative by forcing the enemy to respond to friendly action."[57] Throughout, the publication

vaguely relates the concept of initiative to positions of relative advantage, arguing that

"Executing offensive tasks compels an enemy to react, creating or revealing additional

weaknesses that an attacking force can exploit."[58] Further, the manual notes that "seizing the

initiative pressures enemy commanders into abandoning their preferred options and making

mistakes. Enemy mistakes allow friendly forces to seize opportunities and create new avenues for

exploitation."[59] A key idea underlies these statements, namely that every time a military system

commits its forces to a course of action, it assumes risk derived from the vulnerabilities inherent

in the way it arrays itself.[60] These vulnerabilities present opposing systems opportunities for

exploitation. Thus, gaining a position of advantage relative to an enemy force requires either

identifying vulnerabilities and taking action to exploit them or compelling the enemy system

to array itself such that it presents such opportunities to the friendly force.

Sensing the requirement to seize the initiative, US Army commanders act, battering

the enemy with powerful thrusts in the hopes of either identifying a seam or gap within the

enemy position or forcing the enemy to commit an error in their own force employment,

thereby creating an opportunity for friendly forces to exploit. Yet, there can be no guarantee

that such friendly actions will unmask an enemy vulnerability. Further, these statements

understate the fact that friendly forces themselves must assume risk associated with

vulnerabilities inherent in their attack against the enemy system. US Army doctrine does not

imply that these risks do not exist, but it also fails to acknowledge them explicitly, making the

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[57] Ibid.

[58] Ibid.

[59] Ibid.

[60] "Thoughts on the Role of Reconnaissance in Exploiting the Enemy's Vulnerabilities," *The Tactical Leader*, accessed April 7, 2019, https://www.thetacticalleader.com/blog/2017/5/27/thoughts-on-the-role-of-reconnaissance.

conceptual linkages between initiative and positions of advantage unclear. Without explicit conceptual linkages, military leaders may misinterpret the US Army's theory of action and engage in an attritional style of warfare that attacks the enemy system where it exists, losing sight of the necessity to identify or create opportunities for future exploitation.

Against adaptive enemies, positions of advantage are usually temporary. *FM 3-0* acknowledges this fact but underemphasizes its implications. Sufficiently robust and resilient enemy systems will adapt to threats posed by friendly forces, eroding the value of a position of advantage as time progresses. To retain the initiative and continue progression towards the military objective, the seizure and exploitation of a position of relative advantage at one level must translate into opportunities for maneuver at progressively higher levels. Failure to achieve this will result in culmination of the friendly force, ceding of the initiative, and a return to a protracted, attritional-style of warfare at that level.

Thus, acting—by itself—does not confer one side the initiative over a well-prepared enemy force. Nor does seizure and exploitation of the initiative guarantee a continuation of that advantage. Army forces must act in a way that provides the initiative and—once in possession of it—act in a way that allows them to then maintain it. A previous doctrinal publication, *Army Doctrinal Publication 3-0, Operations* 2011 provides some clarity, explaining that "To seize, retain, and exploit the initiative, Army forces strike the enemy, both lethally and nonlethally, in time, places, or manners for which the enemy is not prepared."[61] Striking an enemy system in a time, place, or manner for which it is not prepared is the very definition of surprise. Thus, if US Army leaders wish to seize the initiative, they will have to achieve surprise by either identifying and striking an enemy vulnerability or employing military deception to create one.

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[61] US Department of the Army, *Army Doctrinal Publication (ADP) 3-0, Operations* (Washington, DC: Government Printing Office, 2017), 13.

Identifying enemy vulnerabilities and potential positions of relative advantage remains a challenging task for the US Army, as the conceptual linkages between reconnaissance, security, and positions of relative advantage are unclear. Though *ATP 2-01.3, Intelligence Preparation of the Battlefield*, *FM 3-55, Information Collection*, and *FM 3-90-2, Reconnaissance, Security, and Tactical Enabling Tasks* provide an overview of various parts of the process, no single doctrinal publication provides the a holistic view, complete with clearly articulated conceptual linkages between reconnaissance and security operations and positions of relative advantage.[62] This is problematic because it is primarily through reconnaissance that US Army forces are likely to identify enemy vulnerabilities and potential positions of advantage, thus enabling them to strike the enemy system in time, place, or manner for which it is unprepared.

Military deception offers another means of striking the enemy in a location, time, or manner for which he is unprepared. Yet, here too, the conceptual linkages prove vaguely defined and understated. *FM 3-0* defines military deception as "actions executed to deliberately mislead adversary military, paramilitary, or violent extremist organization decision makers, thereby causing the adversary to take specific actions (or inactions) that will contribute to the accomplishment of the friendly mission."[63] *FM 3-0* states further that commanders may employ military deception to gain a tactical advantage or mask friendly vulnerabilities. This latter description of military deception's role requires elaboration and greater emphasis.

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[62] "Picking 'Unfair Fights': Understanding Maneuver," *The Tactical Leader*, accessed April 7, 2019, https://www.thetacticalleader.com/blog/picking-unfair-fights.

[63] US Department of the Army, *Field Manual (FM) 3-0, Operations*. p. 86

US Army Doctrine, Anticipation and Adaptation

Military practitioners have only a severely limited ability to predict the outcomes of interactions between military forces within complex environments. US Army doctrine acknowledges the complexity of future operating environments and these implications for planning and execution. The US Army operations process—plan, prepare, execute, assess—serves as a conceptual framework for understanding how US Army forces anticipate and adapt to their environment. While US Army doctrine recognizes a need to adapt during execution, US Army culture places a great deal of emphasis on planning and underemphasizes the importance of organizational adaptive capacity, limiting the adaptive capacity of US Army formations.

Army Doctrinal Publication (ADP) 5-0, The Operations Process defines planning as "the art and science of understanding a situation, envisioning a desired future, and laying out effective ways of bringing that future about."[64] Additionally, *ADP 5-0, The Operations Process* asserts that "planning results in a plan and orders that synchronize the action of forces in time, space, and purpose to achieve objectives and accomplish missions."[65] Similarly, it defines execution with reference to the plan, stating that "execution is putting a plan into action by applying combat power to…seize, retain, and exploit the initiative to gain and maintain a position of relative advantage."[66] These descriptions of the output of planning capture the dominant perception about the plan's relationship to the actions of subordinate organizations during execution—the plan serves to direct components of the formation on how to best coordinate their individual actions to achieve greater effects. This conceptualization of planning emphasizes a certain necessity for top-

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[64] US Department of the Army, *Army Doctrinal Publication (ADP) 5-0, The Operations Process* (Washington, DC, 2012), p. 6.

[65] Ibid.

[66] Ibid., 12.

down control of the components to ensure synchronization of their individual actions in time and

space such that, combined, they achieve the desired effect on the adversary's system.[67]

Yet, US Army doctrine also acknowledges the limitations inherent in planning as a

predictive exercise. Indeed, *ADP 5-0* states: "Any plan or order is a framework from which to

adapt, not a script to follow to the letter. The measure of a good plan is not whether execution

transpires as planned, but whether the plan facilitates effective action in the face of unforeseen

events." To address unforeseen events, US Army doctrine demands the development of flexible

plans and a willingness by subordinate commanders to accept prudent risk and seize the initiative.

Of the former, *ADRP 5-0* notes that:

> "Flexible plans help units adapt quickly to changing circumstances. Commanders
> and planners build opportunities for initiative into plans by anticipating events.
> This allows them to operate inside of the enemy's decision cycle or to react
> promptly to deteriorating situations. Identifying decision points and designing
> branches ahead of time—combined with a clear commander's intent—help create
> flexible plans."[68]

How the latter—the exercise of disciplined initiative and acceptance of prudent risk – by

subordinate leaders—contribute to the formation's flexibility in the face of unforeseen

opportunities or challenges is less clear.

Though US Army doctrine emphasizes the need to act and thereby seize the initiative, it

fails to establish a clear, conceptual linkage between a mission command philosophy and the

friendly force's ability to adapt to changing conditions on the battlefield while still, as a

formation, seizing, retaining, and exploiting positions of relative advantage. As a result, US Army

leaders' conceptualization of adaptability in execution links more strongly to predictive planning

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[67] US Army culture emphasizes planning as a predictive tool. This is evident in the recently released Center for Army Lessons Learned (CALL) Bulletins that provide FY18 Trends and Key Observations from the US Army's Combat Training Centers (CTCs) and the Mission Command Training Program, respectively. Observations overwhelmingly focus on formations' failures to synchronize the actions of subordinate formations and recommend further detailed planning of control measures and centralized decision-making to coordinate individual unit actions to achieve desired effects.

[68] US Department of the Army, *Army Doctrinal Reference Publication (ADRP) 5-0, The Operations Process* (Washington, DC, 2012), 2-23.

and top-down control than to bottom-up, self-organized emergent maneuver by subordinate military leaders coordinating laterally to achieve the commander's intent. Such collaborative maneuver compliments adjustment decisions when the formation faces unanticipated opportunities or threats, allowing forces to adjust to changing situations more rapidly and thereby retain the initiative until the commander can make an adjustment decision.
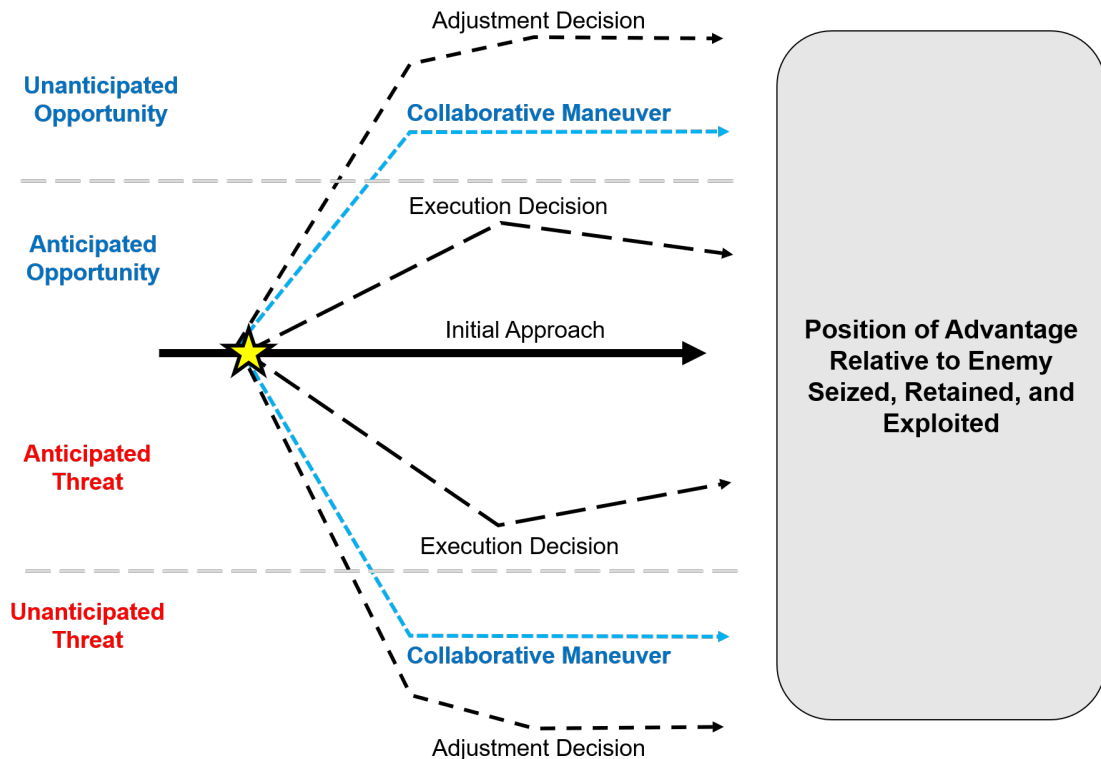
<figure>
Adjustment Decision

Unanticipated Opportunity

Collaborative Maneuver

Execution Decision

Anticipated Opportunity

Initial Approach

Position of Advantage Relative to Enemy Seized, Retained, and Exploited

Anticipated Threat

Execution Decision

Unanticipated Threat

Collaborative Maneuver

Adjustment Decision
</figure>

Figure 13. Integrating Concept of Collaborative Maneuver into Execution and Adjustment Decisions. *Source*: Figure adapted from Department of the Army, *Army Doctrinal Reference Publication (ADRP) 5-0, The Operations* Process (Washington, DC, 2012), 4-5.

US Army Doctrine and Self-Organization

This concept of the adaptive capacity of military organization relates directly to the US Army's commitment to a mission command philosophy. Indeed, FM 3-0 defines mission command as "the exercise of authority and direction by the commander using mission orders to enable disciplined initiative within the commander's intent to empower subordinates in the

conduct of unified land operations."[69] Yet, in differentiating between detailed command and directive command, US Army doctrine focuses primarily on the relationship between commander and individual subordinates. Such a focus on hierarchical relationships comes at the expense of lateral relationships, limiting bottom-up adaptation to the narrow actions of a single subordinate formation rather than an ideal form in which subordinate units collaborate to preserve unity of effort.

A certain degree of top-down coupling, or the centralized development of the military aim is vital to focusing the organization on actions that achieve a position of relative advantage on the largest scale possible. Commander's intent provides the aim for the formation, focusing the organization and providing subordinate leaders the shared understanding necessary to achieve unity of effort. Commanders use mission orders to assign tasks, set priorities, and allocate resources to subordinate commanders. The two related principles of mission command—provide a clear commander's intent and use mission orders—are the means which allow the formation to achieve and maintain its coherence, or unity of effort.[70]

Unity of effort can also occur as the result of decentralized, bottom-up coordination. A combined arms or joint military force's performance is heavily dependent on the extent to which the individual components leverage the synergistic effects that come from cooperation. Unity of effort during self-organization, or collaborative maneuver, by subordinate military forces requires shared internal models. As *ADRP 6-0* states, unity of effort requires "creating shared understanding of their operational environment, the operations' purpose, problems, and approaches to solving them." Subordinate formations' interdependence and the related principles

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[69] US Department of the Army, *Army Doctrinal Reference Publication (ADRP) 3-0, Operations* (Washington, DC, 2012), 3-19.

[70] US Department of the Army, *Field Manual (FM) 3-0, Operations*; Naveh, *In Pursuit of Military Excellence*, 6.

of mission command—build cohesive teams through mutual trust and create shared understanding—promote unity of effort from the bottom-up.

US Army doctrine narrowly describes the exercise of disciplined initiative—a fifth principle of the mission command philosophy—as the act of individual commanders, exercising increased levels of autonomy. Though US Army doctrine recognizes the role of decentralized operations in rapidly identifying and exploiting local windows of opportunity, its heavy focus on the individual subordinate commander downplays the interdependencies that exist between his formation and the larger force. While US Army doctrine acknowledges the need for lateral coordination, it places insufficient emphasis on the relationships that exist between subordinate commanders operating within a larger force. An unbalanced focus on hierarchical coordination at the cost of enabling lateral coordination denies US Army formations the benefits of increased adaptive capacity and resultant emergent, collaborative maneuver. A collaborative approach to command and control, as depicted in Figure 14, would aid in bridging this gap and allow US Army formations to achieve higher levels of adaptive capacity.
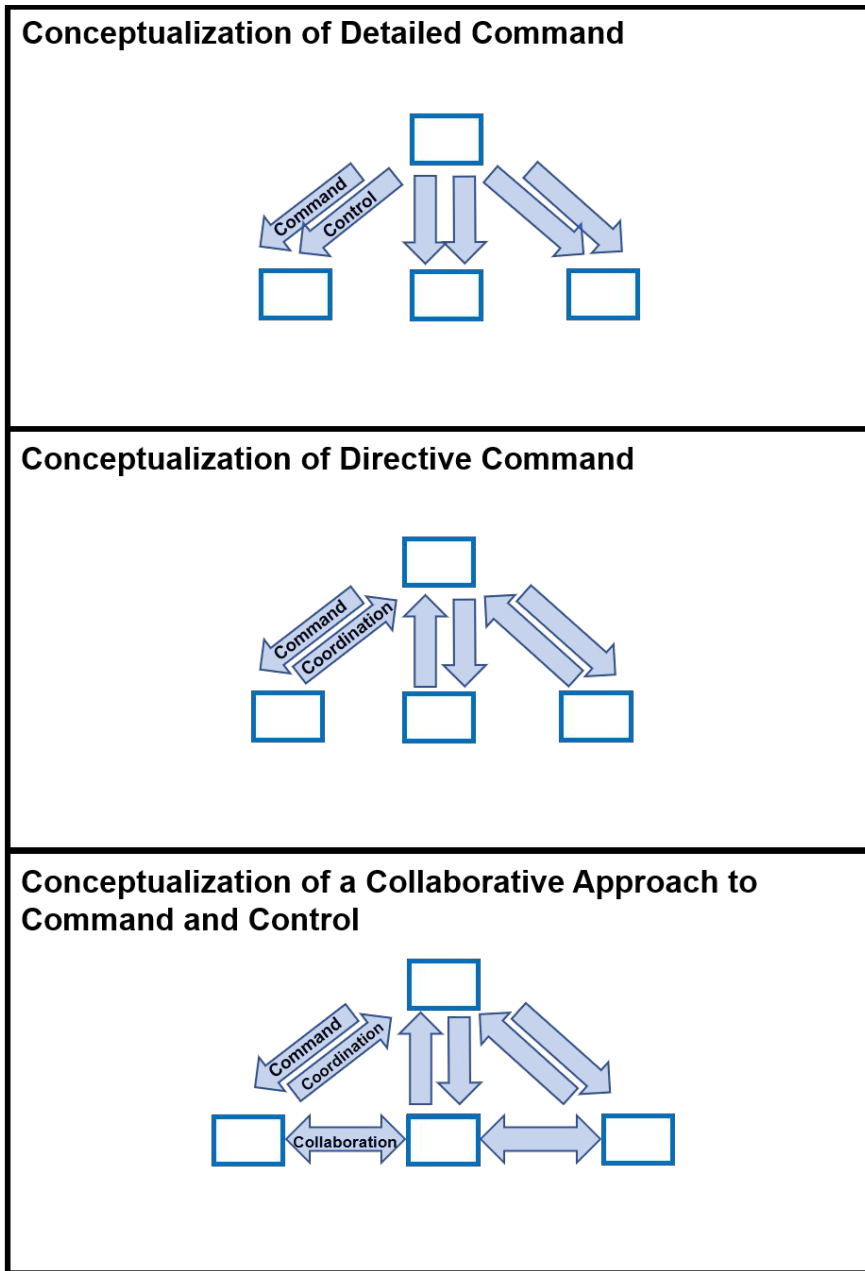
Figure 13. Conceptualizations of Detailed Command, Directive Command, and a Collaborative Approach to Command and Control. *Source*: Figure adapted from Schmitt, J. F. "Command and (Out of) Control: The Military Implications of Complexity Theory," in Alberts, D.S. and Czerwinski, T. J. (eds.) *Complexity, Global Politics and National Security,* Washington, DC: National Defense University, 1997.

Conclusions and Recommendations

"The pursuit of 'efficiency'—getting the most with the least investment of energy, time, or money—was once a laudable goal, but being effective in today's world is less a question of optimizing for a known (an relatively stable) set of variables than

responsiveness to a constantly shifting environment. Adaptability, not efficiency, must become our central competency."

General (R) Stanley McChrystal, *Team of Teams*

Success in large scale combat operations requires that US Army leaders and their organizations act in accordance an operating concept with a coherent basis in sound, clearly communicated theory. Against a peer- or near-pear adversary system, *FM 3-0* states that "It is the exploitation of positions of advantage through maneuver which deters, defeats, or destroys an enemy."[71] Complexity science and the concept of fitness validate this theory of action and help military practitioners develop a deeper appreciation for its meaning. However, the definition of Unified Land Operations, the US Army's current operating concept, does not explicitly describe the relationship between positions of relative advantage and the defeat or destruction of an adversary's system. Future iterations of *FM 3-0, Operations* should restore the concept of positions of relative advantage as a central concept within the US Army operating concept. Further, US Army doctrine should strive to establish clear conceptual linkages between this central concept and related military concepts, such as reconnaissance and security operations and military deception.

US Army leaders and their organizations will operate in complex operating environments. Complexity science indicates that organizations operating in complex environments must prove able to anticipate, adapt, and evolve to survive. *FM 3-0, Operations* acknowledges this fact, warning:

> How the many entities behave and interact with each other within an OE is difficult to discern and always results in differing circumstances…an OE is not static; it continually evolves. This evolution results from opposing forces and actors interacting and their abilities to learn an adapt. The complex dynamic nature of an OE makes determining the relationship between cause and effect difficult and contributes to the uncertain nature of military operations.[72]

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[71] Ibid,1-19.

[72] Ibid., 1–5.

ADP 1-01, *Doctrine Primer,* further describes the implications of the complexity resulting from these many interdependent interactions within the environment:

> The chaotic nature of war makes precise cause-and-effect determinations difficult, impossible, or delayed. The unintended effects of operations often cannot be seen ahead of time and may not be readily apparent in real time. This chaos imposes a great deal of uncertainty in all operations. This demands an approach to the conduct of operations that does not attempt to impose perfect order on operations but accepts the chaotic and uncertain nature of operations and makes allowances to account for this unpredictability.[73]

Thus, the US Army demonstrates an appreciation for the inherent unpredictability of the outcome of military operations within a complex operational environment.[74] However, US Army doctrine and culture remain reliant on planning as a predictive exercise and count on this predictive capability to build flexibility into the plan through the use of branch plans, sequels, and decision points. Future iterations of US Army doctrinal publications such as *ADRP 5-0, The Operations Process* must emphasize the importance of planning as a learning exercise and its limitations as a predictive exercise.[75]

Finally, limitations in a military organization's predictive ability necessitates building the capacity for adaptation in execution. Complexity concepts such as self-organization and emergence provide insights into how organizations might increase their adaptive capacity. Potential for an emergent capacity for higher-level maneuver through self-organized behavior likely exists in a force characterized by collaborative maneuver between self-contained, semi-autonomous combined arms, joint, or multi-domain formations operating at supporting distances or ranges of one another. Such a force, however, requires a significant cultural shift and a hard look in how members of the US Army conceptualize the mission command philosophy. Future

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[73] US Department of the Army, *Army Doctrinal Publication (ADP) 1-01, Doctrine Primer*, 31.

[74] US Department of the Army, *Field Manual* (*FM 3-0), Operations* (Washington D.C., 2017), 1–4.

[75] Credit for the concept of "thinking about planning as a learning exercise rather than a predictive exercise" belongs to Colonel (retired) James Greer, who used the phrase often in conversations with the author.

iterations of FM 6-0 should reframe the US Army's conceptualization of the mission command

philosophy by introducing the concepts of the collaborative approach to command and control

and collaborative maneuver.[76]

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[76] James Greer, "Multi-Domain Propositions" (Unpublished document, 2017).

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