Systems, Complexity & Networks in U.S. Military Thought: A Brief History

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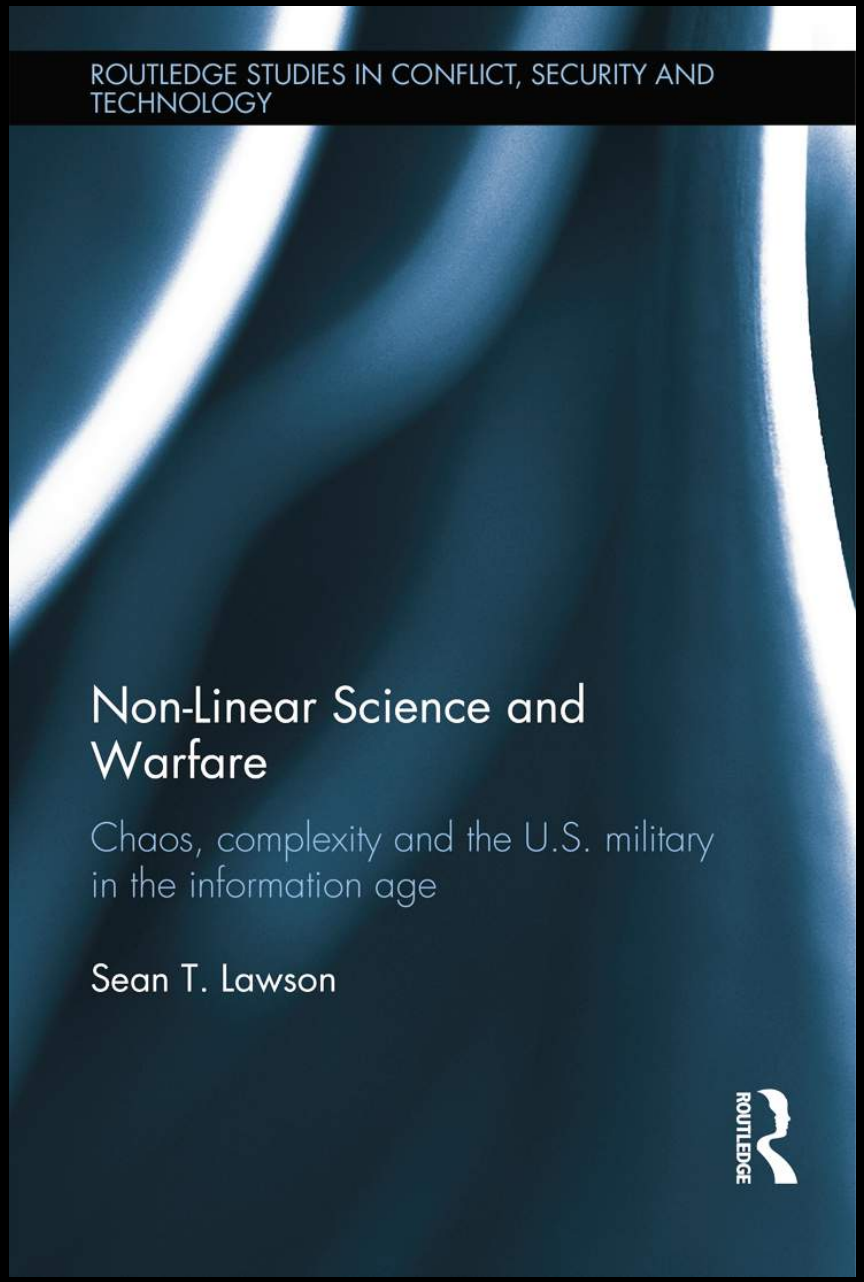

ROUTLEDGE STUDIES IN CONFLICT, SECURITY AND TECHNOLOGY
Non-Linear Science and Warfare
Chaos, complexity and the U.S. military in the information age
Sean T. Lawson
ROUTLEDGE

"The significant problems we have cannot be solved at the same level of thinking with which we created them."

- Albert Einstein

"If you know your enemies and ***know yourself***, you will not be imperiled in a hundred battles…if you do not know your enemies nor yourself, you will be imperiled in every single battle."

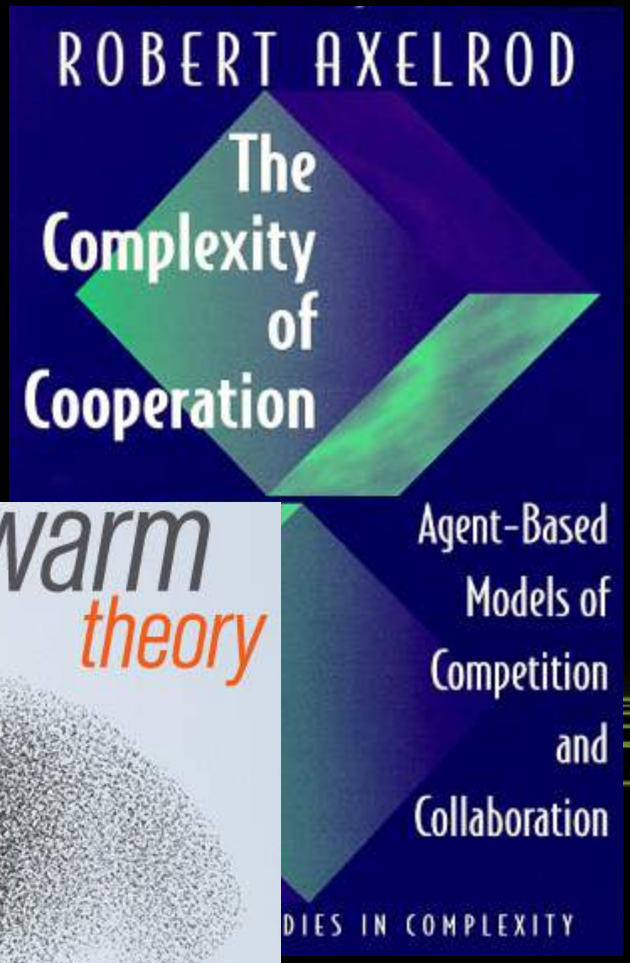
- Sun Tzu

overview

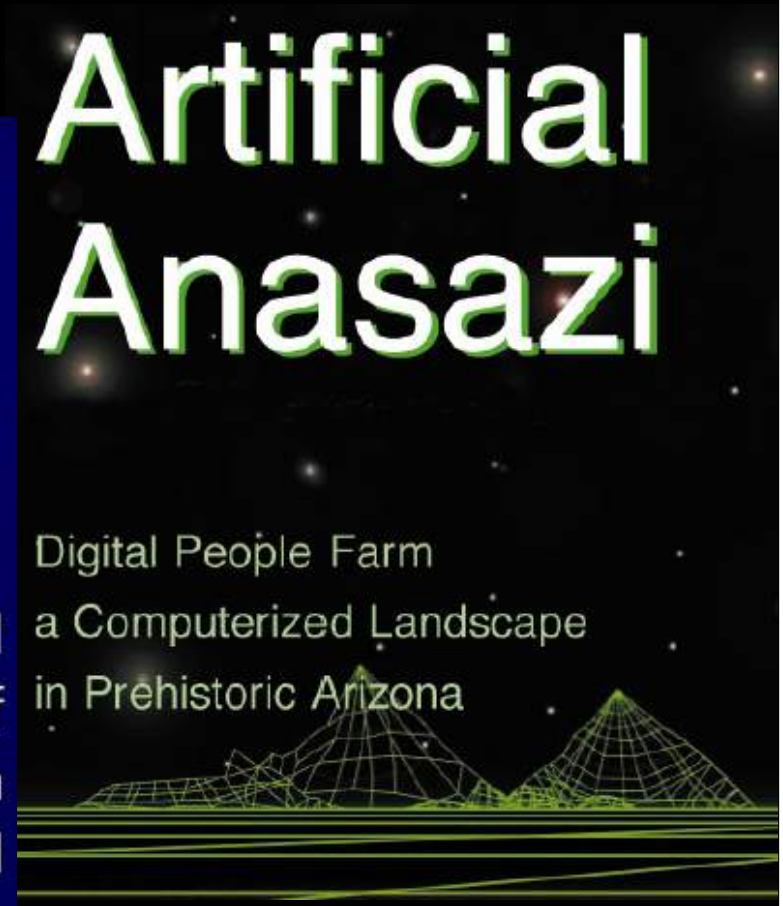
- Nonlinear Science Defined
- Warfare as Complex System: From Systems Science to Maneuver Warfare
- Meeting Complexity with Complexity: NCW, COIN & CT
- Assessment: From Outcomes to Process

Nonlinear Science Defined


Nonlinear
Systems ...


ROBERT AXELROD
The Complexity of Cooperation
Agent-Based Models of Competition and Collaboration
DIES IN COMPLEXITY


swarm
theory
By Peter Miller
Photograph by Manuel Presti
A single ant or bee isn't smart, but their colonies are. The study of swarm intelligence is providing insights that can help humans manage complex systems, from truck routing to military robots.


Artificial
Anasazi
Digital People Farm
a Computerized Landscape
in Prehistoric Arizona


Chaos

- ***large number of interacting elements***
- interactions are dynamic, nonlinear, involving ***positive and negative feedback***
- ***sensitivity to changes in initial conditions-***-i.e. small changes can lead to disproportionately large impacts, AKA ***"the butterfly effect"*** or ***"system perturbations"***
- interaction is recursive or iterative
- "open" systems, susceptible to "outside" environmental influence
- systems are ***"path dependent"***--i.e. they are evolutionary, have a history
- order or structure is an ***"emergent" effect*** of nonlinear interaction
- ***"self-organization"***
- largely (but not entirely) ***unpredictable***
- systems are "far from equilibrium"; they exhibit "dynamic stability"
- and others...

Warfare as Complex System

From Systems Science to Maneuver Warfare

The Systems Sciences

"They are all problems which involve dealing simultaneously with a sizable number of factors which are interrelated into an organic whole ... A very substantial number of relevant variables is involved here, and they are all interrelated in a complicated, but nevertheless not in helter-skelter, fashion."

- Warren Weaver, 1948

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Science and Complexity

Warren Weaver

Science has led to a multitude of results that affect men's lives. Some of these results are embodied in mere conveniences of a relatively trivial sort. Many of them, based on science and developed through technology, are essential to the machinery of modern life. Many other results, especially those associated with the biological and medical sciences, are of unquestioned benefit and comfort. Certain aspects of science have profoundly influenced men's ideas and even their ideals. Still other aspects of science are thoroughly awesome.

How can we get a view of the function that science should have in the developing future of man? How can we appreciate what science really is and, equally important, what science is not? It is, of course, possible to discuss the nature of science in general philosophical terms. For some purposes such a discussion is important and necessary, but for the present a more direct approach is desirable. Let us, as a very realistic politician used to say, let us look at the record. Neglecting the older history of science, we shall go back only three and a half centuries and take a broad view that tries to see the main features, and omits minor details. Let us begin with the physical sciences, rather than the biological, for the place of the life sciences in the descriptive scheme will gradually become evident.

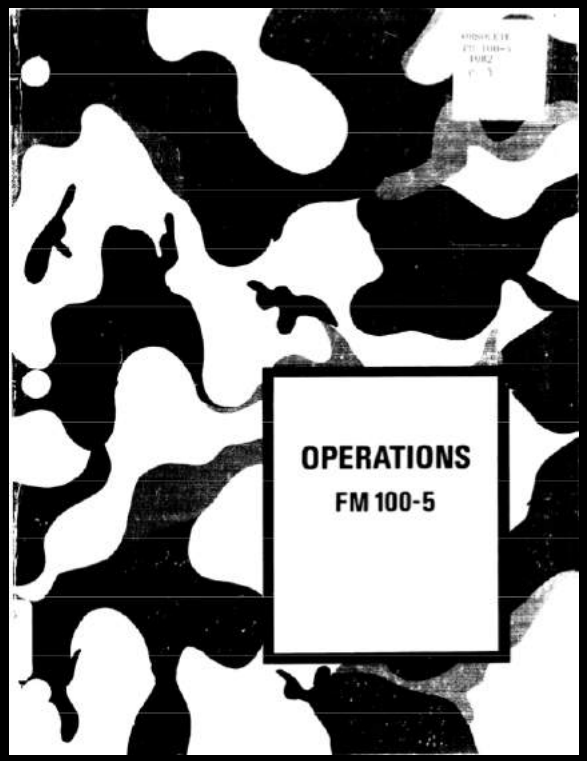
Problems of Simplicity

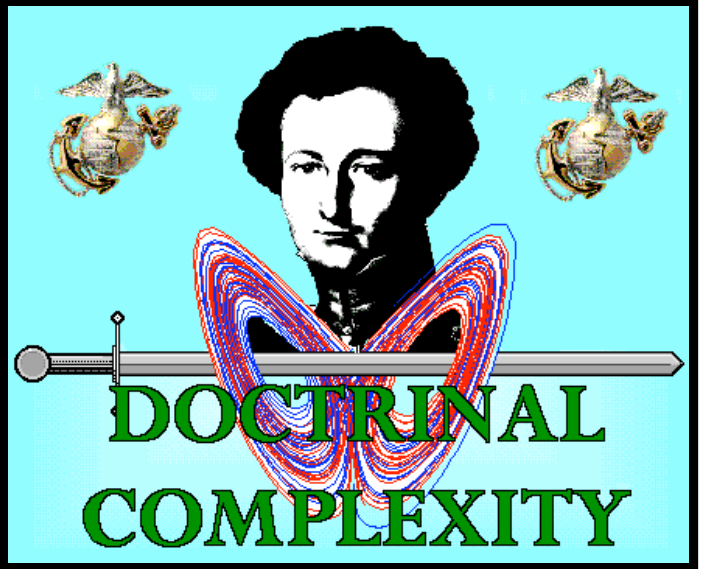
Speaking roughly, it may be said that the seventeenth, eighteenth, and nineteenth centuries formed the period in which physical science learned variables, which brought us the telephone and the radio, the automobile and the airplane, the phonograph and the moving pictures, the turbine and the Diesel engine, and the modern hydroelectric power plant.

The concurrent progress in biology and medicine was also impressive, but that was of a different character. The significant problems of living organisms are seldom those in which one can rigidly maintain constant all but two variables. Living things are more likely to present situations in which a half-dozen, or even several dozen quantities are all varying

From *American Scientist* **36**, 536.

OODA Loops & Maneuver Warfare


OPERATIONS
FM 100-5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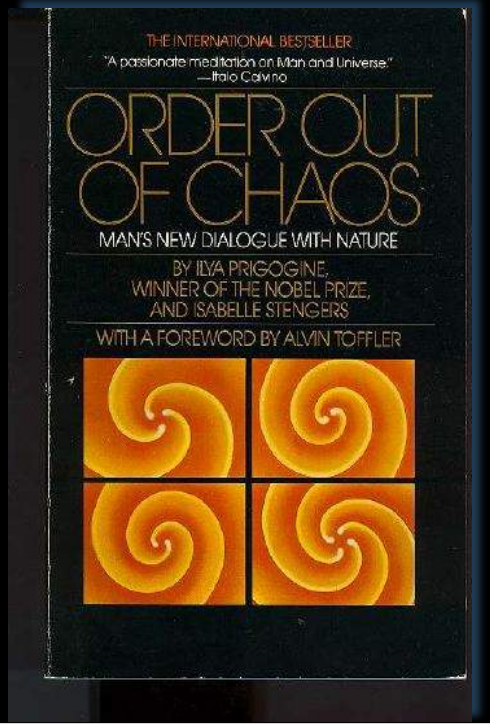
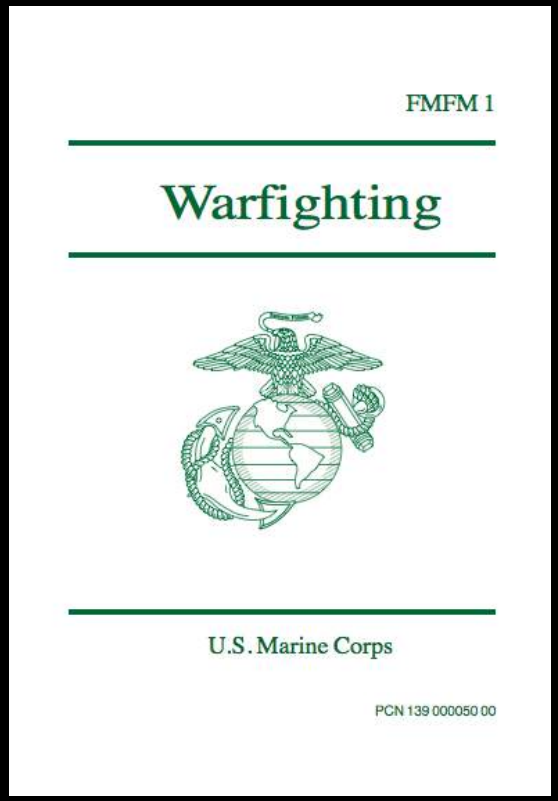
COMPLEXITY


THE INTERNATIONAL BESTSELLER
"A passionate meditation on Man and Universe."
—Italo Calvino
ORDER OUT OF CHAOS
MAN'S NEW DIALOGUE WITH NATURE
BY ILYA PRIGOGINE,
WINNER OF THE NOBEL PRIZE,
AND ISABELLE STENGERS
WITH A FOREWORD BY ALVIN TOFFLER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Warfighting
U.S. Marine Corps
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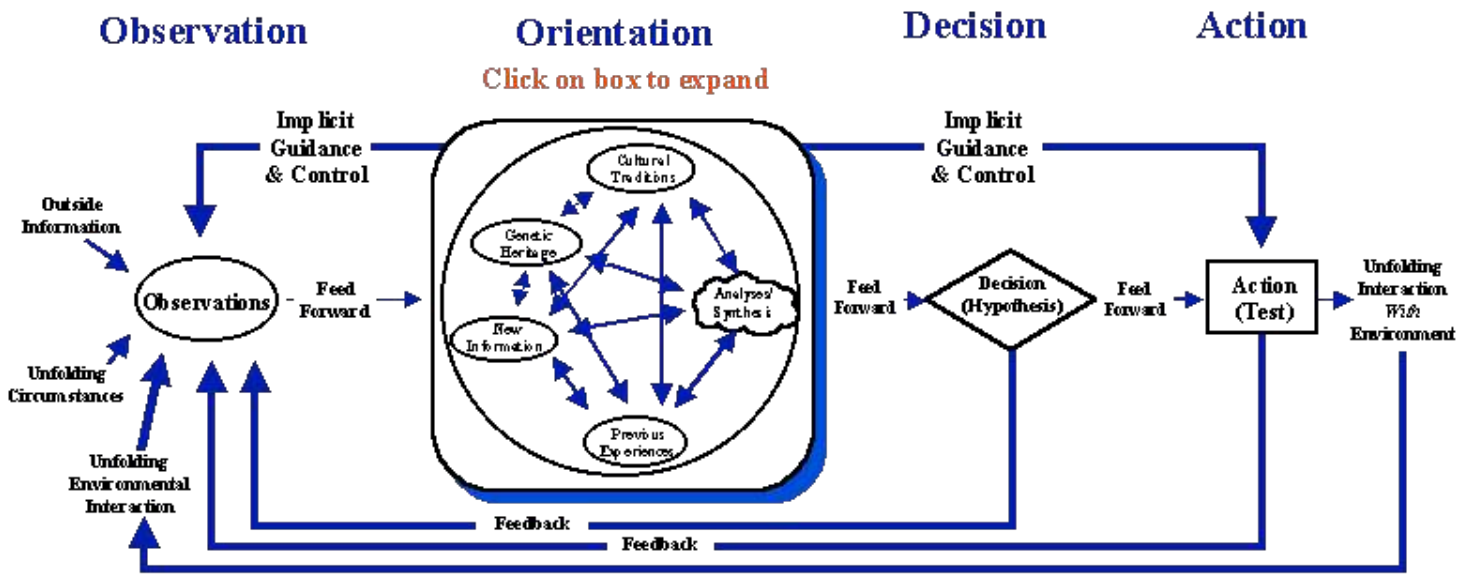
The OODA "Loop"
Sketch



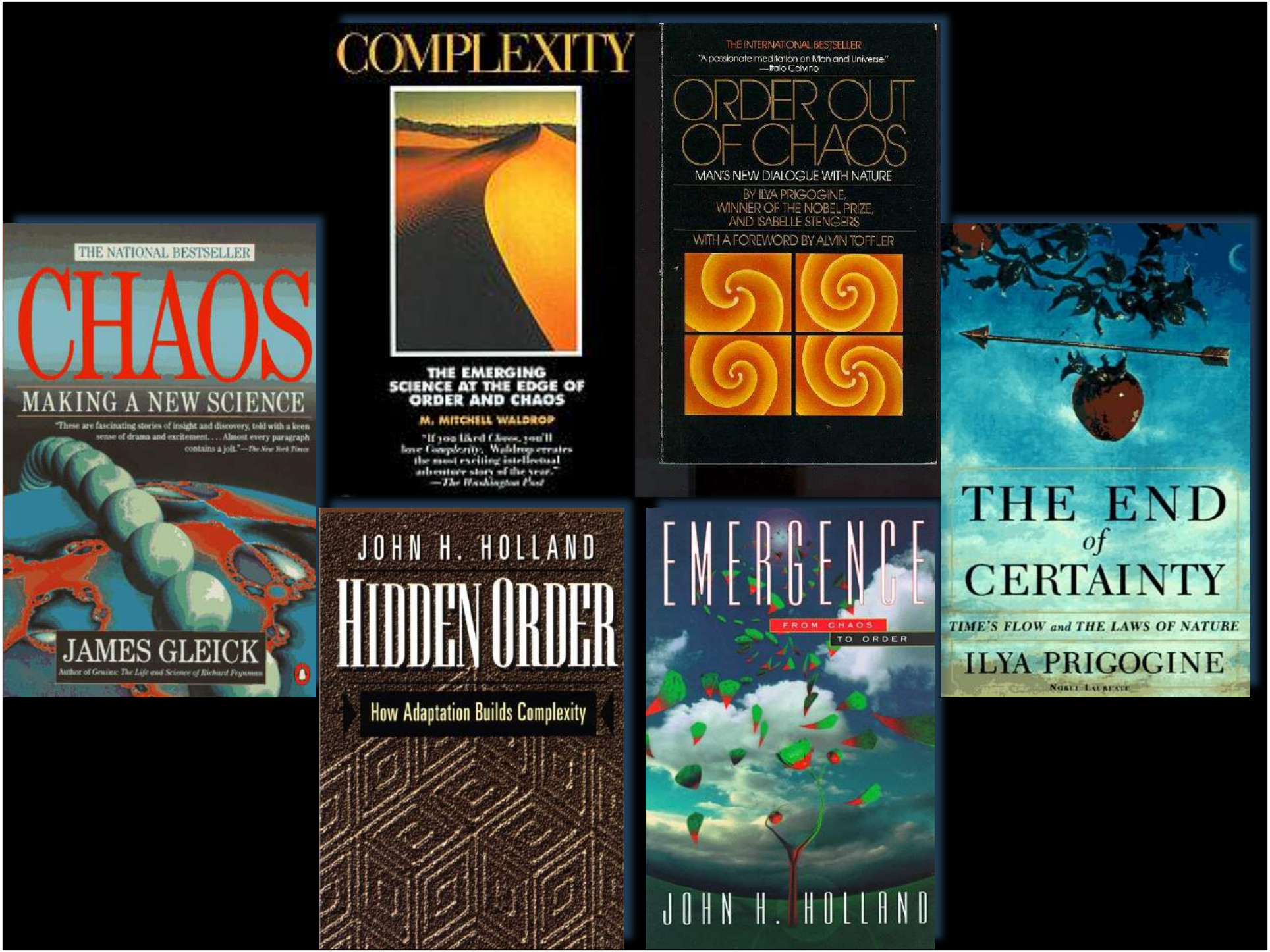
Insights:

Note how orientation shapes observation, shapes decision, shapes action, and, in turn, is shaped by the feedback and other phenomena coming into our sensing or observation window.

Also note how the entire "loop" (not just orientation) is an ongoing many-sided implicit cross-referencing process of projection, empathy, correlation, and rejection.

Meeting Complexity with Complexity

Network-Centric Warfare, Counterinsurgency & Counterterrorism


COMPLEXITY
THE EMERGING SCIENCE AT THE EDGE OF ORDER AND CHAOS
M. MITCHELL WALDROP
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THE NATIONAL BESTSELLER
CHAOS
MAKING A NEW SCIENCE
JAMES GLEICK
JOHN H. HOLLAND
HIDDEN ORDER
How Adaptation Builds Complexity
EMERGENCE
FROM CHAOS TO ORDER
JOHN H. HOLLAND
THE END of CERTAINTY
TIME'S FLOW and THE LAWS OF NATURE
ILYA PRIGOGINE

Network-Centric Warfare

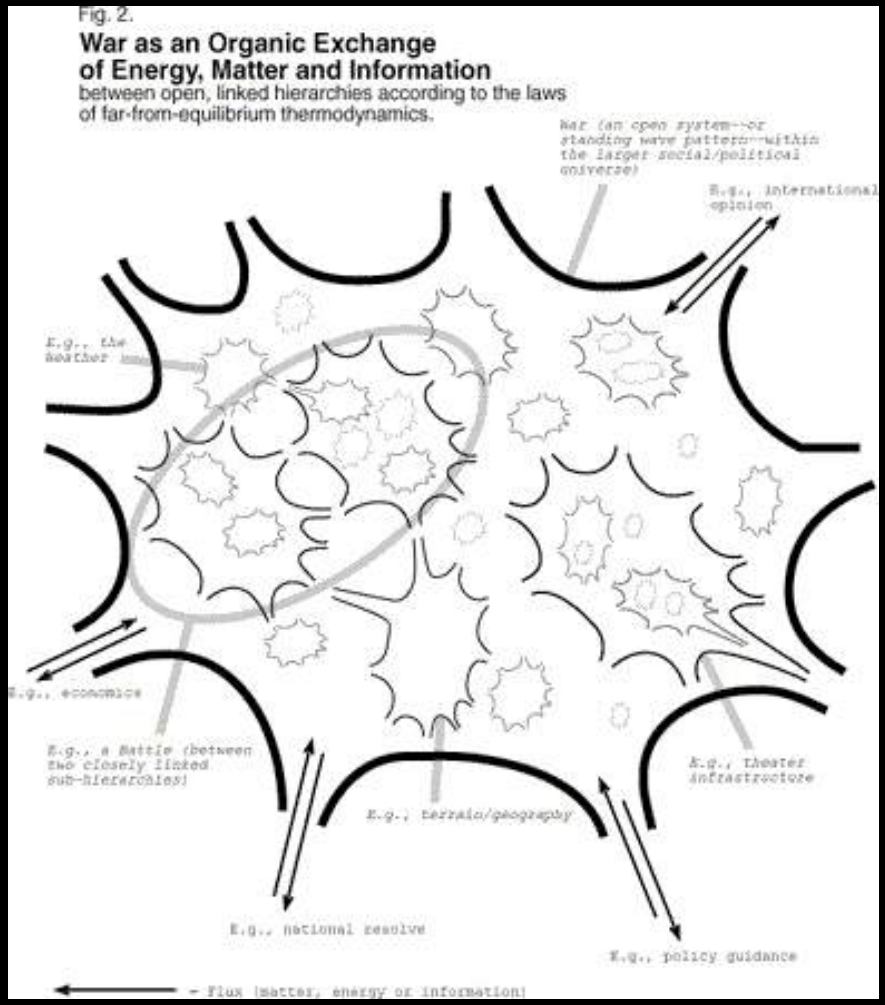
VADM Arthur Cebrowski

Problems:

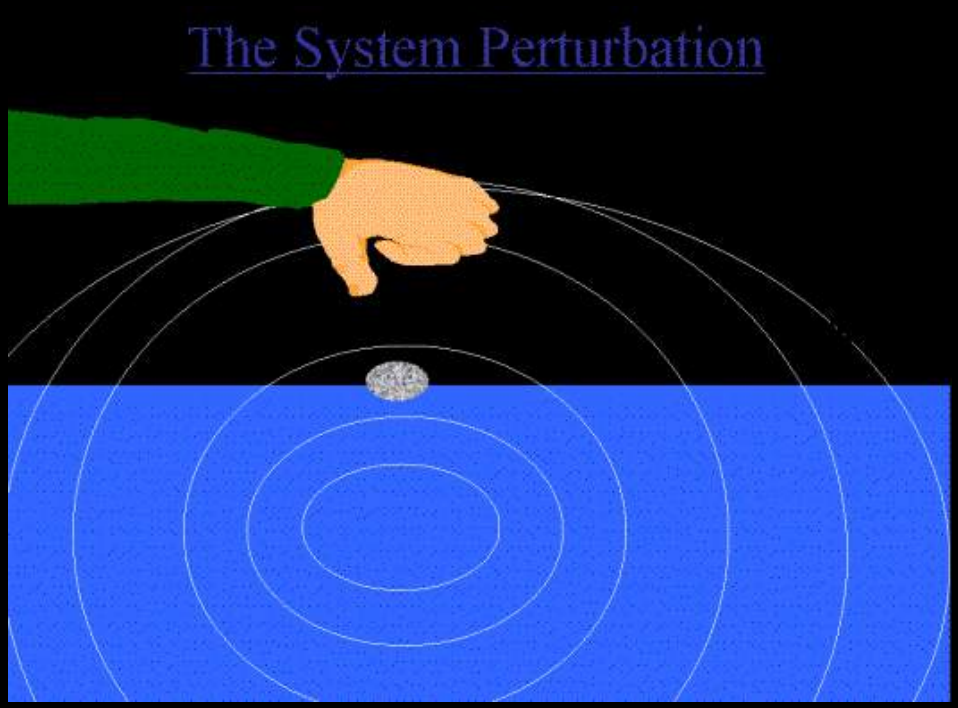
- World, war & enemies = complex systems
- Dangerous system perturbations

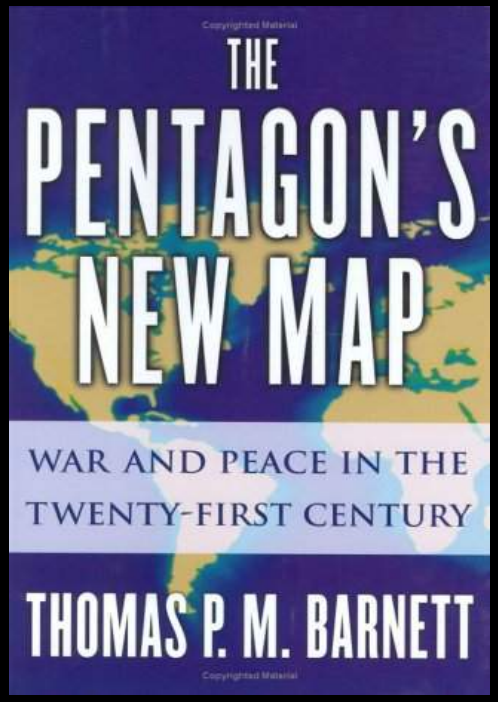
Solutions:

- Use networked IT to become a complex system
- Offensive action to alter initial conditions, prevent system perturbations



"***<u>In the Information Age</u>***, more than at any other time, we are aware that ***<u>warfare is a highly path dependent activity</u>***. That is, ***<u>small changes in initial conditions can result in profound changes in outcome</u>***. The ability to seize the initiative, alter those initial conditions, has enormous power. We want a force that is capable of doing that. Not all forces can do that." (Cebrowski, 2003)





"This is an ***information age phenomena***. A systems perturbation is essentially a ***vertical shock to the international system from which horizontal waves propagate***... It has a ripple effect and it is so disruptive that when it happens ***new rules are created***, they mix with old ones, and ***a new reality is created***. What is happening here is that ***propagation is related to the density of the medium. In the information age we have an increasingly dense medium*** and sometime in the late-1990s, we crossed a threshold where the medium became sufficiently dense where ***it can sustain the propagation of the perturbation. That is much of what we witnessed post-9/11***." (Cebrowski, 2003)

"Military operations are enormously complex, and ***complexity theory tells us*** that such enterprises organize best from the bottom-up... ***[B]ottom-up organization yields self-synchronization***." (Cebrowski & Garstka, 1998)

"Network-centric warfare enables forces to organize from the bottom up--or to self-synchronize." (Cebrowski & Garstka, 1998)

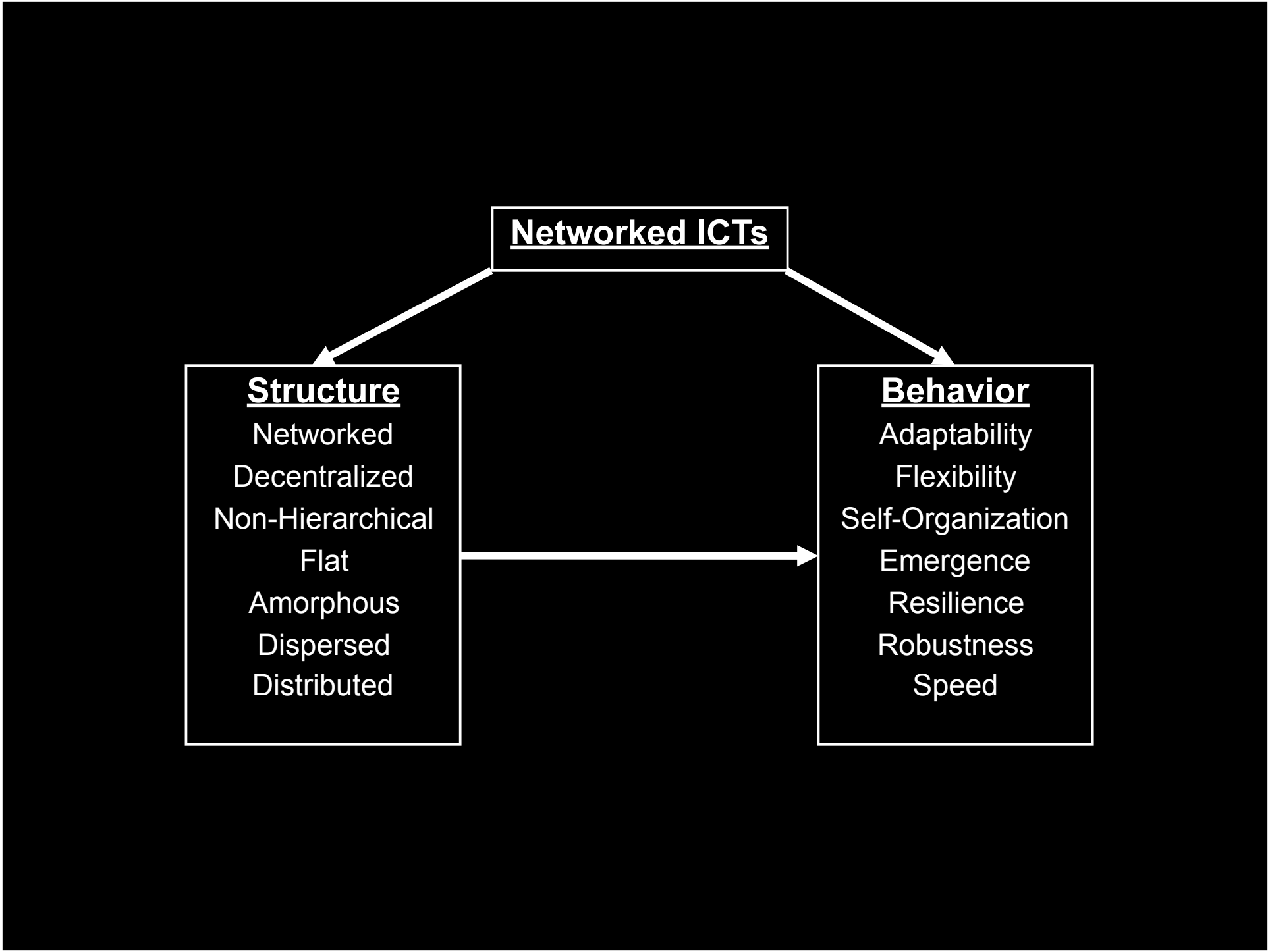
"When we put all this together we see that ***a new American way of war is emerging***...[that] recognize[s] the value of ***shared awareness*** and that a ***dispersed force*** is key to generating the ***non-contiguous [i.e. nonlinear] battle space***." (Cebrowski, 2003)

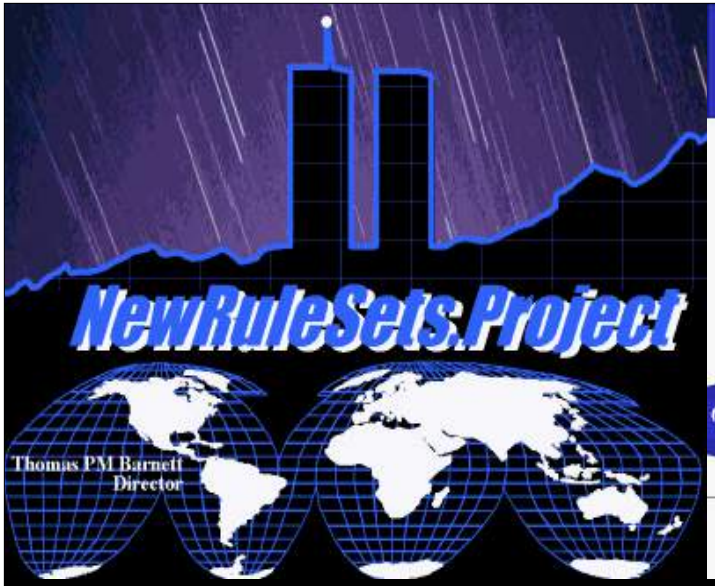
"***Such awareness [i.e. "shared awareness"]...***is a matter of the co-evolution of that technology with operational concepts, doctrine, and organization. ***The enabler, of course, is technology***." (Cebrowski & Garstka, 1998)

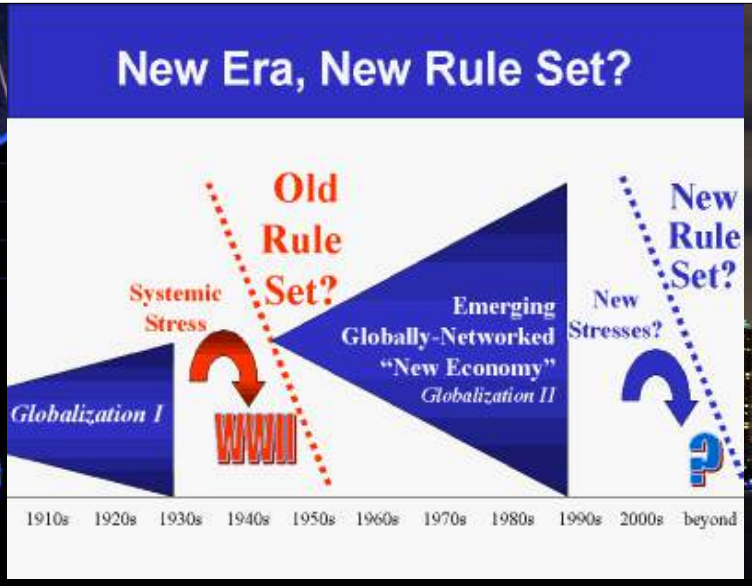
"In the increasingly transparent battle space, the speed and access of our ***networked forces open the way to profoundly altering initial conditions of conflict***, developing high rates of change that cannot be outpaced, and sharply narrowing an enemy's strategic choices." (Cebrowski & Barnett, 2003)

"[A] superior information position is turned into a competitive advantage...by the decisive ***altering of initial conditions***... ***[A]ll elements of the operating situation [are] parts of a complex adaptive ecosystem***..." (Cebrowski & Garstka, 1998)

"***Self-synchronization*** is the ability of the well-informed force to organize and ***synchronize complex warfare activities from the bottom up... Self-synchronization is enabled by a high level of knowledge***..." (Cebrowski & Garstka, 1998)


Networked ICTs
Structure
Networked
Decentralized
Non-Hierarchical
Flat
Amorphous
Dispersed
Distributed
Behavior
Adaptability
Flexibility
Self-Organization
Emergence
Resilience
Robustness
Speed





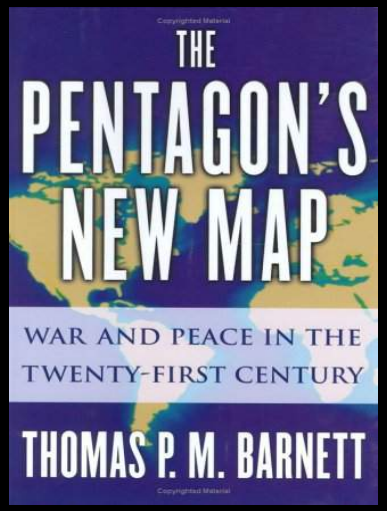
"***Across the 1990s global rule sets became seriously misaligned***, with economics racing ahead of politics (as evidenced by current corporate scandals) and technology racing ahead of security (e.g., the rise of transnational terrorists exploiting globalization's growing network connectivity). ***Now it is time to play catch up...with the U.S. military once again serving as an instrument of rule-set exportation through the global war on terrorism***." (Cebrowski & Barnett, 2003)

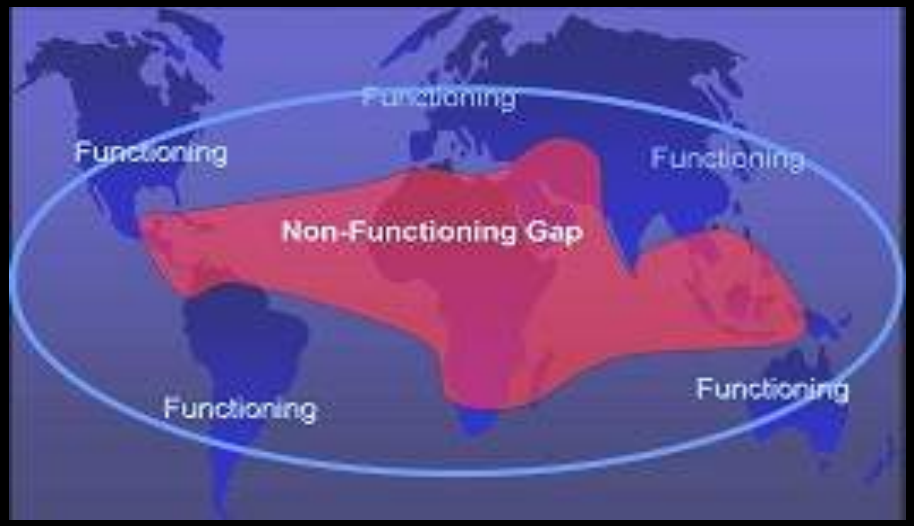
"***The Global War on Terrorism has added focus to the notion of exporting security***. For a long time we said the United States is not the world's policeman. Now you can say that all you want but it doesn't change the reality... ***Deterrence now has to be based on prevention***, which is different...that is being preventative ***and the notion of deter forward*** becomes very, very important." (Cebrowski, 2002)

“Deter forward?”

"It is really about how good a job you’ve done in ***altering the initial conditions***. ***Taking advantage of the path dependency*** of this very complex thing we call warfare." (Cebrowski, 2002)

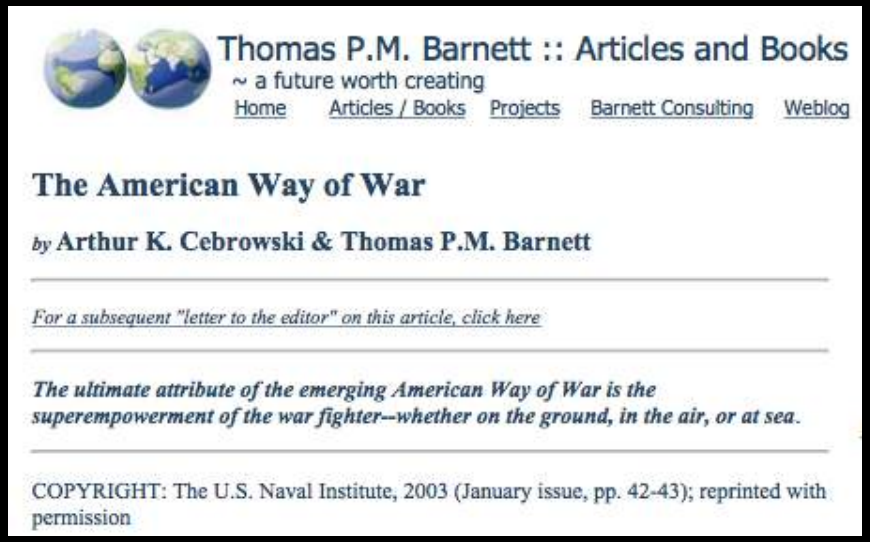
"What are we trying to do here now with Deter Forward? What we want to be able to do is develop very rapid rates of change...***to alter the initial conditions***... But ***the big enabler...is the networking capability***. The entry fee...is a ***network structure***, network centric organizations and ***network centric warfare***." (Cebrowski, 2003)





"***<u>We have to master system perturbations</u>***... ***<u>[O]ur role</u>***, and the role of the members of the core, the functioning core of globalization...our role ***<u>is that of Systems Administrator... [T]he role is to keep the system up and running, just like with your computer system...</u>*** There is a certain ***<u>moral obligation to shrink the Gap</u>*** over time. ***<u>This results in a booming export market for us</u>***. But the export market that I'm concerned about in defense is ***<u>the exporting of security</u>***. It is indeed a growth market. Security is our nation's largest single public sector export, and it's booming... ***<u>If you are fighting globalization, if you reject the rules, if you reject connectivity, you are probably going to be of interest to the United States Department of Defense... This is the chafing we saw in the run- up to Operation Iraqi Freedom</u>***, which is that we are a nation that is increasingly recognizing this view of the world." (Cebrowski, 2003)

"a military of super-empowered individuals [capable of] fighting wars against super-empowered individuals...moves the military toward an embrace of a more sharply focused global cop role: we increasingly specialize in neutralizing bad people who do bad things." - Cebrowski & Barnett, 2003



Thomas P.M. Barnett :: Articles and Books
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The American Way of War

by **Arthur K. Cebrowski & Thomas P.M. Barnett**

For a subsequent "letter to the editor" on this article, click here

The ultimate attribute of the emerging American Way of War is the superempowerment of the war fighter--whether on the ground, in the air, or at sea.

COIN & CT

Chapter Nine

Complex Irregular Warfare: The Face of Contemporary Conflict

OVERVIEW

The 11 September 2001 terrorist attacks ('9/11') presaged several new developments in the global conflict environment. Although the implications of these took some time to become clear, they have begun to force specialists and non-specialists alike, within several advanced Western armed forces, to re-think some basic models and assumptions. This essay explores these new challenges and briefly surveys some of the principal responses to them – responses that are likely to shape the face of twenty-first century conflict, for at least the next few decades.

The RMA – now somewhat doubtful

In the last years of the twentieth century, many Western military forces adopted a style of warfare based on standoff engagement, avoidance of ground combat and reliance on air and maritime strike. This approach was informed by the notion of a Revolution in Military Affairs (RMA) founded on the emerging technologies of stealth, pervasive electronic surveillance and target acquisition, precision engagement, and networked communications. It was epitomised in the US military's 'Transformation' agenda, which sought to replace heavier forces, optimised for intensive ground combat, with medium-weight forces supported by 'reach-back' for precision strike and situational awareness. The assumption was that all-pervasive surveillance, information operations and precision were set to dissipate the 'fog of war', avoiding the need for protracted ground combat, and leading to a new era in warfare. Terms like 'information dominance' and concepts such as 'see first, act first, finish decisively' were seen as central to the future of warfighting.

The conflict environment of the early twenty-first century certainly does represent a new era in warfare: but not the era that Western military planners expected. Instead of pervasive surveillance and information dominance, Western military forces are increasingly being drawn into highly complex and lethal campaigns in urbanised terrain, against irregular enemies invulnerable to many of the advanced technologies central to the RMA approach. Instead of 'network-centric warfare' based upon electronic sensor-to-shooter networks and precision targeting systems, advanced forces are enr
has been described as 'netwars' ba
adaptive human networks. Dealin
conflict environment has caused a
Western forces.

US dominance

Transformation, and the associate
reflected a key feature in the late t
conflict environment: the overwh
tional military dominance of the US.
the economic and technological sup
from its status as the sole remaini
the US has achieved unprecedente
conventional military strength. Th
US forces virtually invincible in tra
tional force-on-force conflict, where
can be brought to bear. Conventiona
tend to be brief, intense and one-si
rapid victory for the US, its allies,
conflict which best approximates
This was the conflict environment
late twentieth-century militaries pla

But, perhaps unsurprisingly,
and potential enemies have also t
conventional superiority and actec
Non-state actors like al-Qaeda dev
'asymmetric' approaches that allow
step US military power – either by
tionally irrelevant, or by operating
where the US cannot bring its conv
ority to bear.

For example, during the 1990s
tives moved within the complex h
local indigenous societies, to atta
installations and platforms – the
facility, the African embassies, the
suffering little or no damage in ret
Qaeda operatives armed only with
mobile phones outflanked the US
tech capabilities. The only effective

UNCLASSIFIED
DRAFT DEVELOPING CONCEPT

COMPLEX WARFIGHTING

EXECUTIVE SUMMARY

- This document, the Future Land Operational Concept (FLOC) analyses the environment of contemporary conflict, in order to determine how land forces (the Army and those elements of the Navy and Air Force that support land operations) must operate in order to succeed in this environment.
- The FLOC identifies the contemporary conflict environment as complex, diverse, diffuse and highly lethal. In this environment, land forces will be required to undertake an extremely wide range of tasks simultaneously within the same geographical area, at short notice and in complex, urbanised terrain.
- To operate in this environment, land forces must be versatile, agile and able to orchestrate effects in a precise and discriminating fashion. This demands modular, highly educated and skilled forces with a capacity for network-enabled operations, optimised for close combat in combined arms teams. These teams will be small, semi-autonomous and highly networked, incorporating traditional elements of the combined arms team as well as non-traditional elements such as civil affairs, intelligence and psychological warfare capabilities. They will have a capacity for protracted independent operations within a joint interagency framework.

PURPOSE OF THIS DOCUMENT

This document represents the Australian Army's **best estimate** of the likely future operating environment, and **a possible response**. The response articulated is not the only possible response, and **is not authoritative doctrine**. Rather, this is a detailed hypothesis for testing, field trials and further development. This concept is a start point for further analysis, experimentation and force design, leading to capability development – it does not represent an endstate in itself.

Future Land Warfare Branch leads the work that defines the Army of the future. It does this through the production of concepts that underpin Army's concept-led and capability-based approach to modernisation. Army's future concepts provide the start point for experimentation and force design within the framework of the Army Continuous Modernisation Process. Future Land Warfare Branch actively encourages feedback and comment from Army and the broader Defence Organisation.

Future Land Operating Concept ***Complex Warfighting***

Correct as at: 7 Apr 04

Concept Author: LTCOL Dave Kilcullen
(02) 6265 5698
david.kilcullen@defence.gov.au

UNCLASSIFED

EFFECTS–BASED OPERATIONS

CHAOS VERSUS PREDICTABILITY

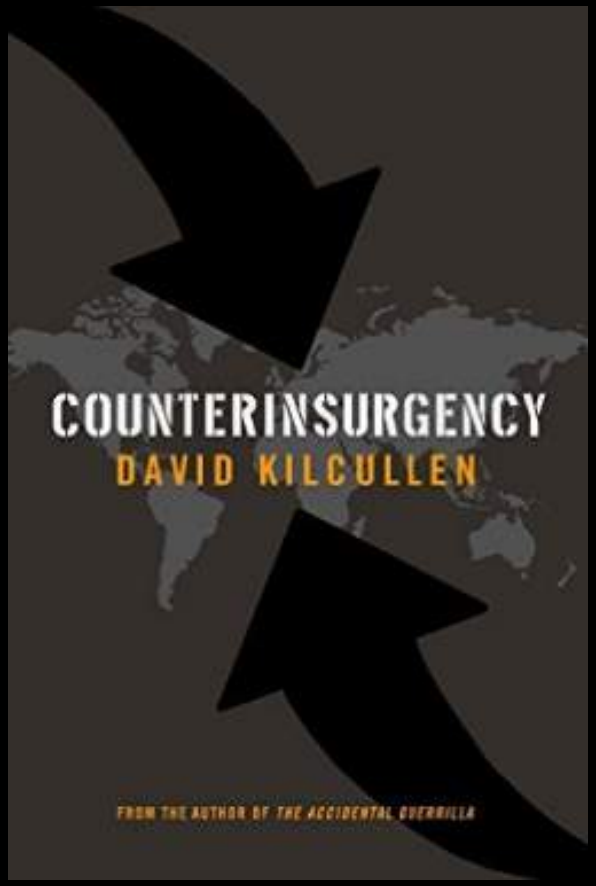
A CRITIQUE OF EFFECTS–BASED OPERATIONS

BRIGADIER JUSTIN KELLY AND LIEUTENANT COLONEL DAVID KILCULLEN

'The manoeuvrist approach … concentrates on the judicious massing of effects rather than massing of physical force.'

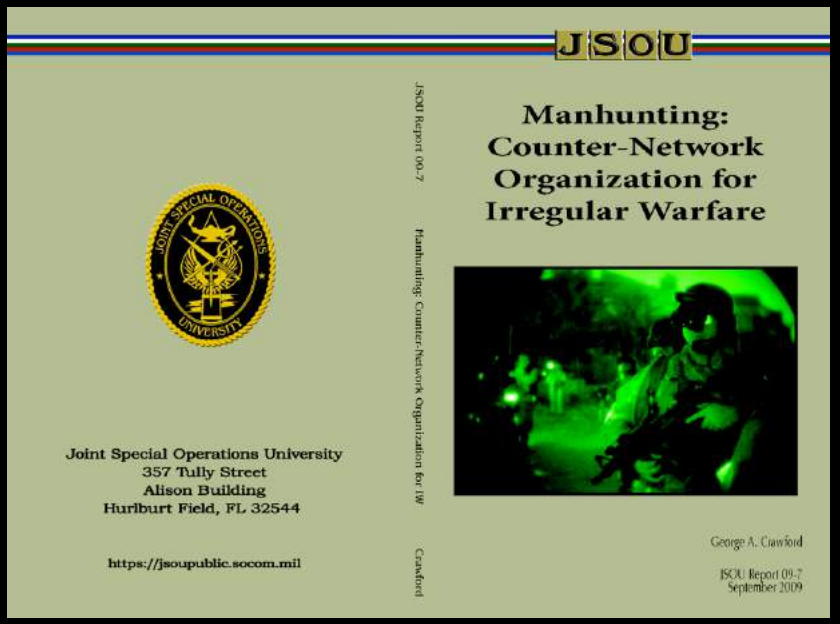
Australian Army, *Future Land Warfare 2032* (1999)

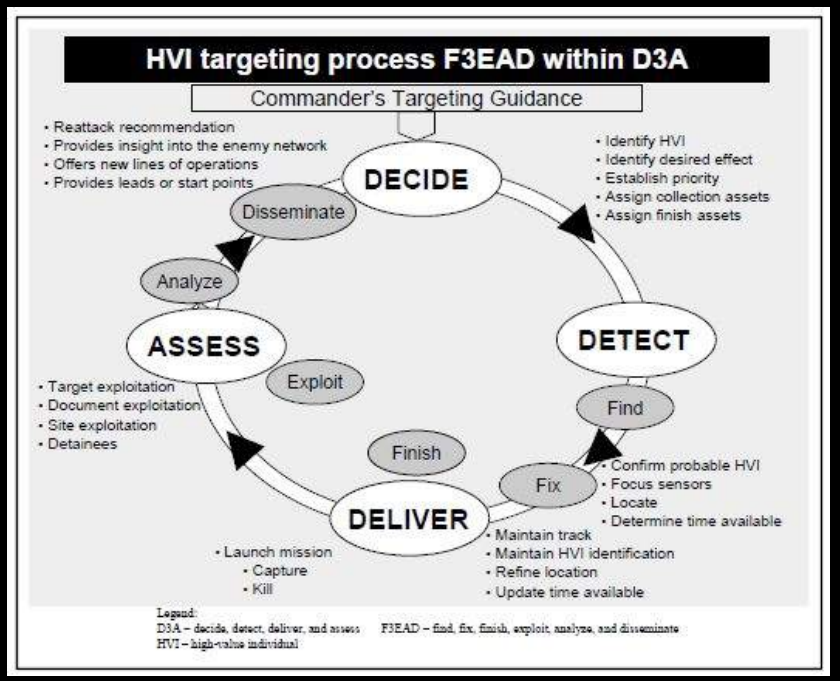
Carl von Clausewitz's insight that war is a free and creative act resting on a clash of wills reflects an enduring reality of war, namely that antagonists always seek to exploit their perceived strengths and weaknesses in order to try to impose control. Modern defence forces in general, and armies in particular, usually apply force as a means to an end. They employ violence as a tool in order to generate physical, cognitive and emotional responses in an adversary. In short, the application of military force in contemporary operations is normally 'effects seeking'. This article argues that, while the aspirations advanced by supporters of effects-based operations (EBO) are laudable, they may not be achievable, particularly in the land warfare environment. The main reasons that EBO may not be practical lie in the process of politics and its relationship with strategy. There are also problems pertaining to the character of democracy, the dynamics of physical force and the nature of war.

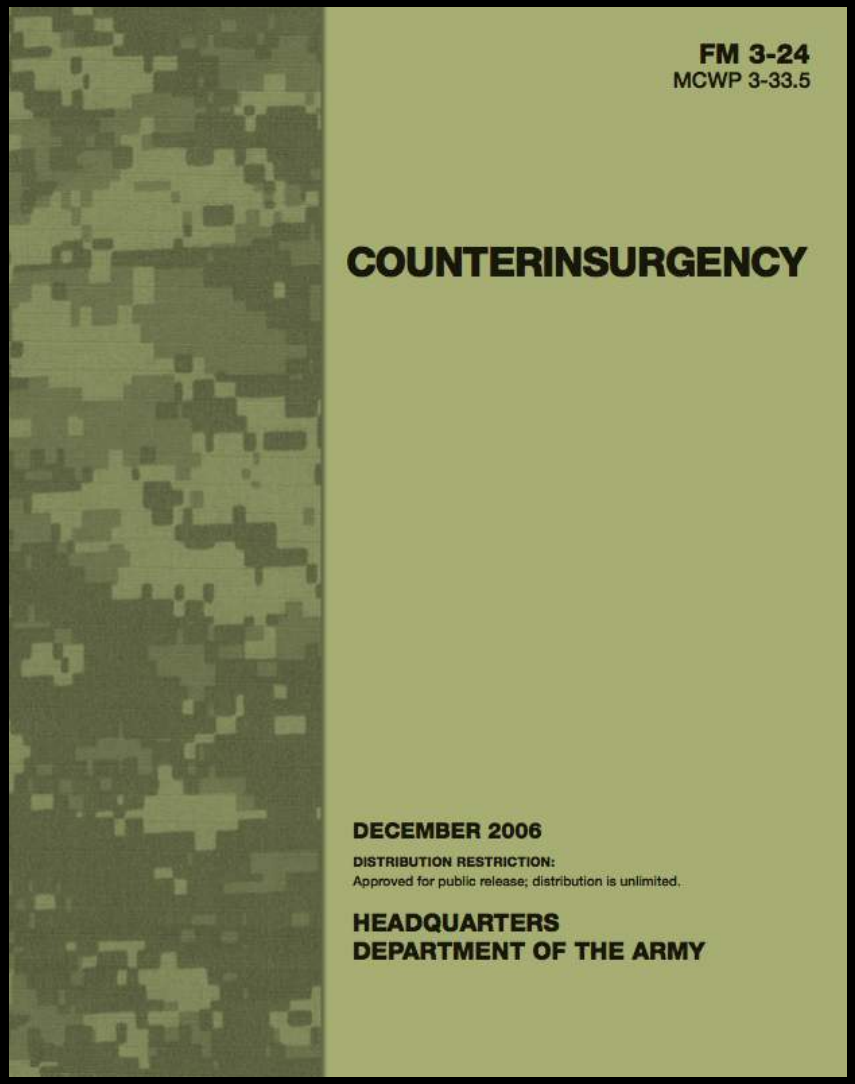


Counter-network operations "generate a lethal momentum that causes insurgent networks to collapse catastrophically."

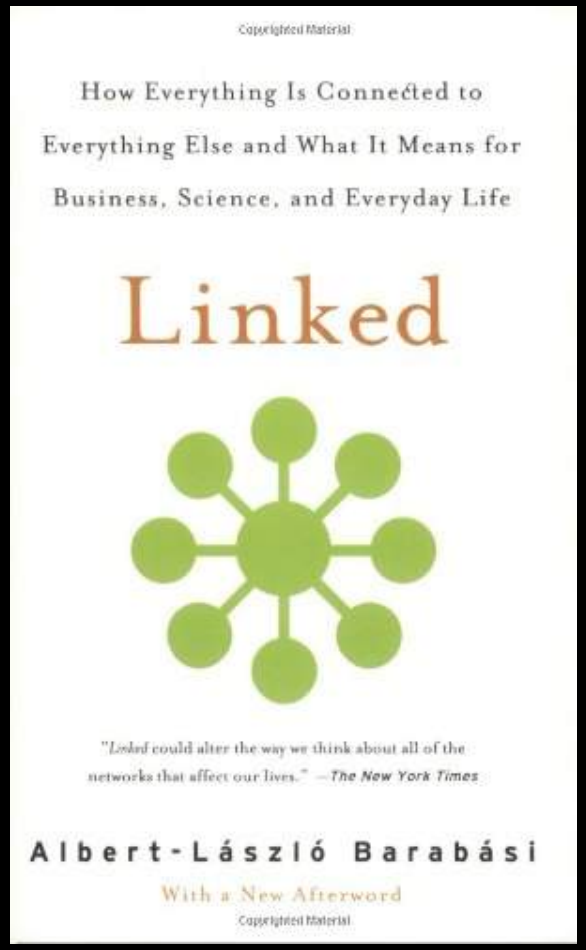
-David Kilcullen







"Systems thinking…is based on the perspective of the systems sciences that seeks to understand the interconnectedness, complexity, and wholeness of the elements of systems in relation to one another."



"[T]he battle against al Qaeda will be won by crippling the network, either by removing enough of its hubs to reach the critical point of fragmentation or by draining its resources, preparing the groundwork for cascading internal failures."

Appendix B

Social Network Analysis and Other Analytical Tools

Situational understanding involves determining the relationships among the factors of METT-TC. This appendix discusses several tools used to describe the effects of the operational environment and evaluate the threat. One of the most important of these is social network analysis, a powerful threat evaluation tool. Commanders and staffs use these tools to help them understand the operational environment. This understanding facilitates making decisions and developing plans and orders.

DESCRIBE THE EFFECTS OF THE OPERATIONAL ENVIRONMENT

B-1. Describing the effects of the operational environment requires an analysis of the terrain, weather, and civil considerations. This discussion addresses terrain and civil considerations at length because of their importance in a counterinsurgency (COIN) environment. Terrain and civil considerations have distinct aspects in COIN that analysts must understand to effectively describe the operational environment. Imagery, geospatial analysis tools, overlays, and graphics can help depict these aspects.

DESCRIBE TERRAIN EFFECTS

B-2. As in conventional operations, terrain analysis in COIN includes examining the terrain's effects on the movement of military units and enemy personnel. However, because COIN focuses on people, terrain analysis usually centers on populated areas and the effects of terrain on the local populace. During COIN operations, Soldiers and Marines spend a lot of time in suburban and urban areas interacting with the populace. This battlefield is three dimensional. Multistory buildings and underground lines of communications, such as tunnels and sewers, can be very important. Insurgents also use complex natural terrain to their advantage as well. Mountains, caves, jungles, forests, swamps, and other complex terrain are potential bases of operations for insurgents. (See FM 34-130 for additional information on terrain analysis. See FMI 2-91.4 for terrain analysis in urban operations.)

B-3. An important terrain consideration in COIN is urban and suburban land navigation. This can be difficult in areas without an address system and in cities where 10-digit grids may not be accurate enough to locate a specific apartment. Knowledge of how local people find one another's houses and what type of address system they use are beneficial. Recent, accurate maps that use overhead imagery are also helpful. In addition, tourist maps and locally produced maps facilitate understanding the names local people use to describe places.

Military Aspects of Terrain for Counterinsurgency

B-4. At the tactical level, Soldiers and Marines consider different details of the military aspects of terrain to describe the operational environment.

- **Observation and fields of fire.** In COIN operations, Soldiers and Marines look for areas with good fields of fire that may serve as ambush points. In addition, they also consider different ways insurgents might observe them. These ways include surveillance, the use of spies and infiltrators, and locations with line of sight on counterinsurgent positions.
- **Avenues of approach.** Insurgents use any means possible to get into counterinsurgent installations. Possible entry points include sewers, rooftops, roads, and sidewalks. Insurgents exploit their ability to blend with the populace. They may try to infiltrate by posing as contractors working for counterinsurgents or the host-nation (HN) government. Along border regions, insurgents

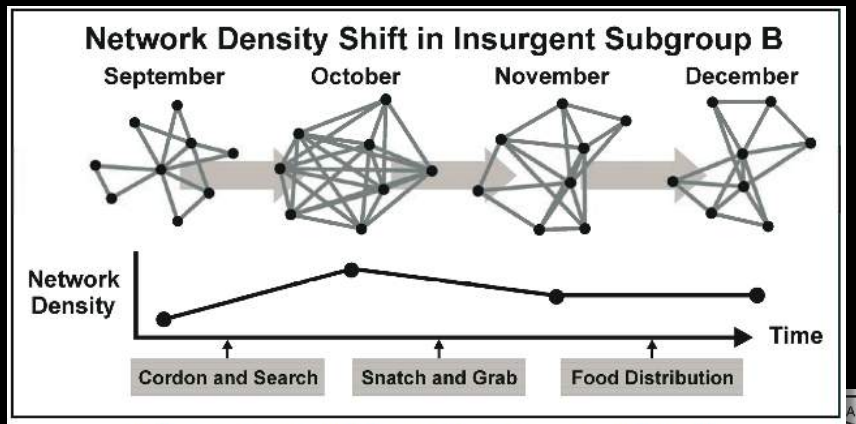


Figure B-7. Example of changes to tactics based on density shift

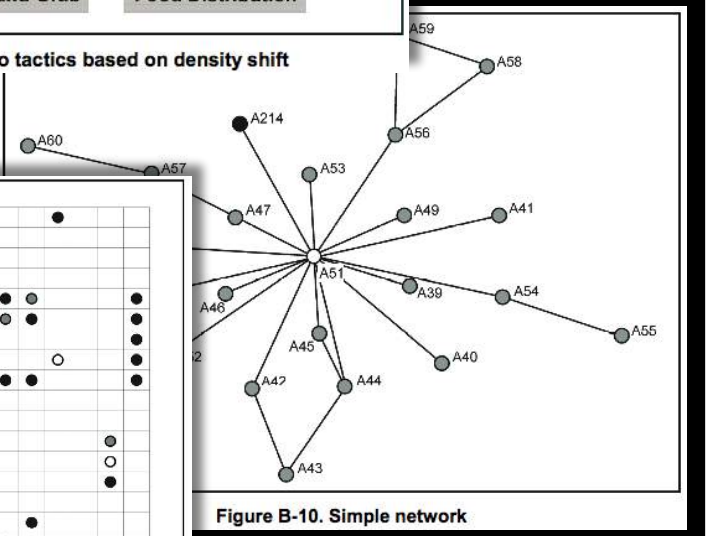


Figure B-10. Simple network

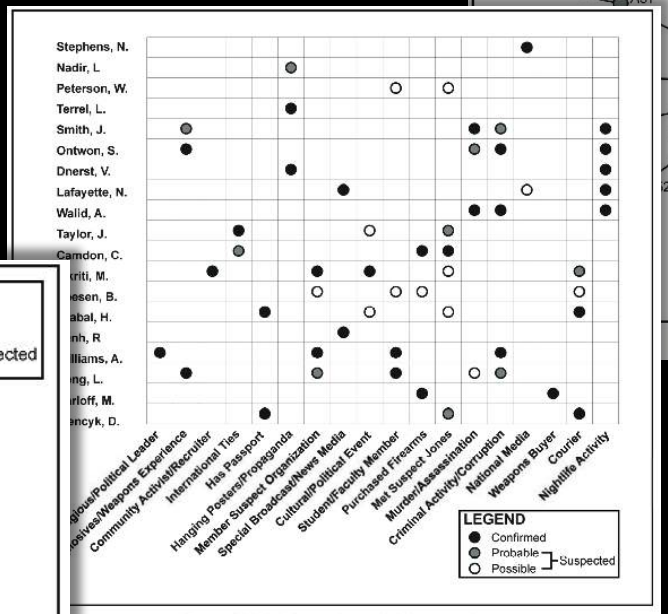


Figure B-11. Example activities matrix

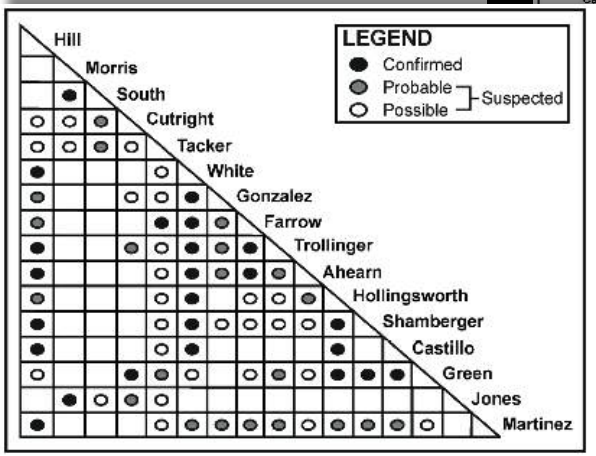


Figure B-12. Example association matrix

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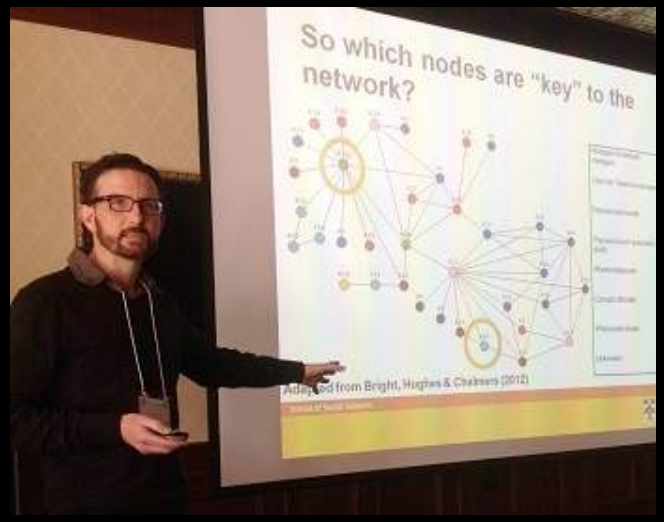
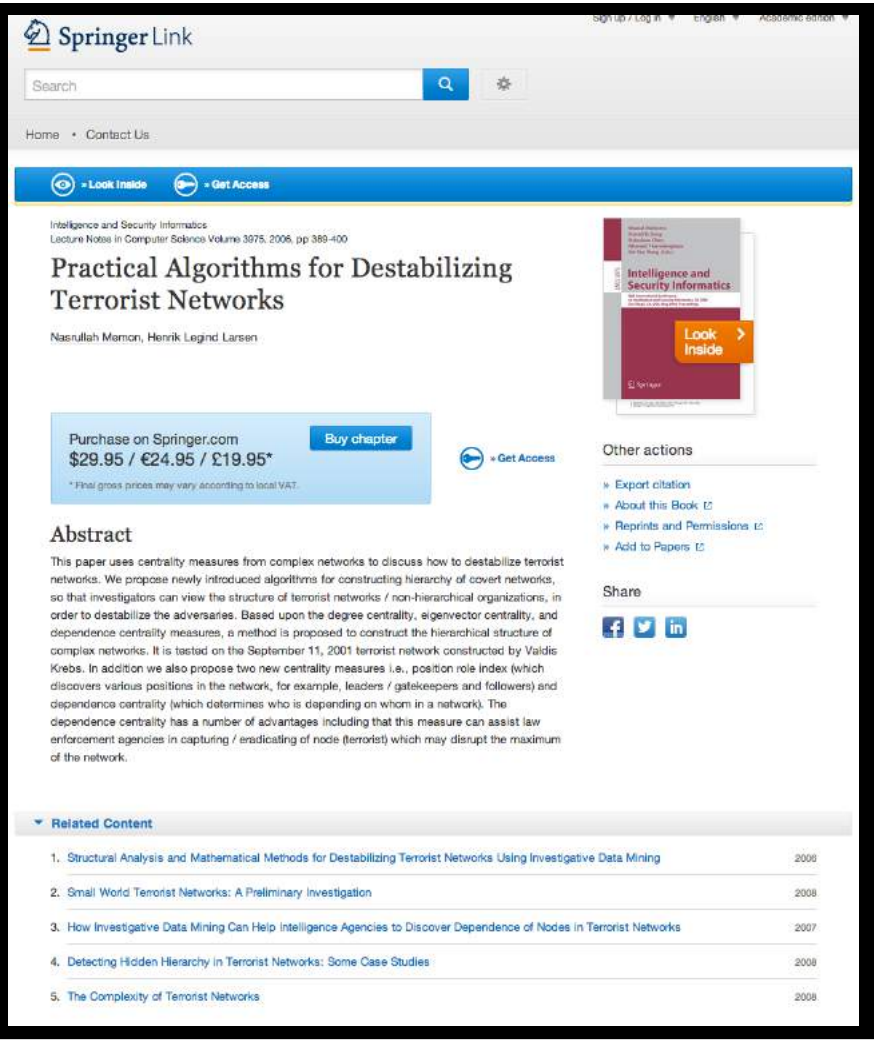
West Point



Dr David Bright, "Dismantling and Disrupting Dark Networks: Lessons from Social Network Analysis and Computer Simulation," at West Point NSC, Nov. 2013.



Assessment

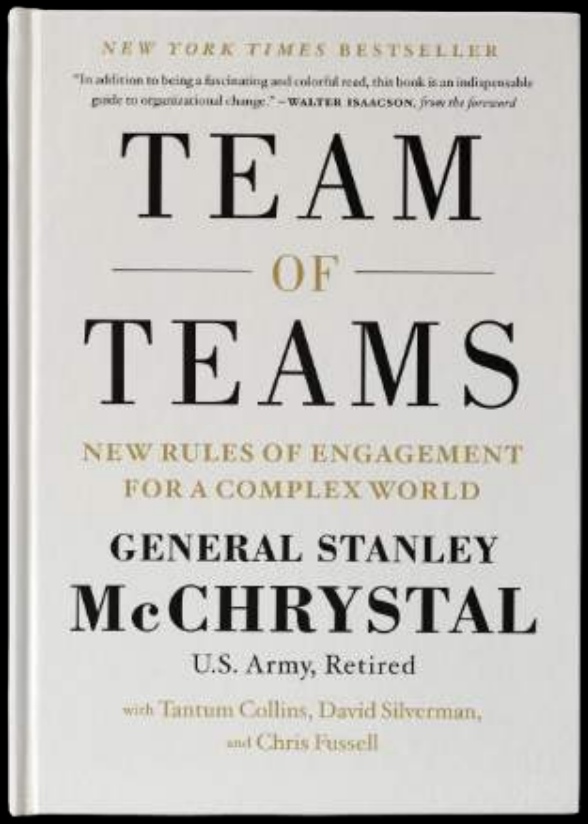
From Outcomes to Process

"The significant problems we have cannot be solved at the same level of thinking with which we created them."

- Albert Einstein

“We're an empire now, and when we act, **we create our own reality**. And while you're studying that reality -- judiciously, as you will -- **we'll act again, creating other new realities**, which you can study too, and that's how things will sort out. **We're history's actors** . . . and you, all of you, will be left to just study what we do.”

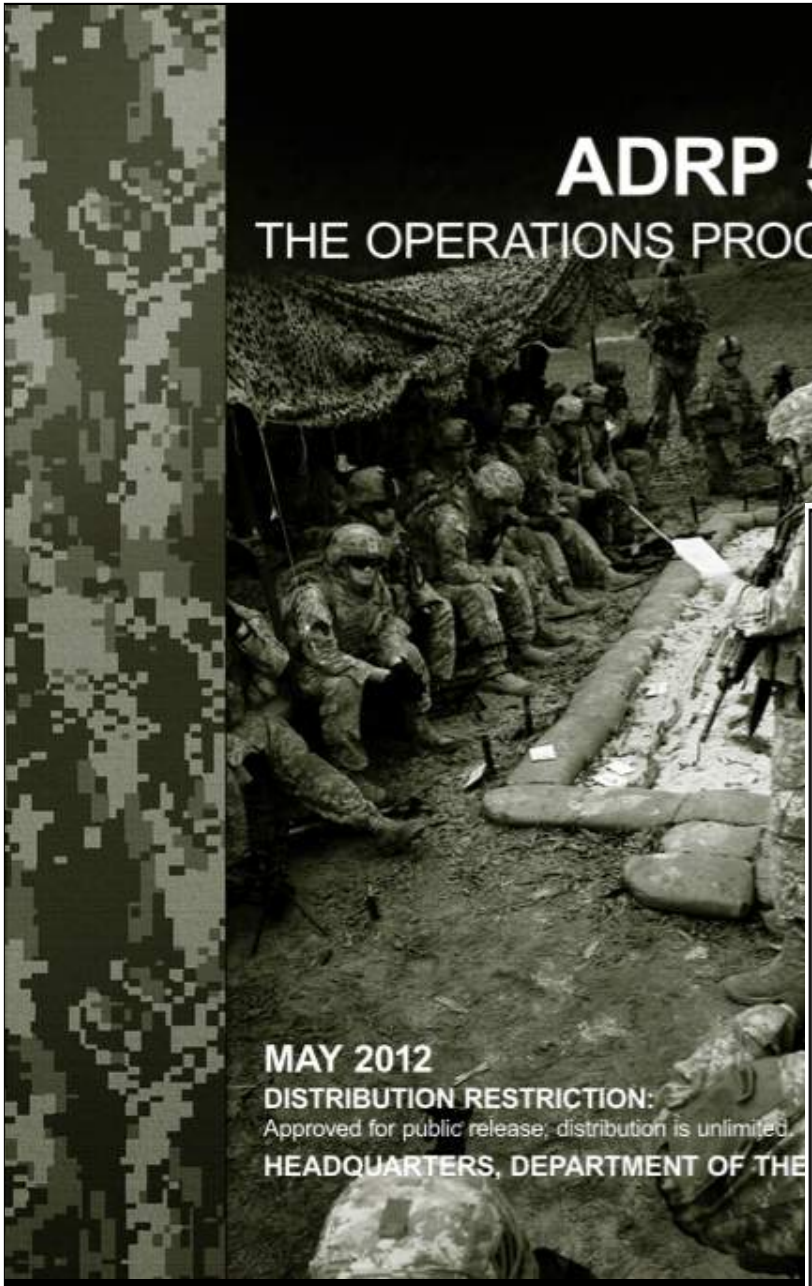
- attributed to Karl Rove



Executing faster than the adversary is not enough, especially if the plan is wrong.

Seeking to exploit butterfly effects ignores that their impacts are fundamentally unpredictable.

Iteratively gather data from nodes to find other nodes rather than rely on big data/mass surveillance to find the key nodes.



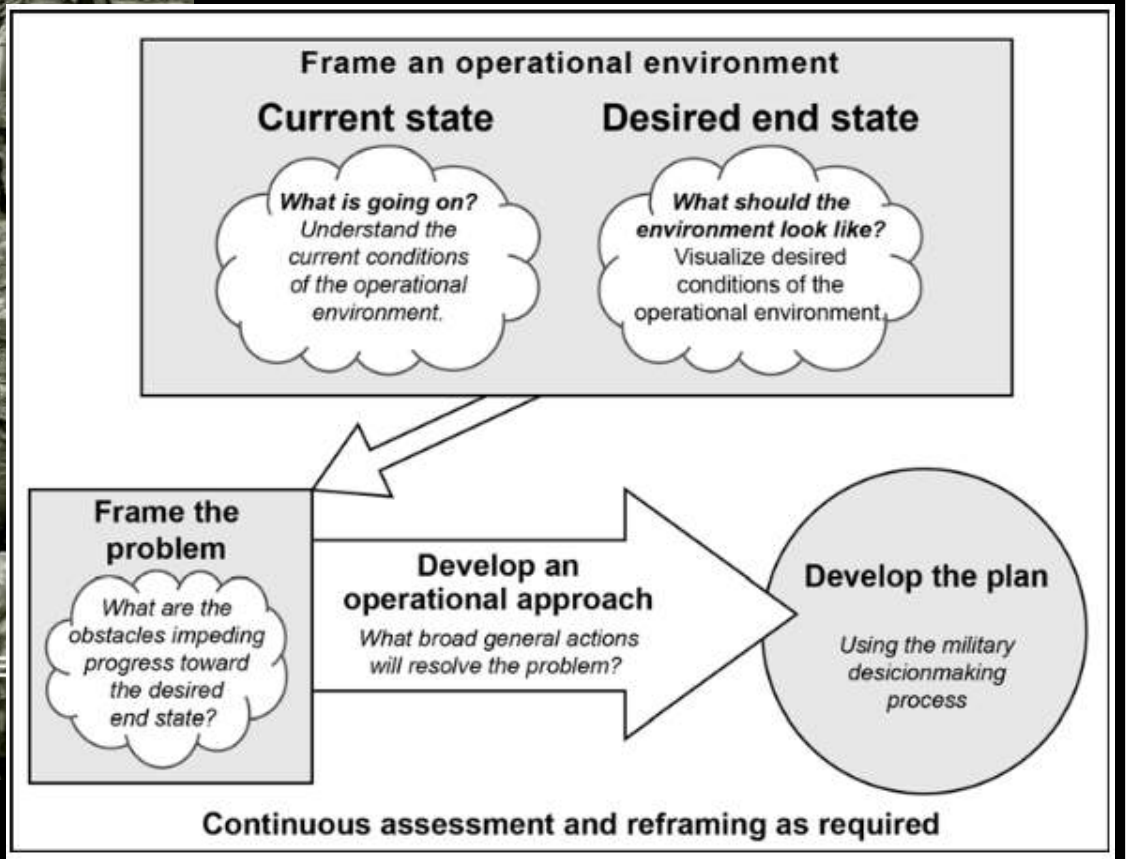


Figure 2-2. Army design methodology

Thank you!