COMING FULL CIRCLE WITH BOYD'S OODA LOOP IDEAS:

AN ANALYSIS OF INNOVATION DIFFUSION AND EVOLUTION

THESIS

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Abstract

The Observe-Orient-Decide-Act (OODA) Loop ideas of Air Force Colonel John Boyd have impacted the Department of Defense (DoD), influenced military thought, paved the way for operational change, and helped to shape fighting doctrines. A wide variety of OODA Loop ideas and interpretations exist in the literature, but are unorganized and have not undergone holistic study to determine how Boyd's ideas have spread or changed over time. As such, this research analyzed a quarter century (1976-2003) sample of the OODA Loop literature to examine the diffusion and evolution of OODA Loop ideas since Boyd's original conceptualizations. This research used qualitative data analysis to examine OODA Loop ideas in light of innovation diffusion theory. Ideas from Boyd's original OODA Loop theories were compared and contrasted with subsequent literature instances to assess diffusion and evolution of OODA Loop ideas in the DoD. This research concluded with a proposed conceptual framework for collectively considering OODA Loop ideas.

Acknowledgements

This research is the product of the support and encouragement of a great number of people (or more accurately, a number of great people). My foremost thanks go to my thesis advisor, Lt Col Summer Bartczak. Her encouragement, vision, and sheer persistence helped me work through tough times of adversity and confusion. She allowed me great freedom of thought while still keeping me on track. Other members of my thesis committee, Dr. Alan Heminger and Lt Col Stephen Swartz, also steered my research labors and helped to illuminate dark places along my winding research journey.

In addition, I express my gratitude to my fellow AFIT classmates. I have been enriched by your friendship, lively discussion, and support during this master's experience. Thank you for making even the hardest times fun. OODA on!

Most importantly, I lift my thanks up to God who has sustained and blessed me and express my heartfelt appreciation and affection to my wonderful wife for her continual patience, understanding, and support.

W. Scott Angerman

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COMING FULL CIRCLE WITH BOYD'S OODA LOOP IDEAS: AN ANALYSIS OF INNOVATION DIFFUSION AND EVOLUTION

I. Introduction

Background

The Observe-Orient-Decide-Act (OODA) Loop ideas (and the warfighting theories they have been used to champion) of Air Force Colonel John Boyd have impacted the Department of Defense (DoD), influenced military thought, paved the way for operational change, and helped to shape fighting doctrines. Following Boyd's many briefings to the defense establishment in the 1980s, there is much existing literature to show that OODA Loops have been extensively considered and utilized in a variety of ways. However, this researcher is unaware of any attempt to organize or collectively study the assorted literature that speaks to OODA Loop concepts or compare and assess the various manifestations of OODA Loop ideas contained within. As such, this research will analyze a quarter century (1976-2003) sample of the OODA Loop literature to examine the diffusion and evolution of OODA Loop ideas since Boyd's original conceptualizations.

OODA Loop Introduction.

Taken at its simplest level, Boyd's OODA Loop consists of four activities: observing, orienting, deciding, and acting. Observing gathers sensory inputs from the

environment of the observer. Orienting makes sense of the observational data in a process of interactive mental "destruction and creation" (Boyd, 1976) that creates a mental picture of the situational reality. Orientations are used to make sense of the input data in light of what is "known". This new knowledge provides the basis for decisions, and the decisions then lead to actions. This can be seen as a series of steps, however, the overall process is an ongoing cycle. Boyd contended that all rational human behavior, individual or organizational, could be depicted as continual cycling through these four processes (Fadok, 1995).

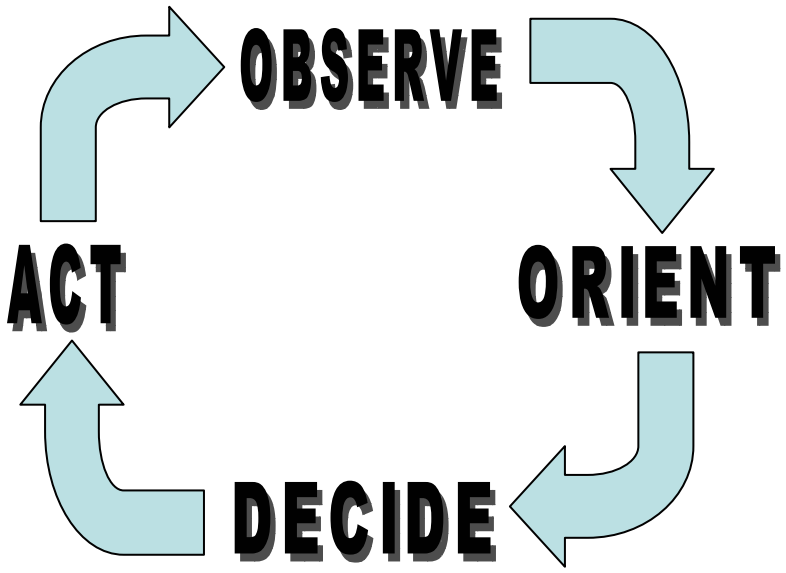


Figure 1. OODA Loop

Although intuitively understandable, this seemingly simple and straightforward model is shorthand for powerful underlying ideas (Coram, 2002) that have extensive applicability. Colin Gray, author of *Modern Strategy* points out,

> The OODA loop may appear too humble to merit categorization as a grand theory, but that is what it is. It has an elegant simplicity, an extensive domain of applicability, and contains a high quality of insight about strategic essentials, such that its author well merits honourable mention as an outstanding general theorist of strategy (Gray, 1999).

Origin and Diffusion of the OODA Loop.

It is said that the ideas behind the OODA Loop were set in motion during air-to-air combat exercises at Nellis Air Force Base in 1974 (Lind, 1985). During this time, Boyd was tasked to evaluate why U.S. pilots flying F-86s fared so well in air-to-air combat against enemy MiGs during the Korean War. During his investigation, Boyd discovered that the U.S. planes were actually inferior to the North Korean MiG-15s in almost all measures of performance. However, two features of the F-86 allowed U.S. pilots to gain an advantage. First, thanks to a bubble-shaped canopy, U.S. pilots had better visibility enabling them to better attune themselves to their air environment. Second, the F-86s had powered hydraulic controls that allowed faster maneuver transitions. U.S. pilots used their superior situational awareness and ability to make rapid changes to force enemy MiGs into a series of maneuvers from which they could not escape. The shock that set in when the enemy realized that they were in trouble only hastened the deadly outcome. Boyd recognized that the ability to cycle through observing, orienting, deciding, and acting faster than an opponent led to a considerable competitive advantage.

Later, Boyd continued to lay out conceptual groundwork for his OODA Loop conceptualizations in his only written work, *Destruction and Creation* (Boyd, 1976). In this 12-page essay, he described the principle mechanisms responsible for a cognitive

engine and also integrated Gödel's Proof, Heisenberg's Uncertainty Principle, and the Second Law of Thermodynamics to describe the nature of closed systems. Boyd used his ideas from this essay as a theoretical foundation for OODA Loop theories that he repeatedly briefed in a series of *Patterns of Conflict* presentations (Boyd, 1986, 1987a, 1987b, 1992).

Boyd never academically published his work or established scientific proof of concept, but this has not prevented his OODA Loop ideas and theory from gaining stature, adoption, and use within DoD operational and doctrinal communities (as well as the competitive business world). Traditionally, the DoD has used the OODA Loop to model human decision-making, command and control processes, and time-based competition cycles at all levels of conflict (i.e., tactical, operational, and strategic) (Fadok, 1995). OODA Loop ideas have been purported to have been incorporated into battle plans prepared and successfully executed in the last two Gulf wars. As one author put it: "Like the rain coming in through a leaky roof, Boyd's ideas thoroughly penetrated the winning strategy of the U. S. forces during the Gulf War, which was based on speed, maneuver and stealth" (Fialka, 1997).

OODA Loop ideas now serve as a foundation for *maneuver warfare* (Lind, 1985; Leonhard, 1991; Burton, 1993; Polk, 1999; Hammond, 2001; Coram, 2002) and play prominently in *strategic paralysis* (Fadok, 1995) and *information warfare* theories (Wood, 1995; Killam, 1996; Osborne, et al., 1996; Schechtman, 1996; Whitehead, 1997; Shalamanov, 1998; Gibb, 2000; Tomes, 2000). OODA Loop ideas are also finding their way into up-and-coming military concepts of *effects based operations* (Davis, 2001;

Smith, 2002), *network-centric warfare* (Alberts, et al., 2001; Randall, 2001; Smith, 2001; Gartska, 2002), and *information/decision superiority* (Van Riper, 1997; Money, 2003).

Additionally, in the last decade, members of scientific and technical communities have started to use OODA Loop representations in their work. Manifestations of OODA Loop ideas have found their way into areas like *cognitive engineering* (Whitaker & Kuperman, 1996; Endsley & Jones, 1997; Kuperman, 1998), *complex adaptive systems* (Tighe, 1999; Beckerman, 1999; Bullock, 2000; Shanahan, 2001; Flaherty, 2003), *intelligent agents* (Linkoping University, 1998; Tighe, 1999; Bullock, 2000; Aragon, 2001; Silverman, et al., 2001; Back, 2002; Heinze, 2002a; Connell, et al., 2003; Heinze, 2003), *entity modeling* (Bullock, 2000; Maxwell, 2000; Detsis, et al., 2001; Shahbazian, 2001, Heinze, 2002b; Kopp, 2002), and *data fusion* (Semerdjiev, 1998; Valin, et al., 1998; Bedworth, 1999; Shahbazian, et al., 1999; Bass, 2000; Bedworth, 2000; Blasch, 2000; Elmenreich, 2001; Shahbazian, 2001; Bladon, et al., 2002; Shahbazian, 2002; Stromberg, 2002, Silk Road, 2003). OODA Loop ideas seem to be flexible, showing intrinsic (or maybe transcendent) ability to be used innovatively in new ways by different adopters.

Research Purpose

It has been twenty years since OODA Loop ideas were first introduced (Boyd, 1983) and seven years since Boyd's last contribution (Boyd, 1996). A cursory investigation of OODA Loop ideas in the literature indicates that, over the years, there have been varying fundamental related ideas, differing descriptions, and a wide range of utilization. However, despite an apparent abundance of use in the literature, this researcher found no holistic research of OODA Loop ideas, how they have spread, or

how they have been re-invented (i.e. changed) by adopters. Also, no attempts to frame or structure the existing variety OODA Loop ideas in the literature were found. Research to fill these voids will help to assess the strengths of the OODA Loop's theoretical base, facilitate common dialogue and shared understanding of concepts, and provide additional reference breadth for future use of OODA Loop ideas.

This thesis will analyze the diffusion and evolution of OODA Loop ideas from the creation by Boyd to the present time. The goal will be to capture and organize OODA Loop ideas found in the literature body and provide an overall integrative assessment. It is intended that this research will provide greater understanding, better characterization, and "big picture" framing of OODA Loop ideas that are spreading, morphing, and being used in various ways to shape DoD thinking.

Specific Problem Statement

This study will attempt to answer the following question: ***"How have OODA Loop ideas diffused and evolved in the literature since Boyd's original conception?"*** This thesis will pursue the following investigative questions in order to resolve the research question:

1. What are the basic ideas that underpin Boyd's original OODA Loop?
2. How have OODA Loop ideas diffused throughout the literature and in what major contexts are they being applied?
3. How have OODA Loop ideas evolved over time?
4. What kind of a conceptual framework could be used to structure OODA Loop ideas found in the literature?

Scope

As stated previously, this research will address the diffusion and evolution of OODA Loop ideas. The researcher will develop a timeline to depict a chronology (1976 through 2003) of OODA Loop idea diffusion in the literature. The researcher will use a sample of OODA Loop literature from the last decade (1992 through 2003) as well as Boyd's works to evaluate the variety, diffusion, and evolution of OODA Loop ideas in the literature. Analysis of OODA Loop idea diffusion and evolution will focus on the DoD organization, although non-military literature will be used in the evaluation. Additionally, the researcher will use appropriate investigative boundaries (including an explicit definition of the "OODA Loop literature") to focus effort and facilitate research data collection, analysis, and report completion.

Research Approach and Overview

This research will use qualitative data analysis to examine OODA Loop ideas in light of innovation diffusion theory. OODA Loop ideas in the literature will be defined, classified, organized, and analyzed according to their content and application. Ideas from Boyd's original OODA Loop theories will be compared and contrasted with subsequent literature instances to assess diffusion and evolution of OODA Loop ideas. This research will attempt to present conceptual framework for collectively considering OODA Loop ideas.

Summary

This chapter has presented an introduction to Boyd's OODA Loop and has outlined a plan to study their diffusion and evolution throughout the literature. Chapter II will review research specifications and definitions, theory related to diffusion of

innovation, and Boyd's original OODA Loop ideas. Chapter III will present and discuss the qualitative methodology utilized in pursuing this research. Chapter IV will attempt to extract Boyd's core OODA Loop themes, discuss OODA Loop ideas found in the literature since Boyd's conception, and conduct a holistic analysis of OODA Loop idea diffusion and evolution. Finally, Chapter V will draw conclusions from the analysis (and relate them to researcher investigative questions), propose a conceptual framework for collectively considering OODA Loop ideas, and make suggestions for future research.

II. Literature Review

Overview

This literature review is designed to provide the reader with background concepts relevant to making sense of a qualitative analysis on the diffusion and evolution of OODA Loop ideas. As such, this chapter is divided into three parts: 1.) a brief discussion of research terminology, 2.) a review of theory related to diffusion of innovations, and 3.) a chronological examination of Boyd's essay and presentations for his original OODA Loop ideas. All in all, the literature review will provide a critical foundation for the analysis conducted in Chapter IV and for researcher findings documented in Chapter V.

Part I: Research Terminology

How does one qualitatively describe complex ideas and delineate them from each other? This question is pertinent when analyzing and evaluating qualitative ideas. As stated previously in Chapter I, the purpose of this research is to provide greater understanding, better characterization, and "big picture" framing of OODA Loop ideas that are spreading, morphing, and being used in various ways to shape DoD thinking. This research attempts to describe OODA Loop ideas while maintaining proper consistency in research language. This constancy of language required the practice of setting specific boundaries for idea themes and defining underlying terminology. By formalizing research language in this manner, the researcher hopes to facilitate consistent research descriptions and categorizations ("apples and apples" comparisons) and

common frames of reference for OODA Loop ideas for any future dialogues and knowledge exchanges.

In that train of thought, and in an attempt to improve this qualitative research's reliability and validity by making an ontological commitment (Borgo, 2002), the following terms/definitions will be used consistently for the scope of this research:

- An ***idea*** is defined to mean "a mental representation of something" (Collins English Dictionary, 2000). This research focused on diffusion, evolution, and relationships of OODA Loop ideas in the literature.
- A ***framework*** is defined to mean "a basic conceptual structure of ideas that illustrates and simplifies the elements that constitute a complex concept or construct" (Merriam Webster's Collegiate Dictionary, 1995). One product of this research will be a proposed conceptual framework to collectively consider OODA Loop ideas.

Part II: Diffusion of Innovation Theory

The Diffusion of Innovation Theory outlined below will serve as a theoretical foundation and backdrop for this research's qualitative analysis. It describes how innovations diffuse as they are introduced within a social system (in this case, the DoD). This section covers what diffusion of innovation means, outline the stages associated with Innovation-Decision Process Theory, describe how innovations can be re-invented by adopters, and explain the role of "change agents". This section concludes with a discussion of innovation diffusion rates and description of innovation adopters.

Diffusion of Innovation.

What is an innovation? Everett Rogers in his landmark text, *Diffusions of Innovations*, describes an ***innovation*** as "an idea, practice, or object that is perceived as

new by an individual or other unit of adoption" (Rogers, 1995). Innovations are spread by means of ***diffusion***, a "process by which an innovation is communicated through certain channels over time among the members of a social system" (Rogers, 1995). This process has four important terms (innovation, communication, time, and social system), each of which contributes to innovation diffusion and rates of adoption:

1. The innovation itself – Rogers identifies five characteristics of innovations that help explain the differences in adoption rates (Rogers, 1995).

Table 1. Characteristics of Innovations (Rogers, 1995)

Relative Advantage	Degree to which the innovation is perceived to be superior to the idea that it replaces
Compatibility	Degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters
Complexity	Degree to which an innovation is perceived as difficult to understand and use
Trialability	Degree to which an innovation may be experimented with on a limited basis
Observability	Degree to which the results of an innovation are visible to others

This research considers Boyd's OODA Loop ideas innovations that have diffused and evolved over time.

2. Communication – Communication is the means by which a new idea travels from one individual to another. Rogers states "diffusion is a particular type of communication in which the message content that is exchanged is concerned with a new idea" (1995, p.17). Thus, the diffusion process involves the spread of a new idea from its source to potential adopters. Different communication methods can have different diffusion effects. Mass mediums (such as television, radio, newspapers, etc.) are considered more effective ways

to generate awareness of an innovation. However, interpersonal communications are considered more effective in influencing an individual's decision to adopt (Rogers, 1995).

3. Time – Time relates to the speed with which an innovation is adopted by potential adopters (and is thus related to rate of diffusion). The rate of adoption is positively related to perceived relative advantage, compatibility, trialability, and observability, and is negatively related to perceived complexity of the innovation (Rogers, 1995).

4. Social System - Rogers defines a social system as "a set of interrelated units that are engaged in joint problem-solving to accomplish a common goal" (1995, p.23). The members of a social system may be individuals, informal groups, or organizations working toward a common goal. Culture within the social system and the individuals who make up the social systems can affect the diffusion of new ideas (Rogers, 1995). The Department of Defense is considered the primary social system for the purposes of this research.

Innovation-Decision Process Theory.

Rogers' Innovation-Decision Process theory states that diffusion within a social system is a process that occurs over time and can be seen as having five distinct stages. The stages in the process are knowledge, persuasion, decision, implementation, and confirmation (Rogers, 1995). Potential adopters of an innovation must first be exposed to the innovation's existence and gain some understanding of how it functions (knowledge). Potential adopters must then be persuaded as to the merits of the innovation (persuasion). A choice must be made to either adopt or reject the innovation (decision). The adopter then makes use of the innovation (implementation). Finally, an adopter reaffirms the

decision to adopt the innovation (confirmation) or reverses their earlier decision and discontinues use (Rogers, 1995).

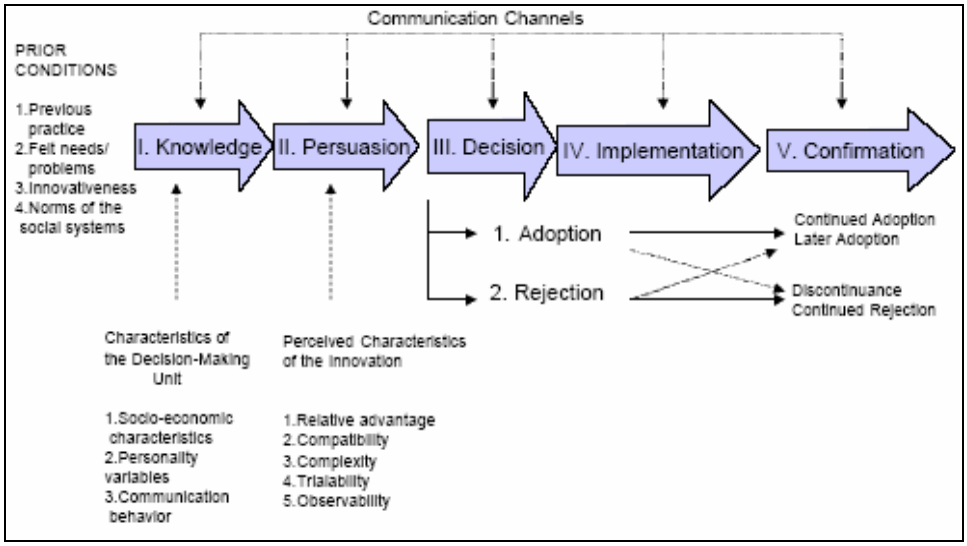


Figure 2. A Model of Stages in the Innovation-Decision Process (Rogers, 1995)

Re-invention.

An innovation does not necessary remain the same during the innovation decision and diffusion processes. *Re-invention* is the degree to which an innovation is changed or modified by a user in the process of its adoption and implementation. Some innovations are difficult or impossible to re-invent; others are more flexible in nature and they are "re-invented by many adopters who implement them in a wide variety of different ways" (Rogers, 1995).

Change Agents.

Innovations do not go through the innovation decision process by themselves. Central to the rate and degree of innovation adoption in Rogers' view is the effectiveness of "change agents" who initially establish a need for change and drive the diffusion process through its multiple phases (Rogers, 1995). Rogers defines a change agent as "an

individual who attempts to influence clients' innovation-decisions in a direction that is deemed desirable by a change agency" (Rogers, 1995). Often in large-scale social systems change requires multiple change agents since few individuals have the motivation, skill, and persistence to remain effective throughout the innovation process (Rogers, 1995). It is common for change agents to use social system opinion leaders (those in informing and influential positions at the center of interpersonal communication networks) "as their lieutenants in diffusion campaigns" (Rogers, 1995, p.28).

Adoption of Innovation.

Various innovations are different and rates of adoption and diffusion in a social system can differ. However, a reoccurring finding from over 3,000 studies in the diffusion of innovation literature is the sigmoid (or S-shaped) cumulative adoption curve (Rogers 1995, p.23). The S-curve graphically represents the diffusion of an innovation, with the number or percentage of adopters plotted on the vertical axis and time represented on the horizontal axis.

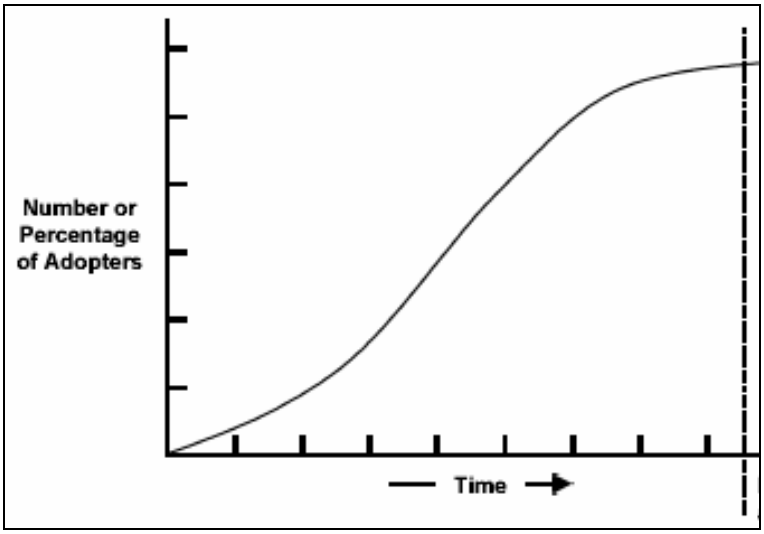


Figure 3. S-shaped Diffusion Curve (Rogers, 1995)

Rogers describes a S-shaped adoption distribution that rises slowly at first, with few adopters in each time period. It then accelerates to a maximum rate of adoption until half of the members of the social system have adopted. The S-curve continues to increase at a slower and slower rate until a certain (saturation) level is reached (Rogers, 1995).

Rogers suggests five different descriptions of adopter categories within the social system with regard to innovation acceptance (Rogers, 1995):

1. *Innovators* - (risk takers; able to cope with high level of uncertainty)
2. *Early Adopters* - (respected role models; greatest level of opinion leadership)
3. *Early Majority* - (frequent peer interaction; deliberate before accepting new ideas)
4. *Late Majority* - (respond to pressure from peers; skeptical; cautious)
5. *Laggards* - (isolated; reference the past; suspicious of innovations)

The frequency of the adopter categories forms a (normal) bell-shaped curve. It is this normal distribution curve that gives the diffusion curve its S-shape when the cumulative number of adopter is plotted (Rogers, 1995).

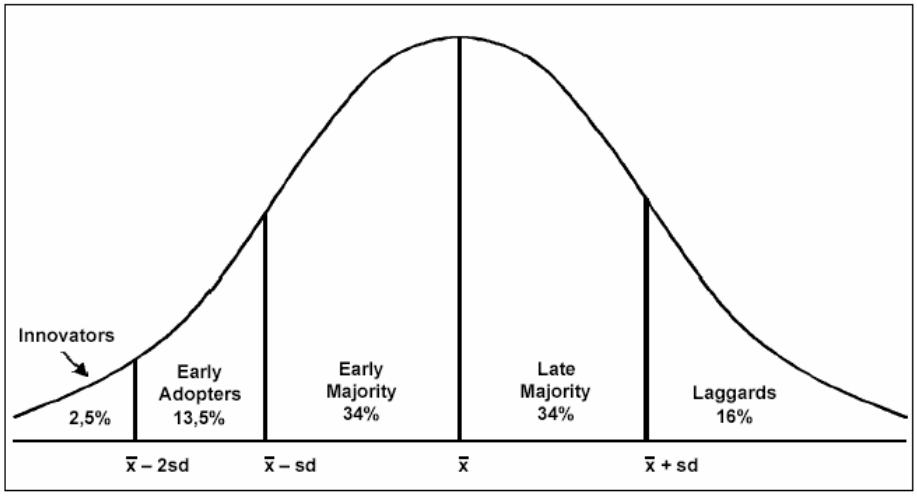


Figure 4. Adopter Categorization on the Basis of Innovativeness (Rogers, 1995)

Rogers postulates that there is a point during the acceptance and adoption of an innovation within a social system where no additional change effort is required and an innovation diffuses on its own. In his words, "the critical mass occurs at the point at which enough individuals have adopted an innovation so that the innovation's further rate of adoption becomes self-sustaining" (Rogers, 1995).

Part III: Chronological Review of Boyd's Original OODA Loop Ideas

This section documents Boyd's OODA Loop ideas found within his essay (1976) and series of briefings (1976 - 1996). This research considers Boyd's original OODA Loop ideas the initial state of the innovation (before any associated diffusion and/or evolution). This research reviewed the following work of Col John Boyd for its OODA Loop ideas:

Table 2. Boyd's Works (Boyd, 1976a, 1976b, 1986, 1987a, 1987b, 1992, 1996)

Title	Document Type	Release Date	Length
Destruction and Creation	Essay	Sept 1976	12 pages
New Conception for Air-To-Air Combat	Slide Presentation	Aug 1976	24 slides
Patterns of Conflict	Slide Presentation	Dec 1986	193 slides
Organic Design for Command and Control	Slide Presentation	May 1987	37 slides
The Strategic Game of ? and ?	Slide Presentation	June 1987	59 slides
Discourse on Winning and Losing	Slide Presentation	July/Aug 1992	38 slides
Essence of Winning and Losing	Slide Presentation	Jan 1996	4 slides

Introduction to Boyd's Work.

Boyd's work and theories were not created in a vacuum. According to his close associates and biographer, Boyd was a voracious reader and utilized ideas and published

works from many different fields (physics, mathematics, logic, information theory, evolutionary biology, genetics, cognitive psychology, cultural anthropology, sociology, political science, economics, etc.) (Spinney, 1997) and times (Sun Tzu's era to modern day authors) (Coram, 2002). Accordingly, Boyd made prolific references to sourced material. Boyd's *Destruction and Creation* (1976a) bibliography has 36 references and his *Patterns of Conflict* (1986) presentation contains 7 slides displaying 240 sourced references.

This research has attempted to conserve Boyd's diction and presentation method (and at time pulls "snapshots" from Boyd's original presentation slides). All quoted reference material from Boyd in the paragraphs below that are italicized and/or underlined were done so by Boyd for his emphasis.

The following section documents "OODA Loop ideas" that Boyd described within his literary work and publications. These ideas serve as "innovation point of origin" benchmarks for analyzing idea diffusion and evolution. It is noteworthy that not all Boyd's ideas pertain to "OODA Loop ideas".

Chronology of Boyd's OODA Loop Work.

Destruction and Creation (Boyd, 1976)

Boyd's first published work, the essay *Destruction and Creation,* does not contain any direct "OODA Loop" references within it, but does make references to observers/observations, orientations, decisions, and an individual's goal to "*improve our capacity for independent action*" (1976a). This essay is noteworthy in that is an idea precursor and lays conceptual groundwork for future OODA Loop ideas. The essay is short but compact with ideas (a Boyd biographer described it as "having the specific

density of uranium") (Coram, 2002). It describes the underlying mechanism by which all people comprehend, cope with, and shape their environments. Boyd discusses how mental concepts (the thoughts or concepts of meaning that make up our reality) are developed and manipulated to represent and deal with an observed reality. He begins by explaining that two fundamental mental operations are constantly at work: "we can start from a comprehensive whole and break it down to its particulars or we can start with the particulars and build towards a comprehensive whole" (1976a, p.3). He goes further and contrasts how general-to-specific mental operations are related to deductions, analysis, and differentiation, while specific-to-general mental operations are related to induction, synthesis, and integration. He then relates these "opposing idea chains" to the shattering ("destructive deduction") and construction ("creative induction") of cognitive domains or concepts of meaning (hence the title *Destruction and Creation*). Boyd describes this cycle as the way individuals perceive their reality, structure and unstructure concepts, maintain internal consistency of ideas and paradigms, and deal with uncertainty and disorder while "swimming around in a sea of anarchy" (1976a).

Boyd outlines Gödel's Incompleteness Theorem, Heisenbergs's Uncertainty Principle, and the Second Law of Thermodynamics (dealing with entropy) and then integrates them while focusing on an individual's perception of the world around them. A brief explanation of these theories and Boyd's integration is found in Table 3 on the next page.

Table 3. Boyd's Integration of Gödel's Incompleteness Theorem, Heisenbergs's Uncertainty Principle, and the Second Law of Thermodynamics (1976)

Theory	**Excerpts from Boyd's Explanation**
Gödel's Incompleteness Theorem	"there are true statements or concepts within the system that cannot be deduced from the postulates that make-up the system" (1976a, p.6); "Gödel's Proof indirectly shows that in order to determine the consistency of any new system we must construct or uncover another system beyond it" (1976a, p.7)
Heisenberg's Uncertainty or Inderminacy Principle	"the uncertainty values not only represent the degree of intrusion by the observer upon the observed but also the degree of confusion and disorder perceived by that observer" (1976a, p.9)
Second Law of Thermodynamics	"we cannot determine the character or nature (consistency) of such a system within itself, since the system is moving irreversibly toward a higher, yet unknown, state of confusion and disorder" (1976a, p.10)
Boyd's Integration	"Taken together, these three notions support the idea that any inward-oriented and continued effort to improve the match-up of concept with observed reality will only increase the degree of mismatch" (1976a, p.10)

Boyd later applies these ideas to his destructive deduction-creative induction cycle,

> In other words, as suggested by Gödel's Proof of Incompleteness, we imply that the process of Structure, Unstructure, Restructure, Unstructure, Restructure is repeated endlessly in move to higher and broader levels of elaboration. In this unfolding drama, the alternating cycle of entropy increase toward more and more disorder and the entropy decrease toward more and more order appears to be one part of a control mechanism that literally seems to drive and regulate this alternating cycle of destruction and creation… (1976a, p.11).

Boyd finishes this train of thought by concluding,

> …I believe we have uncovered a Dialectic Engine that permits the construction of decision models needed by individuals and societies for determining and monitoring actions in an effort to improve their capacity for independent action (1976a, p.11).

Boyd's ideas expressed in *Destruction and Creation* set the stage for his later OODA Loop ideas. Boyd made repeated reference to *Destruction and Creation* ideas in his later works.

New Conception for Air-to-Air Combat (Boyd, 1976)

In the same year he penned *Destruction and Creation*, Boyd prepared a slide presentation titled *New Conception for Air-to-Air Combat* (1976b). Within this presentation, Boyd describes the desirability of a physical maneuverability (i.e. tight turn rates) for fighter aircraft. Noteworthy (and pertinent to OODA Loop idea investigation) is the introduction to a theory of "fast transients." Boyd states, "in order to win or gain superiority – we should operate at a faster tempo than our adversaries or inside our adversaries time scales" (1976b, p.19). Boyd says that such faster operations will "will make us appear ambiguous (non-predictable) thereby generate confusion and disorder among our adversaries" (1976b, p.19). Boyd justifies the effects of this time-based competition by referencing his earlier integration of Gödel's Proof, Heisenberg Principle, and the Second Law of Thermodynamics and proposes this fast transient strategy as a new way to fight. Boyd describes the generation of a fast paced activity environment ("quick/clear observations, fast tempo, fast transients, quick kill" (1976b, p.22)) while denying an adversary the ability to adapt to such changes, "causing him to over and under react because of activity that appears uncertain, ambiguous, and chaotic" (1976b, p.22). Boyd concludes with the observation, "he who can handle the quickest rate of change survives" (1976b, p.24). Again, while the "OODA Loop" had not yet been formally presented, the Fast Transient ideas proposed in *New Conception for Air-to-Air Combat* (Boyd, 1976b) were heavily utilized in future OODA Loop works.

Patterns of Conflict (Boyd, 1986)

It is within *Patterns of Conflict* (Boyd, 1986) where the OODA Loop is first mentioned, drawing from Fast Transient theory:

> Idea of fast transients suggest that, in order to win, we should operate at a faster tempo or rhythm than our adversaries—or, better yet, get inside adversary's Observation-Orientation-Decision-Action time cycle or loop (Boyd, 1986, p.5)

Boyd states that actions should be taken to "simultaneously compress own time and stretch-out adversary time to generate a favorable mismatch in time/ability to shape and adapt to change" (1986, p.7). The goal, as in *New Conception for Air-to-Air Combat* (Boyd, 1976b), is to collapse the enemy into confusion and disorder by appearing menacing, ambiguous, chaotic, and/or misleading.

Boyd then begins a historical analysis of conflict and conquest by drawing a parallel between the "Theory of Evolution by Natural Selection" and "The Conduct of War" (1986, p.11). He outlines some general operational attributes advantageous to survival and independent action. According to Boyd, "variety/rapidity/harmony/initiative (and their interaction) seem to be key qualities that permit one to shape and adapt to an everchanging environment" (1986, p.12). Boyd instructs the reader to consider these qualities "together with our notion of getting inside an adversary's O-O-D-A loop" in the historical investigation to follow. Boyd then goes on to provide an extensive in-depth analysis of various battle strategies, operations, and tactics utilized from time of the Sun Tzu ("around 400 BC") all the way to World War II and modern guerilla campaigns. In the course of his analysis, Boyd equates getting inside an adversary's OODA loop with getting inside his "mind-space-time". This sense of "mind-space-time" is introduced

during a description of how German officers achieved a common outlook through long periods of training in which they gained "the same tactical education, the same way of thinking, identical speech, hence a body of officers to whom all tactical concepts were fully clear" (1986, p.74). Boyd describes how shared mind-space-time of strategic goals (or "Schwerpunkt") was used by German Blitzkriegers as:

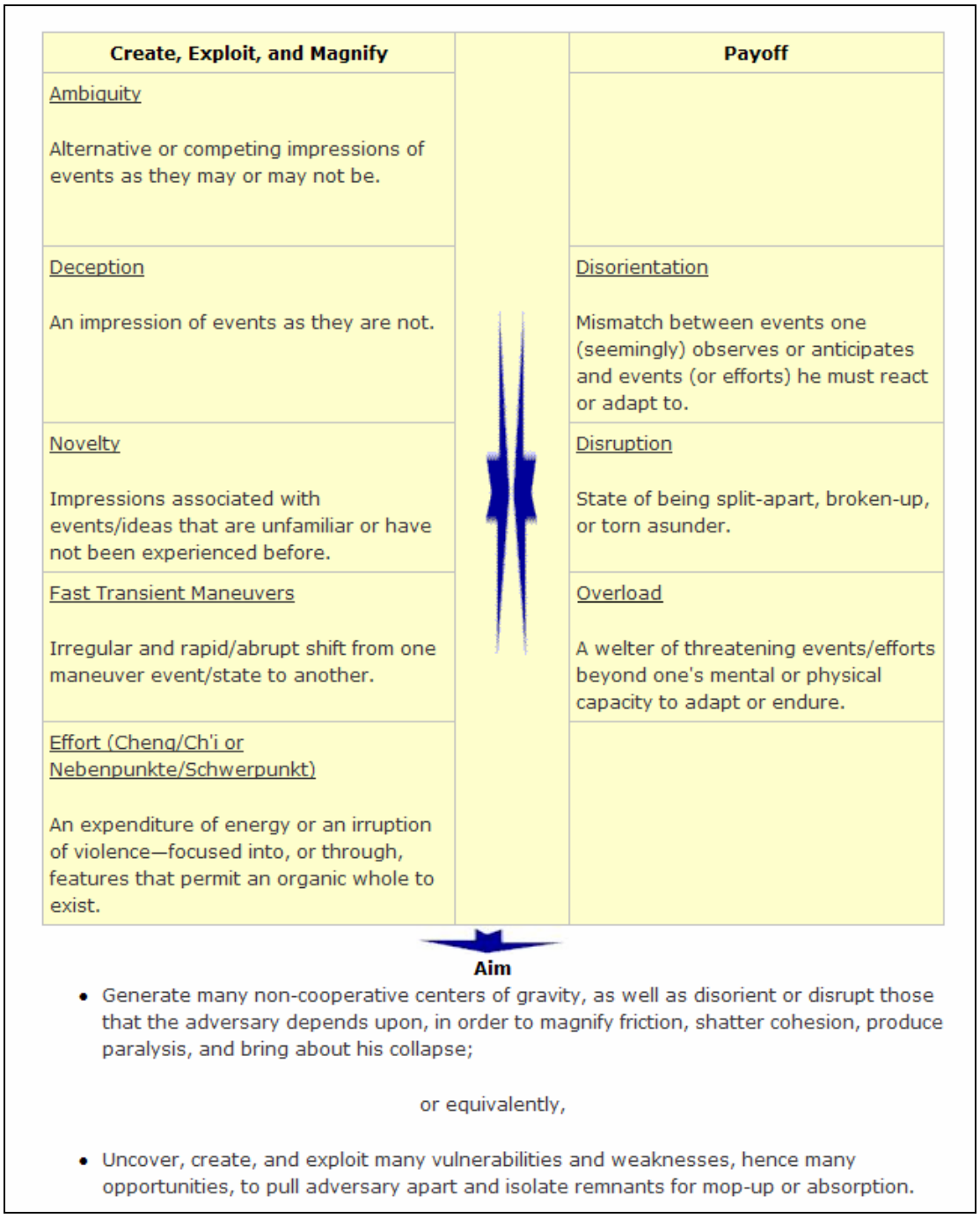
> …a unifying medium that provides a directed way to tie initiative of many subordinate actions with superior intent as a basis to diminish friction and compress time in order to generate a favorable mismatch in time/ability to shape and adapt to unfolding circumstances (1986, p.78).

German Blitzkriegers used their diminished friction and compressed time "to repeatedly operate inside their adversary's observation-orientation-decision-action loops" (1986, p.79). Later, in a following section, answering the question, "Why have Blitz[krieg] and Guerilla tactics been so extraordinarily successful?", Boyd states that,

> Blitz and Guerillas, by operating in a directed, yet more indistinct, more irregular, and quicker manner, operate inside their adversaries' observation-orientation-decision-action loops or get inside their mind-time-space as basis to penetrate the moral-mental-physical being of their adversaries in order to pull them apart, and bring about their collapse (1986, p.101).

Boyd employs his observations of historic patterns to lay out the "Essence of Maneuver Conflict" (Figure 5) and the "Essence of Moral Conflict" (Figure 6) that draw heavily from OODA loop observation, orientation, decision making, and action themes.

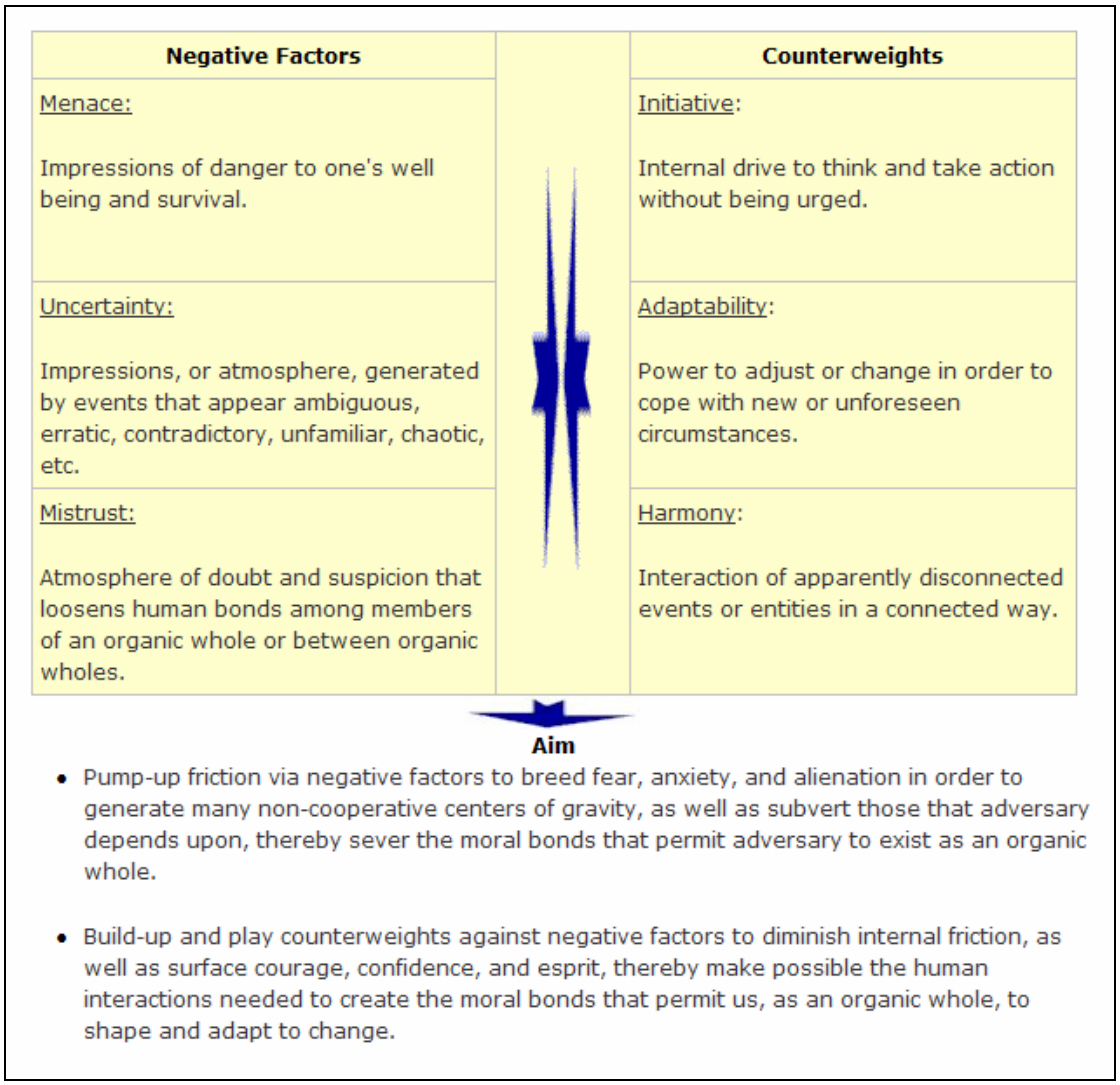
Figure 5 below describes how to inflict physical and psychological damage (i.e. maneuver warfare) to incapacitate an enemy and render him ineffective.



Create, Exploit, and Magnify	Payoff
Ambiguity Alternative or competing impressions of events as they may or may not be.	
Deception An impression of events as they are not.	Disorientation Mismatch between events one (seemingly) observes or anticipates and events (or efforts) he must react or adapt to.
Novelty Impressions associated with events/ideas that are unfamiliar or have not been experienced before.	Disruption State of being split-apart, broken-up, or torn asunder.
Fast Transient Maneuvers Irregular and rapid/abrupt shift from one maneuver event/state to another.	Overload A welter of threatening events/efforts beyond one's mental or physical capacity to adapt or endure.
Effort (Cheng/Ch'i or Nebenpunkte/Schwerpunkt) An expenditure of energy or an irruption of violence—focused into, or through, features that permit an organic whole to exist.	

Figure 5. Essence of Maneuver Conflict excerpt from *Patterns of Conflict* (1986, p.117), courtesy of http://www.belisarius.com

Figure 6 below describes negative moral factors to inflict on an adversary while promoting positive moral counterweights in one's own forces.



Negative Factors	Counterweights
Menace: Impressions of danger to one's well being and survival.	Initiative: Internal drive to think and take action without being urged.
Uncertainty: Impressions, or atmosphere, generated by events that appear ambiguous, erratic, contradictory, unfamiliar, chaotic, etc.	Adaptability: Power to adjust or change in order to cope with new or unforeseen circumstances.
Mistrust: Atmosphere of doubt and suspicion that loosens human bonds among members of an organic whole or between organic wholes.	Harmony: Interaction of apparently disconnected events or entities in a connected way.

Figure 6. "Essence of Moral Conflict" excerpt from *Patterns of Conflict* (1986, p.125), courtesy of http://www.belisarius.com

These "essences" are then used by Boyd to develop his overall Grand Tactics and Grand Strategy (Figure 7).

National Goal

• Improve our fitness, as an organic whole, to shape and cope with an everchanging environment.

Grand Strategy

• Shape pursuit of national goal so that we not only amplify our spirit and strength (while undermining and isolating our adversaries) but also influence the uncommitted or potential adversaries so that they are drawn toward our philosophy and are empathetic toward our success.

Strategic Aim

• Diminish adversary's capacity while improving our capacity to adapt as an organic whole, so that our adversary cannot cope while we can cope with event/efforts as they unfold.

Strategy

• Penetrate adversary's moral-mental-physical being to dissolve his moral fiber, disorient his mental images, disrupt his operations, and overload his system, as well as subvert, shatter, seize, or otherwise subdue those moral-mental physical bastions, connections, or activities that he depends upon, in order to destroy internal harmony, produce paralysis, and collapse adversary's will to resist.

Grand Tactics

• Operate inside adversary's observation-orientation-decision-action loops, or get inside his mind-time-space, to create tangles of threatening and/or non-threatening events/efforts as well as repeatedly generate mismatches between those events/efforts adversary observes, or imagines, and those he must react to, to survive;

thereby

• Enmesh adversary in an amorphous, menacing, and unpredictable world of uncertainty, doubt, mistrust, confusion, disorder, fear, panic, chaos,…and/or fold adversary back inside himself;

thereby

• Maneuver adversary beyond his moral-mental-physical capacity to adapt or endure so that he can neither divine our intentions nor focus his efforts to cope with the unfolding strategic design or related decisive strokes as they penetrate, splinter, isolate or envelop, and overwhelm him.

Tactics

• Observe-orient-decide-act more inconspicuously, more quickly, and with more irregularity as basis to keep or gain initiative as well as shape and shift main effort: to repeatedly and unexpectedly penetrate vulnerabilities and weaknesses exposed by that effort or other effort(s) that tie-up, divert, or drain-away adversary attention (and strength) elsewhere.

Figure 7. Grand Strategy and Grand Tactics excerpt from *Patterns of Conflict* (1986, p.141)

Boyd closes *Patterns of Conflict* with a critique of so-called "principles of war" (i.e. Objective, Offensive, Mass, Economy of Forces, etc….) that he points out are not really principles, per se, but "seem to be some kind of a (shifting) static check of laundry list or what should be adhered to" (1986, p.182). Given this alleged misnomer, Boyd points out that such "a list of principles does not reveal how individual principles interact nor the mechanism for doing so" (1986, p.182). To remedy this shortfall, Boyd attempts to "evolve statements that reflect the essence of conflict dynamics in a connected sense" (1986, p.183). Figure 8 outlines Boyd's conflict dynamics statements.

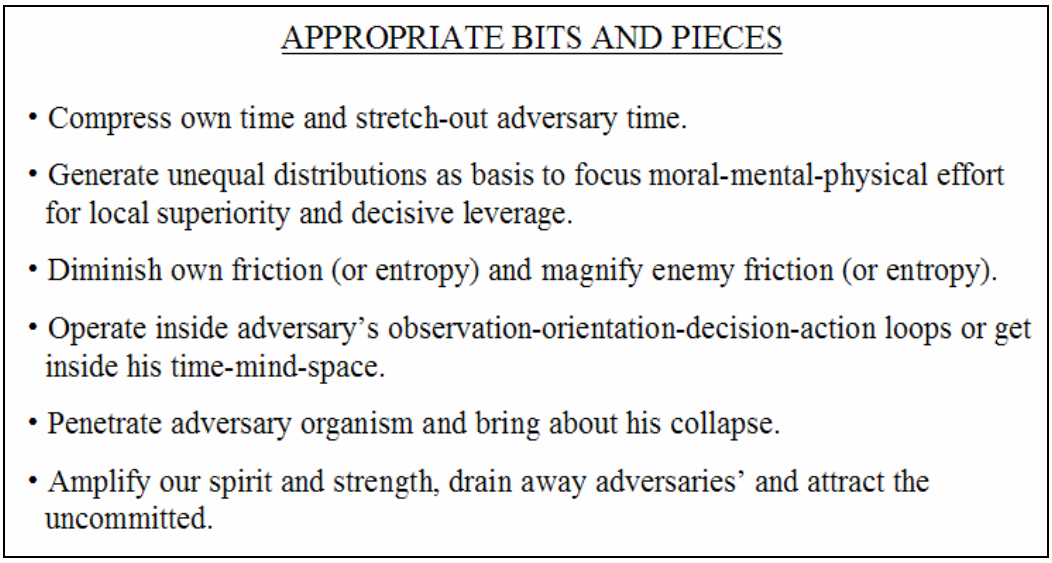


Figure 8. Essence of Conflict Dynamics excerpt from *Patterns of Conflict* (1986, p.184)

He then condenses these ideas to conclude his presentation:

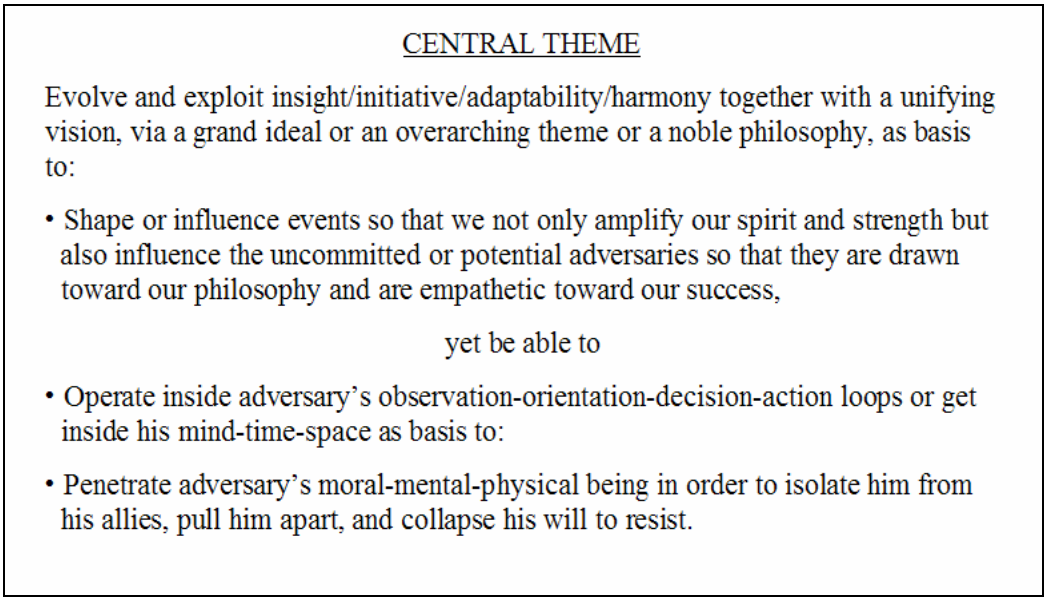


Figure 9. Essence of Conflict Dynamics excerpt from *Patterns of Conflict* (1986, p.185)

Organic Design of Command and Control (Boyd, 1987)

Boyd's next work, *Organic Design of Command and Control* (1987a), builds off of *Patterns of Conflict* (1986) by emphasizing the implicit human side of command and

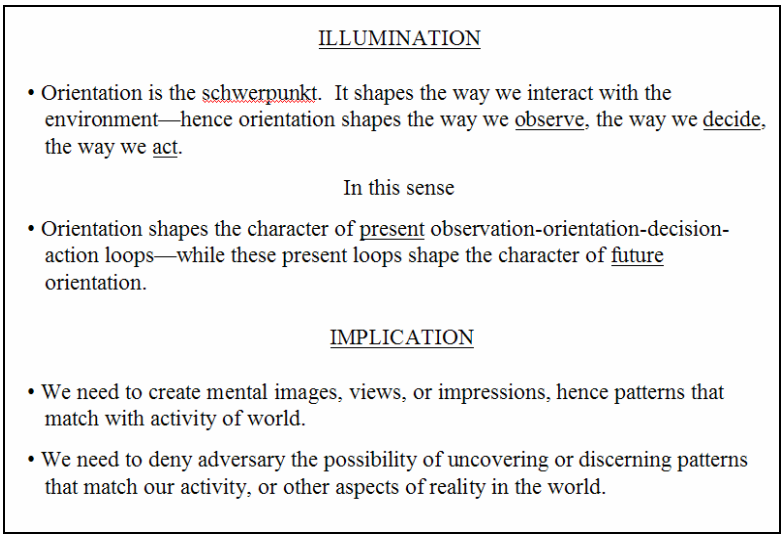
control (C2) operations. In doing so, Boyd puts forward a counter-point for what he says is an institutional push for hardware as the C2 solution, or as he puts it, a desire for:

> …more and better sensors, more communications, more and better computers, more and better display devices, more satellites, more and better fusion centers, etc.—all tied into one giant fully informed, fully capable C&C system (1987a, p.2).

In investigating the command and control environment, Boyd says, "We must uncover those interactions that foster harmony and initiative—yet do not destroy variety and rapidity" (1987a, p.9). In exploring the interactions that occur in a C2 environment, Boyd more fully develops a description of "orientation". He states that:

> …orientation is an interactive process of many-sided implicit cross-referencing projections, empathies, correlations, and rejections that is shaped by and shapes the interplay of genetic heritage, cultural tradition, previous experiences, and unfolding circumstances (1987a, p.15).

Boyd follows this up by showing the dependence of the rest of the OODA Loop on process of orientation, and states the importance of making accurate orientations while denying adversaries the ability to do the same.



ILLUMINATION

- Orientation is the schwerpunkt. It shapes the way we interact with the environment—hence orientation shapes the way we observe, the way we decide, the way we act.

In this sense

- Orientation shapes the character of present observation-orientation-decision-action loops—while these present loops shape the character of future orientation.

IMPLICATION

- We need to create mental images, views, or impressions, hence patterns that match with activity of world.
- We need to deny adversary the possibility of uncovering or discerning patterns that match our activity, or other aspects of reality in the world.

Figure 10. Orientation excerpt from *Organic Design for Command and Control* (1987a, p.16)

Boyd reiterates the idea from *Patterns of Conflict* (1986) that an effective command and control system should emphasize implicit communications and trust. To accomplish this, Boyd advocates exposing individuals to "a variety of situations—whereby each individual can observe and orient himself simultaneously to the others and to the variety of changing situations" in order to achieve "similar mental images or impressions….by repeatedly sharing the same variety of experiences in the same ways" (1987a, p.18). The payoff of such training comes in:

> …a command and control system, whose secret lies in what's unstated or not communicated to one another (in an explicit sense)—in order to exploit lower-level initiative yet realize higher-level intent, thereby diminish friction and compress time, hence gain both quickness and security (1987, p.18).

Boyd warns against designing a command and control system with too much of an inward focus (to the neglect of the external environment) by returning to the idea that "one cannot determine the character or nature of a system within itself" and that "attempts to do so lead to confusion and disorder" (1987a, p.20). Boyd predicts "any command and control system that forces adherents to look inward, leads to dissolution/disintegration (i.e., system comes unglued)" (1987a, p.21) and points to the use of "implicit bonds or connections" as appropriate countermeasures. Boyd lays out the mechanism and benefits of a C2 system using "implicit orientation" on the next page in Figure 11:

MESSAGE

• Suppress tendency to build-up explicit internal arrangements that hinder interactions with external world.

Instead

• Arrange setting and circumstances so that leaders and subordinates alike are given opportunity to continuously interact with external world, and with each other, in order to more quickly make many-sided implicit cross-referencing projections, empathies, correlations, and rejections as well as create the similar images or impressions, hence a similar implicit orientation, needed to form an organic whole.

Why?

•A similar implicit orientation for commanders and subordinates alike will allow them to:
-- Dimininish their friction and reduce time, thereby permit them to:
-- Exploit variety/rapidity while maintaining harmony/initiative, thereby permit them to:
-- Get inside adversary O-O-D-A loops, thereby:
-- Magnify adversary's friction and stretch-out his time (for a favorable mismatch in friction and time), thereby:
-- Deny adversary the opportunity to cope with events/efforts as they unfold.

Figure 11. Implicit Orientation for C2 excerpt from *Organic Design for Command and Control* (1987a, p.23)

Boyd then equates the process of the OODA loop to command and control processes, re-emphasizing orientation as the most important activity.

ILLUMINATION

• The process of observation-orientation-decision-action represents what takes place during the command and control process—which means that the O-O-D-A loop can be thought of as being the C&C loop.

• The second O, orientation—as the repository of our genetic heritage, cultural tradition, and previous experiences—is the most important part of the O-O-D-A loop since it shapes the way we observe, the way we decide, the way we act.

IMPLICATION

• Operating inside adversary's O-O-D-A loop means the same thing as operating inside adversary's C&C loop.

Figure 12. OODA Loop same as Command and Control process excerpt from *Organic Design for Command and Control* (1987a, p.26)

Boyd finishes *Organic Design for Command and Control* with an examination of what 'command and control' really mean.

> Direction and shaping, hence "command", should be evident while assessment and ascertainment, hence "control", should be invisible and should not interfere—otherwise "command and control" does not exist as an effective means to improve our fitness to shape and cope with unfolding circumstances (1987a, p.31).

Boyd contrasts this view with a traditional view of command and control that he says "represents a top-down mentality applied in a rigid or mechanical (or electrical) way that ignores as well as stifles the implicit nature of human beings to deal with uncertainty, change, and stress" (1987a, p.35). His conclusion is that the ideas of 'appreciation' and 'leadership' are more appropriate than 'control' and 'command' for the purposes of his briefing. *Appreciation* is defined by Boyd who says it "refers to the recognition of worth or value, clear perception, understanding, comprehension, discernment, etc" (1987a, p.37). Boyd earlier states that "appreciation must not interact nor interfere with system but must discern (not shape) the character/nature of what is being done or about to be done" (1987a, p.34). *Leadership* is defined by Boyd saying it "implies the art of inspiring people to cooperate and enthusiastically take action toward the achievement of uncommon goals" (1987a, p.37). Boyd clarifies that "leadership must interact with system to shape the character or nature of that system in order to realize what is to be done" (1987a, p.34). Despite apparent similarities in the descriptive terminology, Boyd makes no explicit references to any connections or relationships between *orientation* and *appreciation* and between *decision* and *leadership.*

The Strategic Game of ? and ? (Boyd, 1987)

Boyd uses *The Strategic Game of ? and ?* to recap and integrate ideas from previous presentations (1987b). The first example of this is with Boyd's "Snowmobile" illustration. This illustration uses initial images of 1.) skiers on ski slope, 2.) a motorboat on the water, 3.) a person riding a bicycle, and 4.) a toy tractor or tank with caterpillar treads. It then "pulls off" the skis, outboard motor, handlebars, and rubber treads from these images and integrates them toward a new creation: a snowmobile. In doing so, Boyd (returning to his *Destruction and Creation* roots) provides a concrete example of how a new creation (synthesis) is predicated and related to the "pulling apart" or deconstruction of world perspectives (via analysis).

Boyd uses excerpts from the fields of mathematical logic, physics, thermodynamics, biology, psychology, anthropology, and conflict to illustrate that people relate to their world (and each other) in physical, mental, and moral ways. Figure 13 on the next page describes the physical, mental, and moral interactions that living systems have with an environment. Boyd describes these interactions as required in order to cope, to maintain coherence and focus, to preserve order, and to sustain oneself -- in other words, to survive and thrive.

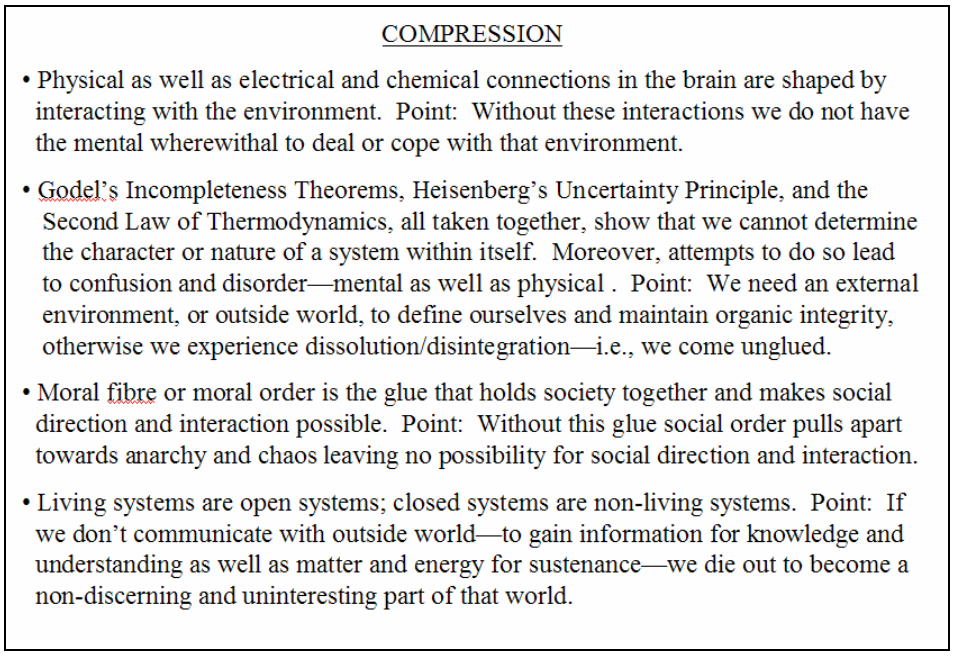


Figure 13. Physical, Mental and Moral Interactions with Environment excerpt from *The Strategic Game of ? and ?* (1987b, p.28)

Boyd arrives at the conclusion that human beings require the sustenance, nourishment, and support of their external environment. As he puts it, "Interaction permits vitality and growth while isolation leads to decay and disintegration" (1987b, p.29). Boyd states that this theme of interaction and isolation recurs throughout *Organic Design for Command and Control* (where interaction is emphasized), *Patterns of Conflict* (where isolation is emphasized), and *Destruction and Creation* (where interaction and isolation are balanced evenly). Boyd reveals "interaction" and "isolation" as the question marks in the title (making it *The Strategic Game of Interaction and Isolation)* and calls it a "game in which we must be able to diminish adversary's ability to communicate or interact with his environment while sustaining or improving ours" (1987b, p.33).

In the next series of slides, Boyd develops his thoughts through a series of self-queries and answers, leading to the question, "How do we fold adversaries back inside

themselves, morally-mentally-physically,…without suffering the same fate ourselves?" (1987b, p.46). In other words, Boyd asks how one isolates their adversaries physically, mentally, and morally while maintaining their own positive interactions. Figure 14 below describes how to isolate adversaries while Figure 15 describes how to maintain one's own interactions.

ILLUMINATION

- Physically we can isolate our adversaries by severing their communications with outside world as well as by severing their internal communications to one another. We can accomplish this by cutting them off from their allies an the uncommitted via diplomatic, psychological, and other efforts. To cut them off from one another we should penetrate their system by being unpredictable, otherwise they can counter our efforts.

- Mentally we can isolate our adversaries by presenting them with ambiguous, deceptive, or novel situations, as well as by operating at a tempo or rhythm they can neither make out nor keep up with. Operating inside their O-O-D-A loops will accomplish just this by disorienting or twisting their mental images so that they can neither appreciate nor cope with what's really going on.

- Morally our adversaries isolate themselves when they visibly improve their well-being to the detriment of others (i.e. their allies, the uncommitted, etc.) by violating codes of conduct or behavior patterns that they profess to uphold or others expect them to uphold.

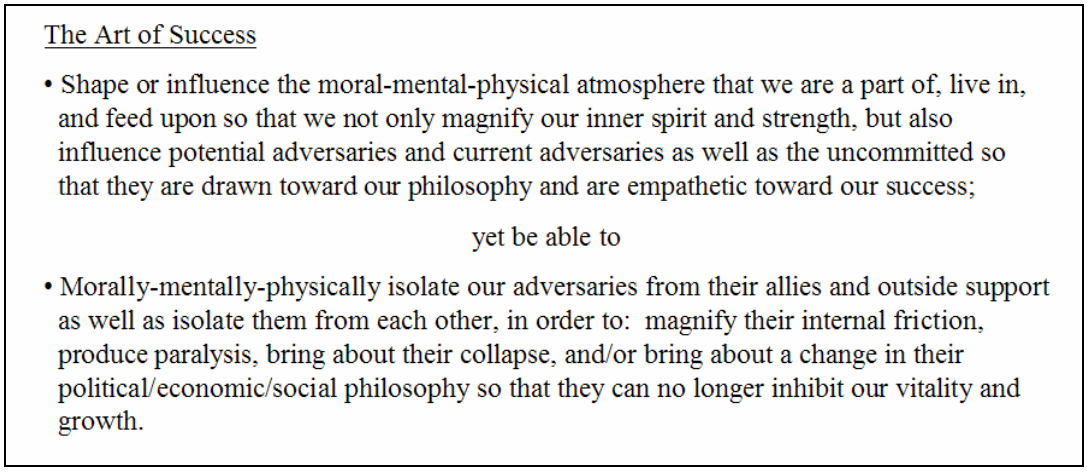
Figure 14. Isolation excerpt from *The Strategic Game of ? and ?* (1987b, p.47)

ILLUMINATION (Continued)

- Physically we interact by opening-up and maintaining many channels of communication with the outside world, hence with others out there , that we depend upon for sustenance, nourishment, or support.
- Mentally we interact by selecting information from a variety of sources or channels in order to generate mental images or impressions that match-up with the world of events or happenings that we are trying to understand and cope with.
- Morally we interact with others by avoiding mismatches between what we say we are, what we are, and the world we have to deal with, as well as abiding by those other cultural codes or standards that we are expected to uphold.

Figure 15. Interaction excerpt from *The Strategic Game of ? and ?* (1987b, p.49)

Boyd uses this competitive strategy of interaction and isolation as a generalized recipe for success (shown in Figure 16):



The Art of Success

- Shape or influence the moral-mental-physical atmosphere that we are a part of, live in, and feed upon so that we not only magnify our inner spirit and strength, but also influence potential adversaries and current adversaries as well as the uncommitted so that they are drawn toward our philosophy and are empathetic toward our success;

yet be able to

- Morally-mentally-physically isolate our adversaries from their allies and outside support as well as isolate them from each other, in order to: magnify their internal friction, produce paralysis, bring about their collapse, and/or bring about a change in their political/economic/social philosophy so that they can no longer inhibit our vitality and growth.

Figure 16. Success through Interaction and Isolation excerpt from *The Strategic Game of ? and ?* (1987b, p.51)

Boyd then outlines "A Moral Design for Grand Strategy" through the use of "moral leverage". He states that this leverage should be used "to amplify our spirit and strength as well as expose the flaws of competing or adversary systems, all the while influencing the uncommitted, potential adversaries and current adversaries so that they are drawn toward our philosophy and empathetic toward our success" (1987b, p.54).

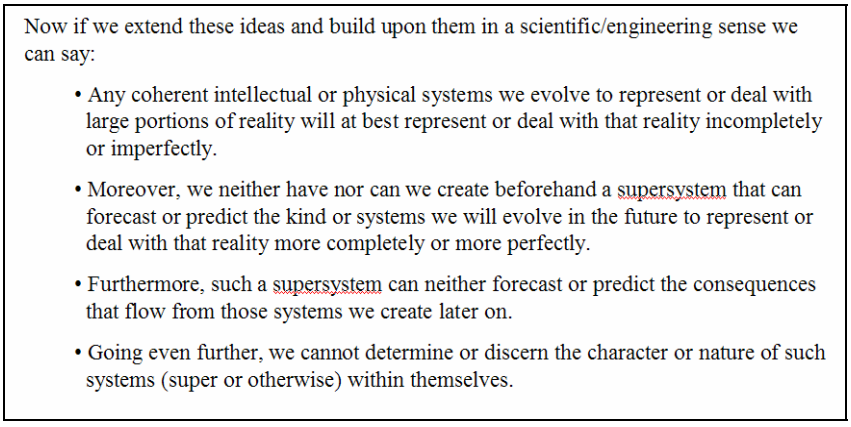
Boyd concludes *Strategic Game of ? and ?* by returning to earlier familiar ideas, stating that the goal of strategy is to "improve our ability to shape and adapt to unfolding circumstance, so that we (as individuals or as groups or as a culture or as a nation-state) can survive on our own terms" (1987b, p.58). He reiterates the central theme of achieving strategy is through the use of "interaction/isolation" brought on through

"moral-mental-physical means" (1987b, p.58). Finally, he describes the mechanism of strategic thought as:

> …an instinctive see-saw of analysis and synthesis across a variety of domains, or across competing/independent channels of information, in order to spontaneously generate new mental images or impressions that match-up with an unfolding world of uncertainty and change (1987b, p.58).

A Discourse on Winning and Losing (Boyd, 1992)

Boyd opens his presentation, *A Discourse on Winning and Losing*, with an examination of the processes of science, engineering, and the pursuit of technology. He presents a simplified view of science as a "self-correcting process of observation, hypothesis, and test" and engineering as "a self-correcting process of observation, design, and test" (Boyd, 1992). In Boyd's eyes, technology simply is the product of the practice of science and engineering. Boyd then presents four slides of examples of scientific and engineering contributions throughout history beginning with Isaac Newton's laws of motion and gravity presented in 1687 and concluding with Sony's 1980 introduction of the video camcorder. Boyd uses identified theorems from Gödel, Lowenheim & Skolem, Tarski, Church, Turing, Chaitlin, and others to contribute some ideas concerning the inability of a theoretical system to completely represent or predict reality:


Now if we extend these ideas and build upon them in a scientific/engineering sense we can say:

- Any coherent intellectual or physical systems we evolve to represent or deal with large portions of reality will at best represent or deal with that reality incompletely or imperfectly.
- Moreover, we neither have nor can we create beforehand a supersystem that can forecast or predict the kind or systems we will evolve in the future to represent or deal with that reality more completely or more perfectly.
- Furthermore, such a supersystem can neither forecast or predict the consequences that flow from those systems we create later on.
- Going even further, we cannot determine or discern the character or nature of such systems (super or otherwise) within themselves.

Figure 17. Theoretical System excerpt from *A Discourse on Winning and Losing* (1992, p.14)

Boyd summarizes, “While we can comprehend and predict some portions of the everchanging world that unfolds before us, other portions seem forever indistinct and unpredictable” (1992, p.16).

Boyd continues his examination of science and engineering contributions, generalizing that they are “new ideas, new systems, new processes, new materials, new etc.”, and concludes that “Science, engineering, and technology produce change via novelty” (1992, p.20). Boyd relates the generation of this novelty to his previously described (Boyd, 1976) reductive processes of analysis and connective processes of synthesis. Boyd states that these processes when applied in the world form an “analytic/synthetic feedback loop for comprehending, shaping and adapting to that world” (1992, p.21) and that this overall process produces novelty.

Boyd theorizes, “the presence and production of mismatches are what sustain and nourish the enterprise of science, engineering, and technology” (1992, p.23). His reasoning is that if our ideas and thoughts perfectly matched the world and if our designed systems and processes worked perfectly, then there would be no necessity for the novelty of new ideas, systems, processes, etc. In this thought stream Boyd develops the case that the pursuit of new science and engineering allows us “to continually rematch our mental/physical orientation with changes” in a changing world. In observing that the process of analysis/synthesis is an inherent and necessary ingredient to both generating novelty and addressing mismatches in the world, Boyd incorporates it in his science and engineering definitions (shown in Figure 18).

Science can be viewed as a self-correcting process of observations, analyses/synthesis, hypothesis, and test

whereas

Engineering can be viewed as a self-correcting process of observation, analyses/synthesis, design, and test.

Figure 18. Science and Engineering excerpt from *A Discourse on Winning and Losing* (1992, p.26)

Boyd returns to the idea of the inevitability of mismatches, that the world continues, "to unfold in an irregular, disorderly, unpredictable manner" (1992, p.29) despite efforts to introduce regularity, order, and predictability. He outlines a series of "features that generate mismatches that, in turn, keep…[the] world uncertain, everchanging, and unpredictable" (1992, p.31). These mismatch features are shown in Figure 19.

THESE FEATURES INCLUDE:

- Uncertainty associated with the unconfinement, undecidability, incompleteness theorems of mathematics and logic.
- Numerical imprecision associated with using the rational and irrational numbers in the calculation and measurement processes.
- Quantum uncertainty associated with Planck's Constant and Heisenberg's Uncertainty Principle.
- Entropy increase associated with the Second Law of Thermodynamics.
- Irregular or erratic behavior associated with far-from-equilibrium, open, nonlinear processes or systems with feedback.
- Incomprehensibility associated with inability to completely screen, filter, or otherwise consider spaghetti-like influences from a plethora of everchanging, erratic, or unknown outside events
- Mutations associated with environmental pressure, replication errors, or unknown influences in molecular and evolutionary biology.
- Ambiguity associated with natural languages as they are used and interact with one another.
- Novelty generated by the thinking and actions or unique individuals and their many-sided interactions with each other.

Figure 19. Mismatch Generation excerpt from *A Discourse on Winning and Losing* (1992, p.32)

Boyd proposes that a continual "conceptual spiral" is the only way to cope with mismatches.

> There is no way out, unless we can eliminate the features just cited. Since we don't know how to do this: we must continue the whirl of reorientation, mismatches, analyses/synthesis over and over again infinitum as a basis to comprehend, shape, and adapt to an unfolding, evolving reality that remains uncertain, everchanging, unpredictable (1992, p.33).

Boyd describes how this conceptual spiral can be a paradigm for fundamental and necessary processes needed for survival and growth in this world. Boyd's description of a conceptual spiral is shown in Figure 20.

If we connect this continuing whirl of reorientation, mismatches, analyses/synthesis and the novelty that arises out of it with the previous discussion we can see that we have:

A
Conceptual Spiral
for

• Exploration	---	Discovery	---	Innovation
• Thinking	---	Doing	---	Achieving
• Learning	---	Unlearning	---	Relearning
• Comprehending	---	Shaping	---	Adapting

hence a
Conceptual Spiral
for generating

• Insight	---	Imagination	---	Initiative

Figure 20. Conceptual Spiral excerpt from *A Discourse on Winning and Losing* (1992, p.34)

Boyd closes *A Discourse on Winning and Losing* with the idea that this conceptual spiral paradigm can be exploited in a competitive world.

> Since survival and growth are directly connected with the uncertain, everchanging, unpredictable world of winning and losing we will exploit this whirling (conceptual) spiral of orientation, mismatches, analyses/synthesis, reorientation, mismatches, analyses/ synthesis…so that we can comprehend, cope with, and shape, as well as be shaped by that world and the novelty that arises out of it (1992, p.38).

The Essence of Winning & Losing (Boyd, 1996)

Boyd's last presentation *The Essence of Winning & Losing* (1996) takes up where *A Discourse on Winning and Losing* (1992) left off, but makes explicit reference to OODA Loops. Boyd relates OODA Loops to his earlier ideas of orientation and analyses/synthesis, saying that OODA Loops enable these processes and make their interactions useful.

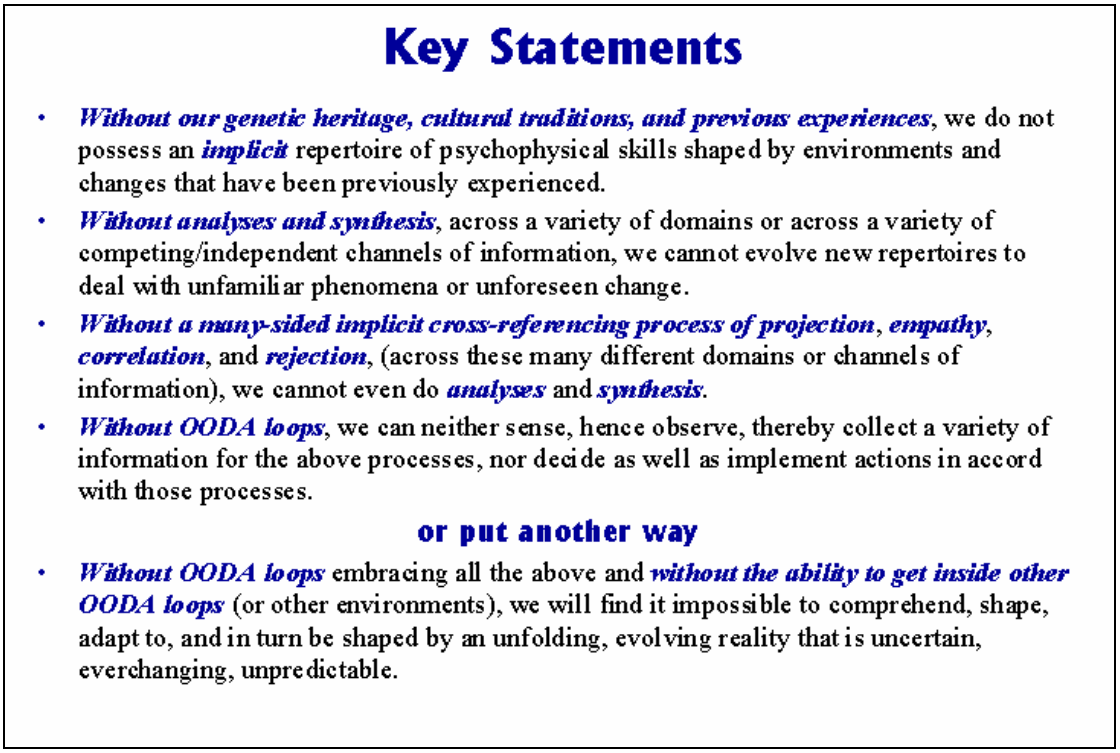


Figure 21. Necessity of OODA Loops excerpt from *The Essence of Winning & Losing* (1996, p.2)

Boyd attempts to “clarify these statements and their interactions” (1996, p.3) by using a sketch shown in Figure 22 on the next page that depicts the complex interdependent interactions occurring within the OODA “Loop”.

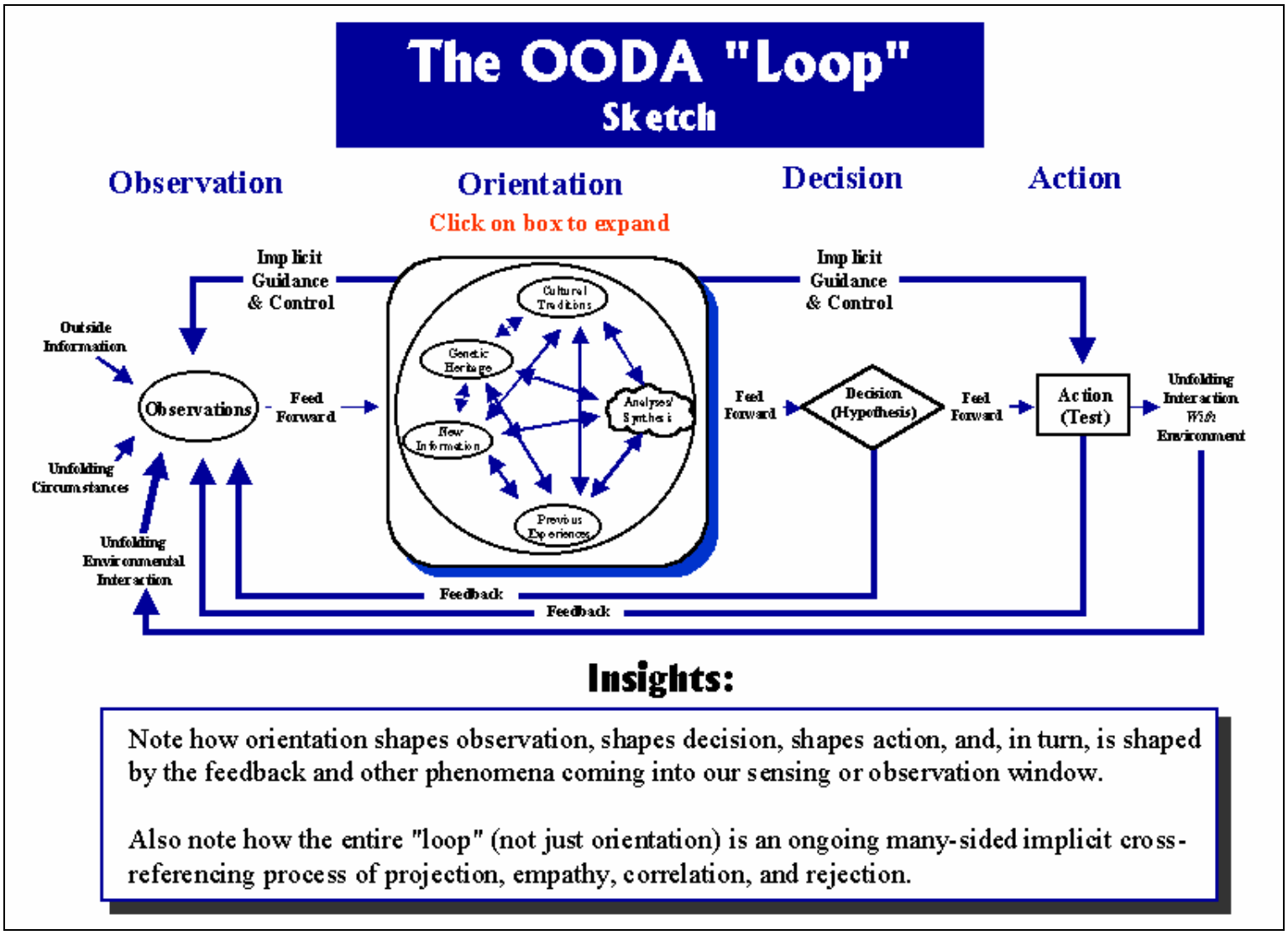


Figure 22. Boyd's OODA Loop Sketch from *The Essence of Winning & Losing* (1996, p.4)

It is worth noting that this multifaceted sketch incorporates Boyd's earlier ideas of mental operations involved in complex orientation, implicit operations (for command and control), dynamic environmental interaction, feedback loops, and relationship to the scientific/engineering process.

Boyd concludes *The Essence of Winning & Losing* repeating earlier statements and stating that the OODA Loop sketch "represent an evolving, open-ended, far-from-equilibrium process of ***self-organization***, ***emergence***, and ***natural selection***" (1996, p.5).

Summary

This chapter has presented the key materials necessary for making an informed assessment of this research's analysis of OODA Loop ideas in the literature as well as their associated diffusion and evolution. The importance of consistent research terminology was discussed and key terms were defined. Diffusion of innovation theory was introduced to explain the backdrop for this research. Finally, a chronological summary of Boyd's works was provided to highlight foundational OODA Loop ideas and establish a baseline from which OODA Loop idea diffusion and evolution assessments can be made. The next chapter will describe the researcher's methodology used to perform this analysis of the OODA literature and arrive at conclusions based on the OODA Loop ideas contained therein.

III. Methodology

General

This chapter explains what data collection, analysis, and display methods were followed to answer the question, "***How have OODA Loop ideas diffused and evolved in the literature since Boyd's original conception?***" In doing so, this study uses qualitative techniques to examine Boyd's original OODA Loop ideas against later OODA Loop ideas using innovation diffusion theory as a guiding framework. The methodology used was specifically designed to answer the researcher's investigative questions:

1. *What are the basic ideas that underpin Boyd's original OODA Loop?*
2. *How have OODA Loop ideas diffused throughout the literature and in what major contexts are they being applied?*
3. *How have OODA Loop ideas evolved over time?*
4. *What kind of a conceptual framework could be used to structure OODA Loop ideas found in the literature?*

Research Design: Qualitative Data Analysis

Research efforts for this study focused on OODA Loop ideas as found within a researcher defined and organized literature. The overall approach was to cast a wide net and capture/identify existing OODA Loop "flavors" and make some sense of them. Since this research attempted to answer "what" and "how" exploratory questions and was focused on the discovery of aspects of complex ideas, a qualitative methodology was used. A qualitative approach allowed the researcher to discover patterns through

observation and analysis of qualitative data; it was a method of discovery rather than explanation (Maykut & Morehouse, 1994).

This thesis research followed the Miles and Huberman (1994) interactive model of qualitative data analysis (see Figure 23). The four steps to this model are data collection, data reduction, data display, and conclusion drawing and verifying.

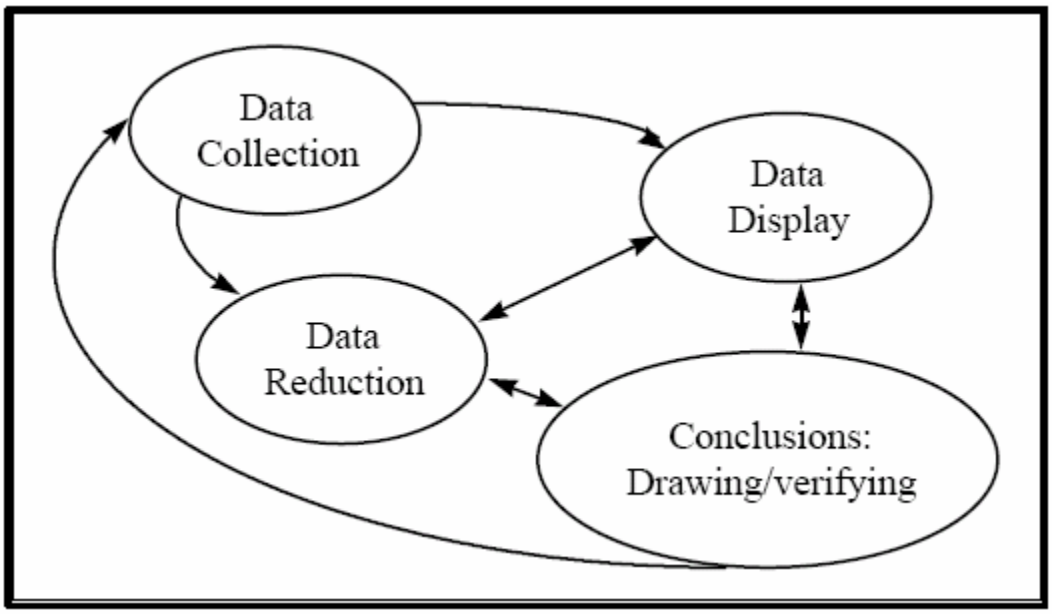


Figure 23. Interactive Model of Data Analysis (Miles & Huberman, 1994)

Data collection was conducted as the researcher collected material concerning innovation diffusion theory, OODA Loop ideas, and related topics. *Data reduction* was used to focus collected material and transform it to usable information (Miles & Huberman, 1994). Literature was coded and categorized according to its idea content and grouped for future analysis. These grouped codes and categories were then organized into a suitable format (*data display*) from which research findings were derived (*conclusion drawing*) and displayed. Conclusions drawn were *verified* against source material, researcher methodology, and external vetting. The above-described steps were

repeated throughout the process of the qualitative data analysis and involved multiple iterative revisions of data collections, reductions, displays, and conclusions. A characteristic of qualitative research is an emergent design, in which data collection and analysis are simultaneous, interactive processes (Miles & Huberman, 1994). This emergent design was evident in this research effort, as repeated and subsequent series of analysis activities were required as the researcher determined appropriate coding and categorization measures, reconfigured displays, and assessed drawn conclusions.

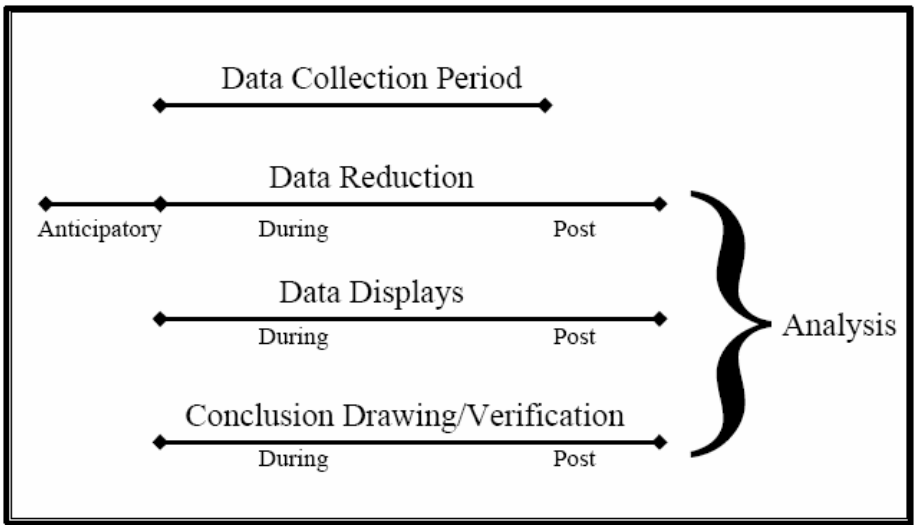


Figure 24. Overlapping Stages of Qualitative Data Analysis (Miles & Huberman, 1994)

Data Collection.

Developing the Focus of Inquiry

The first step to data collection involved defining the focal point and boundary of the matter under study. A research effort has a heart, or focus, and a moderately indeterminate boundary that delineates and steers the investigation (Miles & Huberman, 1994). The area inside the boundary constitutes the setting, concepts, sampling, and other concerns of the study (Miles & Huberman, 1994). In qualitative research with an

emergent design, this model is subject to change as the interactive, iterative activities of data collection and analysis proceed. This research's focus of inquiry was OODA Loop ideas, their diffusion, and their evolution. The only items specified at the beginning of this study were the basic concepts that would be explored—innovations, diffusion, evolution, OODA Loop ideas in the literature —and the notion of some relationship between these concepts. A common way of determining the initial focus of a qualitative study is to draw a cognitive map. A cognitive map displays one's representation of concepts about a particular domain, showing the relationships between them (Miles & Huberman, 1994).

The center cloud in Figure 25 on the next page represents Boyd's original OODA Loop ideas. Over time, that cloud has expanded as Boyd's OODA Loop ideas have diffused and been adopted within the social system of interest (the DoD). During this diffusion and adoption process, there have been new conceptualizations, new characterizations, new utilizations, re-invention, and idea evolution by various adopters. The large outer circle signifies the research bounds for investigative focus. That is, the DoD is the social system of interest for the purposes of analyzing OODA Loop idea diffusion and evolution.

This qualitative analysis focuses on Boyd's ideas as the variables under investigation and studies them under innovation diffusion theory backdrops. Non-military literature documents were collected and considered to promote richness of data and provide a more full analysis, but research focus for OODA Loop idea diffusion and evolution remained confined to within military boundaries.

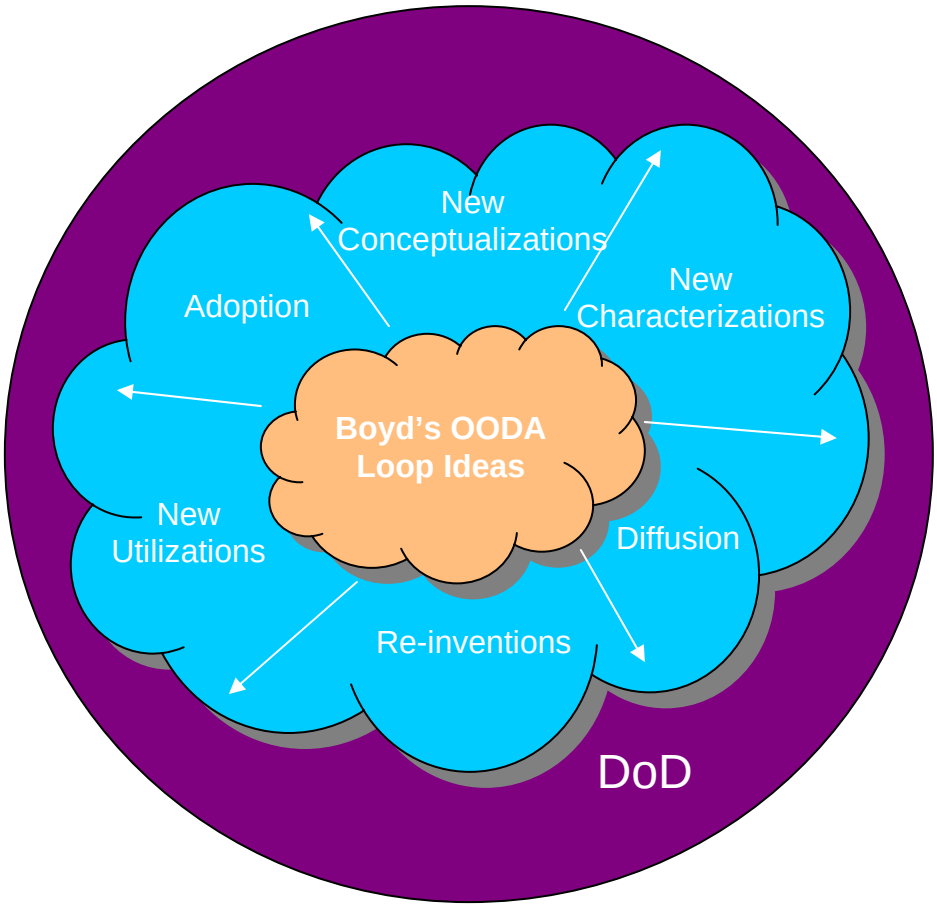


Figure 25. Cognitive Map of Research Concepts and Focus

Defining "OODA Literature" for Analysis

The research scope was focused in order to answer previously mentioned research and investigative questions. Restricting the data sources considered for this analysis was necessary as OODA Loop ideas were present in too many media forums to research them all (i.e. my simple web search of "OODA" using the *Google Search Engine* provided 8,490 hits, an untenably large number for investigation). Obviously, scoping this research in order to facilitate collection, analysis, and completion was warranted. By using nine criteria to define the "OODA Literature", this research focused on

qualitatively analyzing a total of 234 documents. Researcher specified criteria for defining the "OODA literature" is outlined in *Appendix A: Defining the "OODA Literature"*.

OODA Literature Collection Methods

The researcher literature search was conducted using the research tools FirstSearch and EBSCO and the on-line search engine *Google* (www.google.com). Within FirstSearch, academic and business journals, conference proceedings, dissertation databases, and library reference databases were searched. Within EBSCO, the researcher searched academic, scientific, and military databases. The following websites within the .mil domain were also reviewed for materials that pertained to OODA concepts and utilization within the DoD: www.dtic.mil, www.dodccp.org, www.nps.mil, www.au.mil, and https://research.maxwell.af.mil. Searches were conducted using previously specified key words or phrases for the OODA Literature: "OODA"; "Observe" AND "Orient" AND "Decide" AND "Act"; "Observation" AND "Orientation" AND "Decision" AND "Action"; and "Boyd Cycle". Literature searches were conducted periodically during the research effort to capture any recently published information. The researcher practiced the methodology of using any known OODA Literature web site in searches for other OODA Literature. Again, a total of 234 OODA documents were found and used in the course of this research -- 7 from Boyd; 227 from other authors.

Data Reduction.

After every data collection iteration came the process of data reduction which involved "selecting, focusing, simplifying, abstracting, and transforming the raw data" (Miles & Huberman, 1984, p.21). Once OODA literature was collected, it was analyzed

and organized according to its OODA Loop idea content. OODA Loop themes, characteristics, and context of use were continually evaluated by the researcher to form categories designed to capture distinctions in the variety of OODA Loop ideas found in the literature. Each literature article was analyzed for the OODA Loop ideas it contained. These ideas were then categorized according to the theme, characteristic, or context they appeared to support. New categories were created for data that did not fit into pre-existing categories. The determination of idea content, creation of new categories, and categorization of data was a repetitive process performed until the researcher determined all major ideas in the literature sample were accounted for. In addition to categorization by OODA Loop ideas, each document was organized by author and year of publication. All data was recorded within a researcher designed coding matrix that is displayed in *APPENDIX B: Matrix for Qualitative Data Analysis of OODA Loop Ideas*. All OODA Loop ideas were coded and categorized as described below.

Defining Researcher Qualitative Assessments: Coding and Categorization

Each literature article collected was analyzed for its OODA Loop idea content. Each OODA Loop idea identified was coded according to its domain context of the idea (i.e. OODA Loop occurring in human being, technical/computer, both, or indeterminate) and organized within the associated researcher-defined category. Domain coding for OODA Loop ideas was used to provide an indicator of idea evolution (as technical implementations of the OODA Loop are changes from Boyd's original conceptions). Categorization of OODA Loop idea themes was based both on ideas stemming from Boyd's original conceptions and differing "emergent" ideas appearing since Boyd's

original conception. Specific researcher coding and categorization criteria are outlined in *APPENDIX C: Researcher Coding and Categorization*.

Data Display.

The third activity of qualitative analysis is data display, which Miles and Huberman generically describe as "an organized, compressed assembly of information that permits conclusion drawing and action" (1994, p.11). Looking at displays allows researchers to understand what is happening and allow action or further analysis based on that understanding. For this research, two types data displays were prepared. The first type of data display consisted of a matrix used by the researcher to record OODA literature coding and categorization assessments. Design of this display (and its associated coding) utilized data reduction insights described in the earlier section. The second type of data display was prepared to support reader comprehension and emphasize results by providing a visual representation of findings. These displays consist of the tables, graphs, and figures shown in Chapters IV and V.

Conclusion Drawing and Verification.

The final activity involved in qualitative analysis is conclusion drawing and verification. The simultaneous and interactive nature of qualitative analysis allows for broadening or narrowing of the focus of inquiry (what is being studied) in order to include more detailed information or concentrate on specific areas of interest, as necessary (Maykut & Morehouse, 1994; Miles & Huberman, 1994). Data collection, analysis, and theory have reciprocal relationships; in a qualitative approach, the researcher does not begin with a hypothesis or theory and prove it, but rather begins with an area of study and allows the ideas relevant to that area to emerge (Strauss and Corbin,

1990). From the start of data collection, a qualitative analyst is "beginning to decide what things mean—is noting regularities, patterns, explanations, possible configurations, causal flows, and propositions" (Miles & Huberman, 1994, p.11). At first these conclusions are vague, but become increasingly explicit and grounded (Glaser and Strauss, 1967). As conclusions are being tentatively drawn throughout the qualitative analysis, it is important that such conclusions are also *verified* throughout the process as well. As Miles and Huberman put it, "meanings emerging from the data have to be *tested* for their plausibility, their sturdiness, their "confirmability"— that is, their validity" (1994, p.11). Researcher conclusions were continually grounded in the source data or related literature in order to maintain consistency and validity.

For this study, data collection and organization fueled the analysis and findings outlined in Chapter IV. Research design as well as conclusions drawn from the data were tentative at the beginning of the research effort, but became more and more defined as additional research material either supported or weakened researcher premises and hypotheses. Final conclusions from this study included an overall assessment of the diffusion and evolution of OODA Loop ideas, a summary of exhibited OODA ideas, and a synthesized conceptual idea framework to collectively consider them.

Presentation of Analysis

The products of the analysis will be presented in Chapter IV in a manner to reflect answers to the researcher's investigative questions. First, Boyd's OODA Loop ideas presented in Chapter II will be condensed to their fundamentals in an effort to provide an easier reference from which to assess OODA Loop idea diffusion and evolution (i.e. Boyd's initial ideas serve as a starting baseline). Next, OODA Loop idea categories from

the literature will be introduced. OODA Loop idea categories will be determined from Boyd themes and emergent literature content. These categories will be used to present the various OODA Loop ideas found in the literature and analyze their diffusion and evolution. Diffusion of innovation theory will be applied as required to the collective OODA Loop literature and ideas in order to provide an overall holistic assessment of OODA Loop diffusion and evolution trends.

Researcher Framework Construction

The researcher's methodology considers a framework as a frame of reference that describes a complex concept (a construct) in terms of key factors, constructs, or variables and their relationships for the purpose of theory building (Miles & Huberman, 1994). One of the primary outcomes of a qualitative data analysis is using an inductive approach to develop a model or framework that captures key themes and processes judged to be important by the researcher (Thomas, 2003). Such frameworks can be useful because they serve as a guide for identifying, categorizing, and understanding the plethora of ideas, issues, and interrelated components underlying and supporting an unfamiliar complex construct or phenomena. With this in mind, the researcher attempted to use the iterative nature of the data reduction, data display, and conclusion drawing/verification performed in conducting the qualitative data analysis to condense OODA Loop idea themes to their core essences (reoccurring relationships, descriptions, conceptualizations, etc.). It was from these essences that the researcher tried to synthesize an initial exploratory conceptual framework for collectively considering OODA Loop ideas.

Provisions for Research Validity and Reliability

Qualitative studies are difficult to replicate, as they involve evaluation and interpretation of detailed textual information, rather than numerical data suited to quantitative statistical analysis. However, the lack of statistical techniques does not equate to lack of rigor or validity. Some suggested methods for increasing the validity of qualitative research findings include using multiple methods of data collection, building an audit trail, and working with a research team (Maykut & Morehouse, 1994).

This research used various methods of data collection. The majority of data was obtained from online literature and search engines, but some data was collected from hard copy publications and journal articles. In addition, some data collection was achieved in initial searches while other documents were captured by backtracking cited source material. The conceptual map, researcher matrix, and emergent concept framework noted in this research all help to form an audit trail for current and follow-on researchers. This trail is complemented by methodology descriptions outlining researcher collection, reduction, display, and conclusion generating methodology discussed in this chapter. AFIT thesis constraints did not allow true research team collaboration. However, the researcher's thesis committee served as an outside validation source, raising questions about the conclusions drawn and steering the focus of the research. In addition, many researcher conclusions drawn were introduced and discussed with fellow researchers; attention to the diverse viewpoints of over twenty other graduate information resource/systems management students assisted in rooting out unwarranted bias.

The methodology also had provisions for attaining research reliability. In order to facilitate consistent coding reliability, the researcher designed explicit criteria and

definitions for categories used to code data from the literature. The researcher did not use additional coders for research coding and categorization (necessitating the need for inter-coder reliability), but the same aforementioned explicit criteria and definitions would apply. These criteria and definitions are provided in *APPENDIX C: Researcher Coding and Categorization*. Also, the researcher's iterative analysis involved coding and re-coding data as new categories were formed. This iterative coding process and reviews performed during conclusion drawing were used by the researcher as a mechanism for ensuring coding consistency across the literature.

Summary

This chapter discussed the qualitative methodology used to accomplish this research. The next chapter presents the products of the researcher conducted qualitative analysis. It discusses OODA Loop ideas, analyzes their diffusion and evolution, identifies trends and integrates recurring themes expressed in the literature.

IV. Results and Analysis

Introduction

This chapter is focused around answering the researcher's investigative questions. In order to do so, this chapter is divided into three parts. The first part attempts to answer investigative question #1: *What are the basic ideas that underpin Boyd's original OODA Loop?* In this section, the researcher condenses Boyd's ideas and presents "Boyd" idea themes to establish a point of origin for OODA Loop ideas. The second part attempts to answer investigative question #2: *How have OODA Loop ideas diffused throughout the literature and in what major contexts are they being applied?* In this section, the researcher presents "Emergent" OODA Loop idea themes extracted during the course of this research. Both "Boyd" and "Emergent" themes are used to report the major contexts and diffusion end states for OODA Loop ideas captured from an analysis of a sample of the last decade's literature. The third part attempts to answer investigative question #3: *How have OODA Loop ideas evolved over time?* In this section, the researcher constructs an OODA Loop idea timeline to show how OODA Loop themes have changed over time. Additionally, diffusion of innovation theory is used to assess how OODA Loop idea themes have evolved and been re-invented.

Part I: Basic Ideas that Underpin Boyd's OODA Loop

Boyd's original ideas were important to capture in this research as they represent a point of origin benchmark on which assessments of idea diffusion and evolution can be based. Table 4 through Table 10 on the following pages attempt to delineate Boyd's

OODA Loop ideas found within each of his works. The researcher attempted to "chunk" the most important ideas from Boyd's essay and presentations in an effort to provide discrete data points for reference and analysis. This "chunking" of ideas was crucial in providing structure for researcher categorizing efforts made during the qualitative data analysis. The abbreviated entries in the table below are an effort to condense ideas to their fundamentals (and conserve space) and should not be mistaken for an attempt to overly simplify any inherent complexity.

Table 4. Ideas from *Destruction and Creation* (Boyd, 1976a)

Boyd Idea: Basic aim/goal of individuals (and societies) is to improve their capacity for independent action
Boyd Idea: Mental Patterns -- Likens general-to-specific mental operations to deduction to analysis & differentiation; Likens specific-to- general mental operations to induction to synthesis & integration
Boyd Idea: Structuring and unstructuring concepts, domains, paradigms in environment of uncertainty in order to think, make decisions
Boyd Idea: Linking Gödel's incompleteness theorem, Heisenberg's Uncertainty Principle, and the Second Law on entropy -- one cannot determine the nature and character of a system within itself and, furthermore, any attempts to do so will lead to greater disorder and confusion
Boyd Idea: Continual mental operations ("dialectic engine" of "destructive deduction" and "creative induction") unstructure/restructure concepts, deal with uncertainty and disorder (entropy), and allow decision making models for individuals and societies to determine and monitor actions

Table 5. Ideas from *New Conception for Air-to-Air Combat* (Boyd, 1976b)

Boyd Idea: Desirability of high-maneuverability aircraft ("need fighter that can both lose energy and gain energy more quickly while outturning an adversary")
Boyd Idea: Fast Transient Theory -- achieving superiority by operating at a faster tempo than an adversary; "inside our adversaries time scales"; proposed by Boyd as new way of waging war

(cont…)

Ideas from *New Conception for Air-to-Air Combat* (Boyd, 1976b) continued

Boyd Idea: Applying Gödel's incompleteness theorem, Heisenberg's Uncertainty Principle, and the Second Law of Thermodynamics to Fast Transient Theory: faster operations will appear ambiguous and non-predictable to an opponent and will generate confusion and disorder.
Boyd Idea: He who can handle the quickest rate of change survives.

Table 6. Ideas from *Patterns of Conflict* (Boyd, 1986)

Boyd Idea: Observation-Orientation-Decision-Action Loop model. Using faster tempo of operations (Fast Transient Theory) to "get inside adversary's Observation-Orientation-Decision-Action time cycle or loop"
Boyd Idea: Parallel between the "Theory of Evolution by Natural Selection" and "The Conduct of War" – both deal with pursuit of survival and independent action.
Boyd Idea: Using the OODA Loop in combination of variety/rapidity/harmony/initiative (and their interaction) to shape and adapt to an ever-changing environment.
Boyd Idea: Equates getting inside one's OODA loop to getting inside his mind-space-time (their way of thinking).
Boyd Idea: Promotion of "Schwerpunkt" (shared mind-space-time within members of an organization) -- way to "shape focus and direction of effort as well as harmonize support activities with combat operations thereby permit a true decentralization of tactical command within centralized strategic guidance—without losing cohesion of overall effort". (Boyd, 1986, p.78). Heavy emphasis on implicit (or unstated) over explicit communication in order to exploit lower-level initiative yet realize higher-level intent. Way to diminish friction and reduce time (get inside adversary OODA loop).
Boyd Idea: Use of OODA Loop ideas as a basis for "Maneuver Conflict". Use of ambiguity, deception, novelty, fast transient maneuvers, and effort to achieve disorientation, disruption, and overload of an adversary. Generation of "many non-cooperative centers of gravity" to "magnify friction, shatter cohesion, produce paralysis, and bring about his collapse". (Boyd, 1986, p.117)
Boyd Idea: Use of OODA Loop ideas as a basis for "Moral Conflict". Use of negative moral factors (menace, uncertainty, mistrust) to "breed fear, anxiety, and alienation in order to generate many non-cooperative centers of gravity" and "sever moral bonds that permit adversary to exist as an organic whole". Use of positive counterweights (initiative, adaptability, harmony) to combat negative factors and allow build-up of "surface courage, confidence, and spirit, thereby make possible the human interactions needed to create moral bonds that permit us, as an organic whole, to shape and adapt to change." (Boyd, 1986, p.125)

(cont…)

Ideas from *Patterns of Conflict* (Boyd, 1986) continued

Boyd Idea: Systems Thinking -- Couching discussions of individual or organizational conflict, change, and survival within a (shaping or shaped, but dynamic) environment in terms of "organism" or "organic whole".
Boyd Idea: Grand Strategy -- "Shape pursuit of national goal so that we not only amplify our spirit and strength (while undermining and isolating our adversaries) but also influence the uncommitted or potential adversaries so that they are drawn toward our philosophy and are empathetic toward our success." (Boyd, 1986, p.141)
Boyd Idea: Grand Tactics -- ▪ "Operate inside adversary's observation-orientation-decision-action loops, or get inside his mind-time-space, to create tangles of threatening and/or non-threatening events/efforts as well as repeatedly generate mismatches between those events/efforts adversary observes, or imagines, and those we must react to, to survive"; ▪ "Enmesh adversary in an amorphous, menacing, and unpredictable world of uncertainty, doubt, mistrust, confusion, disorder, fear, panic, chaos,…and/or fold adversary back inside himself"; ▪ "Maneuver adversary beyond his moral-mental-physical capacity to adapt or endure so that he can neither divine our intentions nor focus his efforts to cope with the unfolding strategic design or related decisive strokes as they penetrate, splinter, isolate, or envelop, and overwhelm him" (Boyd, 1986, p.141)

Table 7. Ideas from *Organic Design for Command and Control* (Boyd, 1987a)

Boyd Idea: Need for command and control system that emphasizes in <u>implicit</u> human side of operations (instead of just more hardware – sensors/computers/communications/fusion center).
Boyd Idea: Requirements for good command and control system: "We must uncover those <u>interactions</u> that foster harmony and initiative—yet do not destroy variety and rapidity" (1987a, p.9).
Boyd Idea: Description of 'Orientation'. "Orientation <u>is an interactive process</u> of <u>many-sided implicit cross-referencing projections, empathies, correlations, and rejections</u> that is <u>shaped by</u> and <u>shapes</u> the interplay of <u>genetic heritage</u>, <u>cultural tradition</u>, <u>previous experiences</u>, and <u>unfolding circumstances</u>". (1987a, p.15)
Boyd Idea: Importance of Orientation. Orientation shapes way we Observe, Decide, and Act (rest of OODA loop). (1987a, p.16) Orientation is <u>most important part</u> of the OODA Loop. (1987a, p.26)

(cont…)

Ideas from *Organic Design for Command and Control* (Boyd, 1987a) continued

Boyd Idea: Interdependence of Orientation with rest of OODA Loop. Orientation shapes the character of present OODA Loops, while these present OODA loop shape the character of future orientation. (1987a, p.16)
Boyd Idea: Competitive orientations. Importance of making accurate orientations while denying adversaries the ability to do the same. (1987a, p.16)
Boyd Idea: Command and control system that has too much internal focus (cut off from external environment) leads to "confusion and disorder" (1987a, p.20) and "dissolution/disintegration (i.e., system comes unglued)" (1987a, p.21). For same reasons described in *Destruction and Creation* (creation of entropy/disorder/chaos/friction).
Boyd Idea: Use of implicit orientation (bonds, connections, similar understanding between members) for successful Command and Control System. Advocates implicit communications and trust "in order to exploit lower-level initiative yet realize higher-level intent, thereby diminish friction and compress time, hence gain both quickness and security" (1987a, p.18) Advocates continuous interaction of leaders and subordinates with external world and each other to achieve "a similar implicit orientation, needed to form an organic whole" (1987a, p.23)
Boyd Idea: Equivalence of OODA Loop and Command and Control Processes: "Operating inside adversary's O-O-D-A Loop means the same thing as operating inside adversary's C&C loop" (1987a, p.26)
Boyd Idea: Incompatibility of implicit nature of human beings with traditional command and control (i.e. "top-down mentality applied in a rigid or mechanical (or electrical) way" (1987a, p.35)). Substitution of 'Leadership' and 'Appreciation' for 'Command' and 'Control'.
Boyd Idea: Appreciation definition: "refers to the recognition of worth or value, clear perception, understanding, comprehension, discernment, etc." (1987a, p.37) Does not interact or interfere with system. Discerns (but does not shape) character/nature of what is being done or about to be done.
Boyd Idea: Leadership definition: "implies the art of inspiring people to cooperate and enthusiastically take action toward the achievement of uncommon goals" (1987a, p.37). Interacts with system. Shapes the character/nature of system in order to realize what is to be done.

Table 8. Ideas from *The Strategic Game of ? and ?* (Boyd, 1987b)

Boyd Idea: "Snowmobile" illustration: concrete example of how a new creation (synthesis) is predicated and related to the "pulling apart" or deconstruction of world perspectives (via analysis). Uses ideas from *Destruction and Creation* (Boyd, 1976a).

(cont…)

Ideas from *The Strategic Game of ? and ?* (Boyd, 1987b) continued

Boyd Idea: People relate to their world (and each other) in physical, mental, and moral ways. All people are open systems and have to interact (physically, mentally, morally) with their environment (outside world) to get required information, matter, and energy to combat confusion, disorder, chaos, anarchy, etc. and ensure their survival.
Boyd Idea: Theme of isolation and interaction: "Interaction permits vitality and growth while isolation leads to decay and disintegration." (1987b, p.29)
Boyd Idea: *Strategic Game of Interaction and Isolation* -- a "game in which we must be able to diminish adversary's ability to communicate or interact with his environment while sustaining or improving ours" (1987b, p.33). Central theme of achieving strategy is through the use of "interaction/isolation" brought on through "moral-mental-physical means" (1987b, p.58).
Boyd Idea: Physical isolation and interaction. Physically isolate adversary by disrupting their internal communication, severing their connections to the outside world, and separating them from allies or uncommitted. Achieve physical interactions by "opening up and maintaining many channels of information to the outside world" (1987b, p.49)
Boyd Idea: Mental isolation and interaction. Mentally isolate adversary by presenting them with ambiguous, deceptive, or novel situations and/or by operating at a tempo or rhythm they can't appreciate or cope with (i.e. operate inside their OODA Loop). Achieve mental interactions by selecting information from a variety of sources/channels to generate accurate representations of the world we are trying to understand and cope with.
Boyd Idea: Moral isolation and interaction. Adversaries morally isolate themselves when they violate codes of conduct or behave differently then professed norms or outside expectations. Achieve moral interactions by "avoiding mismatches between what we say we are, what we are, and the world we have to deal with" (1987b, p.49) and abiding by cultural codes and standards.
Boyd Idea: Moral leverage – used "to amplify our spirit and strength as well as expose the flaws of competing or adversary systems, all the while influencing the uncommitted, potential adversaries and current adversaries so that they are drawn toward our philosophy and empathetic toward our success" (1987b, p.54)
Boyd Idea: Mechanism of strategic thought --"an instinctive see-saw of analysis and synthesis across a variety of domains, or across competing/independent channels of information, in order to spontaneously generate new mental images or impressions that match-up with an unfolding world of uncertainty and change" (1987b, p.58)

Table 9. Ideas from *A Discourse on Winning and Losing* (Boyd, 1992)

Boyd Idea: Simplified view of science as a "self-correcting process of observations, analyses/synthesis, hypothesis, and test" and engineering as "a self-correcting process of observations, analyses/synthesis, design, and test" (1992, p.26).
Boyd Idea: Ideas on theoretical systems. Intellectual or physical systems can only render "reality" in imperfect and incomplete ways. Inability to create "supersystem" to predict systems of the future or the consequences that flow from these later systems. Inability to discern nature of system within itself. (1992, p.14)
Boyd Idea: "Science, engineering, and technology produce change via novelty" -- "new ideas, new systems, new processes, new materials, new etc." (1992:20). Novelty creation as a process of "analytic/synthetic feedback loop for comprehending, shaping and adapting to the to…world" (1992, p.21)
Boyd Idea: Constant presence and production of "mismatches". Mismatches help to sustain and nourish pursuit of science, engineering, and technology as these pursuits allow us "to continually rematch our mental/physical orientation with changes" in a changing world. Mismatches keep the world "uncertain, everchanging, and unpredictable" (1992, p.31)
Boyd Idea: Sources for mismatches: Uncertainty, Numerical imprecision, Quantum uncertainty, Entropy increase, Irregular or erratic behavior, Incomprehensibility, Mutations, Ambiguity, and Novelty. (1992, p.32)
Boyd Idea: Continual "conceptual spiral" is only way to cope with mismatches: "we must continue the whirl of reorientation, mismatches, analyses/synthesis over and over again infinitum as a basis to comprehend, shape, and adapt to an unfolding, evolving reality that remains uncertain, everchanging, unpredictable." (1992, p.33). Conceptual spiral capable of generating insight, imagination, and initiative (1992, p.34).
Boyd Idea: Conceptual spiral paradigm can be exploited in a competitive world to "comprehend, cope with, and shape, as well as be shaped by… [the] world and the novelty that arises out of it." (1992, p.38)

Table 10. Ideas from *The Essence of Winning and Losing* (Boyd, 1996)

Boyd Idea: Previous experience and environmental factors (cultural traditions and genetic heritage) make up our implicit repertoire of psychophysical skills (part of Orientation).
Boyd Idea: Process of analyses/synthesis using various, competing channels of information (from Observations) allows creation of new ways to deal with unfamiliar or unforeseen (part of Orientation).

(cont….)

Ideas from *The Essence of Winning and Losing* (Boyd, 1996) continued

Boyd Idea: OODA Loops needed to process (conceptual spiral) and make use of above processes.
Boyd Idea: OODA Loop (mental operations) involves getting inside other OODA Loops and/or environments to "comprehend, shape, adapt to, and in turn be shaped by an unfolding, evolving reality that is uncertain, everchanging, unpredictable" (1996, p.2)
Boyd Idea: OODA "Loop" sketch. Incorporates Boyd's earlier ideas of mental operations involved in complex orientation, implicit operations (for command and control), dynamic environmental interaction, feedback loops, and relationship to the scientific/engineering process. (1996, p.4)
Boyd Idea: Orientation shapes Observations, Decisions, and Actions and is in turn shaped by new Observation feedback. (1996, p.4)
Boyd Idea: Entire OODA loop (not just Orientation) is "an ongoing many-sided implicit cross-referencing process of projection, empathy, correlation, and rejection" (1996, p.4)
Boyd Idea: OODA Loop paradigm represents "an evolving, open-ended, far-from-equilibrium process of ***self-organization***, ***emergence***, and ***natural selection***" (1996, p.5)

"Boyd" OODA Loop Idea Themes.

Once Boyd's basic ideas were identified (above), they needed to be shaped into discrete themes that the OODA Loop literature could be judged against and categorized into. From Boyd's ideas listed in Table 4 through Table 10, the researcher determined reoccurring themes, relationships, and contexts and constructed 16 categories for assessing Boyd's OODA Loop ideas in the literature:

1. **Conceptual Spiral** – This category was designed to capture literature references to the OODA Loop as a mental process or the way by which a person makes sense of their reality (i.e. one's "mind-space-time" or the "dialectic engine" described in *Destruction and Creation* (Boyd, 1976a)).

2. **Gödel's Incompleteness Theorem, Heisenberg's Uncertainty Principle, and the Second Law on Entropy** – This category was designed to capture explicit references to Boyd's integration of these three theories (i.e. one cannot determine the nature and character of a system within itself and, furthermore, any attempts to do so will lead to greater disorder and confusion).

3. **Competition** – It is an understatement to say that competition is highly prevalent in Boyd's work. This category was designed to assess whether OODA Loop usage in the literature was used in a competitive context (i.e. whether OODA Loops were being used to defeat an opponent, outmaneuver an adversary, etc.).

4. **Fast Transient Theory** – This category was designed to capture OODA Loop literature references in which superiority was achieved by operating at a faster tempo and/or by changing faster than an opponent. The key word here is "faster".

5. **Success Factors -** This category was designed to capture explicit references to specific factors that Boyd said were critical to achieving success in conflict. According to Boyd, success factors in conflict involved the proper combination of *variety*, *rapidity*, *harmony*, and *initiative.*

6. **Emphasis on Human Aspects –** Boyd was a big believer in "Humans first, ideas second, things third" (Hammond, 2000). This category was designed to capture literature references that denoted Boyd's focus on the importance of implicit communications and shared mindset in conducting operations, "Schwerpunkt", trust, common experience/training, and/or commander's intent.

7. **Maneuver Conflict** - This category was designed to capture explicit literature references to the OODA Loop as used in maneuver conflict.

8. **Moral Conflict –** This category was designed to capture explicit literature references to the OODA Loop as used in moral conflict or 4th Generation warfare.

9. **Systems Thinking –** Boyd made many references to theoretical systems and couched much of his theories in systems terms (i.e. "organic whole", "overload the system", etc.). This category was designed to capture "systems" literature references. References could be made to physical, mental, or moral systems.

10. **Interaction and Isolation –** A recurring theme (focused on exclusively in *The Strategic Game of ? and ?)* in Boyd's work is interaction and isolation: "Interaction permits vitality and growth while isolation leads to decay and disintegration." (1987b, p.29). This category was designed to capture "interaction/isolation" literature references as pertaining to OODA Loop use. References could be made to physical, mental, or moral interaction or isolation.

11. **Orientation –** Boyd considered orientation the most important part of the OODA Loop process as it affects observations, decisions, and actions. According to Boyd, **"**Orientation is an interactive process of many-sided implicit cross-referencing projections, empathies, correlations, and rejections that is shaped by and shapes the interplay of genetic heritage, cultural tradition, previous experiences, and unfolding circumstances". (Boyd, 1987a, p.15) This category was designed to capture literature

emphasis on "orientation" themes (more than describing orientation as being a phase in the OODA Loop).

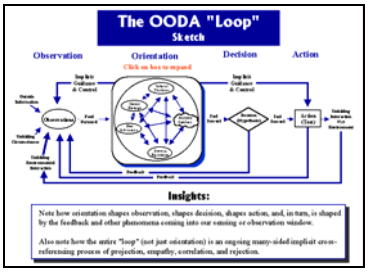
12. **Command and Control** – Boyd describes the OODA Loop as a Command and Control loop. "Operating inside adversary's O-O-D-A Loop means the same thing as operating inside adversary's C&C loop" (1987a, p.26). This category was designed to capture explicit literature references to the OODA Loop as being a command and control process.

13. **Decision Making –** This category was designed to capture explicit literature references to the OODA Loop as being a decision making process.

14. **Information Processing** – Boyd makes references to entropy and information channels in his description of the OODA Loop. This category was designed to capture explicit literature references to the OODA Loop as being associated with information processing.

15. **Scientific/Engineering Process** – Within *A Discourse on Winning and Losing* (Boyd, 1992), Boyd compares the OODA Loop to a scientific or engineering process (recurring cycle of observations, analyses/synthesis, hypothesis/design, and testing). This category was designed to capture similar literature references denoting process improvement or problem solving related to the OODA Loop in this vein.

16. **OODA Loop "Sketch"** – Boyd's OODA Loop "Sketch" in *The Essence of Winning and Losing* (Boyd, 1996) was his last rendering of his OODA Loop ideas. This category was used to capture explicit references to Boyd's OODA Loop "Sketch" in order to assess how it has diffused and been adopted.



(See Figure 22 in Chapter II for larger version).

Part II: Diffusion of OODA Loop Ideas in the Literature

In this section, Boyd's OODA Loop ideas from the previous section as well as other emergent OODA Loop ideas found in the literature from the last decade will be used to answer the question: *How have OODA Loop ideas diffused throughout the literature and in*

what major contexts are they being applied? In keeping with the research methodology, "Boyd" and "Emergent" OODA Loop idea themes extracted during the course of the qualitative data analysis were used to construct categories for research and constitute the major contexts and diffusion end states for OODA Loop ideas in the literature.

"Emergent" OODA Loop Idea Themes.

The researcher identified 11 new (different from Boyd) OODA Loop idea themes that emerged during the course of the research of the OODA literature. These new idea themes were used to create additional categories for the qualitative data analysis. These emergent themes can be considered OODA Loop idea evolutions since they were not involved in Boyd's original conceptions. The below "emergent" OODA Loop idea themes were deemed by the researcher as warranting their own categories:

17. **C4ISR Architecture** – Various literatures referred to OODA Loops as describing functions of computer and communications hardware as part of a C4ISR systems architecture (i.e. computer networks, system of systems, Global Grid, cyberspace, etc.). This category is designed to capture architecture references of this sort.

18. **Operations Cycles** – This category was created to capture OODA Loop references to reoccurring operating cycles (i.e Air Tasking Order cycle, Intelligence cycle, etc.). These cycles of activity are relating to the observation, orientation, decision, and action phases of the OODA Loop and described as taking various amounts of time to complete a cycle (at tactical, operational, and strategic levels).

19. **Military Strategy/Doctrine –** This category was used to document OODA Loop use in warfighting strategies (besides maneuver warfare – already captured in category #7) (i.e. strategic paralysis, information warfare, network-centric warfare, etc.) or literature references to OODA Loops found in official doctrine.

20. **Data Fusion –** This category was used to capture OODA Loop use in work concerning data fusion.

21. **Intelligent Agents –** This category was used to capture OODA Loop use in work concerning intelligent agents, artificial intelligence, autonomous agents, etc. OODA Loop use had to pertain to computer software (non-human) references.

22. **Cognitive Engineering** – This category was used to capture OODA Loop use pertaining to breaking down specific cognitive functions (i.e situational awareness, perception, etc.).

23. **OODA Loop linked to Data, Information, Knowledge, and Wisdom hierarchy –** This category was used to capture literature references to the OODA Loop as relating to the information hierarchy, epistemology, knowledge management, information engineering, and related topics.

24. **Control/Feedback Loops –** This category was used to capture explicit literature references to the OODA Loop as "control loops" or "feedback loops".

25. **Entity Modeling –** This category was designed to capture adopters using the OODA Loop to model behavior of individual or organizational entities.

26. **Complex Adaptive Systems** – This category was designed to capture literature references or comparisons of the OODA Loop to complex adaptive systems.

27. **OODA Loop occurring in Cognitive, Information, and Physical Domains** – This category was used to capture explicit literature references to the OODA Loop occurring in all three of these domains.

Results of Idea Theme Diffusion.

In order to determine the state of diffusion of OODA Loop ideas in the literature from the last decade, the researcher used the above 27 categories in performing research qualitative data analysis assessment. The researcher used non-Boyd literature exclusively in order to determine and evaluate the end states of OODA Loop ideas diffusion. These end states can be used to answer the question, "*How have OODA Loop ideas diffused throughout the literature and in what major contexts are they being applied*?" Table 11 on the following page shows the results of researcher qualitative data analysis incorporating coding and categorization schemes to non-Boyd OODA Literature. Table 11 also rank orders the categories from occurring most often to occurring least often in the literature. For each of the OODA Loop idea themes, an instance count and percentage is provided out of the total

OODA Loop literature sampled. Additionally, these counts and percentages are divided according to their domain (i.e. “human OODA”, “computer/technical OODA”, both, indeterminate/generic reference) use in the literature. (As described in the research methodology, identifying these OODA Loop domains assisted the researcher in assessing OODA Loop idea evolutions). The domain with the highest count and percentage per category is highlighted for emphasis.

Table 11. Overall Result of Qualitative Data Analysis by Category and Code

OODA Loop Idea Theme/ Analysis Category	Boyd or Emergent	Count (# of findings)	% Of Total Sample	Rank By Count	Count / Percent by Domain Context			
					Human	Tech / Comp.	Both	Indeterm.
Competition	Boyd	165	74%	**1**	163 / 98%	1 / 1%	1 / 1%	0 / 0%
Fast Transient	Boyd	135	60%	**2**	130 / 96%	1 / 1%	4 / 3%	0 / 0%
Decision Making	Boyd	125	56%	**3**	122 / 98%	2 / 2%	1 / 1%	0 / 0%
Conceptual Spiral	Boyd	115	51%	**4**	113 / 98%	0 / 0%	2 / 2%	0 / 0%
Information Processing	Boyd	114	51%	**5**	48 / 42%	12 / 10%	51 / 45%	3 / 3%
Operations Cycles	Emergent	90	40%	**6**	71 / 79%	5 / 6%	14 / 15%	0 / 0%
Command & Control	Boyd	83	37%	**7**	80 / 96%	2 / 2%	1 / 1%	0 / 0%
C4ISR Architecture	Emergent	67	30%	**8**	0 / 0%	15 / 22%	52 / 78%	0 / 0%
Military Strategy	Emergent	67	30%	**8**	59 / 88%	2 / 3%	6 / 9%	0 / 0%
Systems Thinking	Boyd	64	29%	**10**	58 / 91%	3 / 5%	2 / 3%	1 / 1%
Interaction / Isolation	Boyd	54	24%	**11**	42 / 78%	7 / 13%	4 / 7%	1 / 2%
Orientation	Boyd	41	18%	**12**	40 / 98%	0 / 0%	0 / 0%	1 / 2%
Maneuver	Boyd	38	17%	**13**	30 / 79%	1 / 3%	0 / 0%	7 / 18%
Human Aspects	Boyd	30	13%	**14**	30 / 100%	0 / 0%	0 / 0%	0 / 0%
Cognitive Engineering	Emergent	28	13%	**15**	23 / 82%	1 / 4%	4 / 14%	0 / 0%
Data Fusion	Emergent	26	12%	**16**	1 / 4%	21 / 81%	3 / 11%	1 / 4%
Data / Info / Knowledge	Emergent	25	11%	**17**	19 / 76%	3 / 12%	2 / 8%	1 / 4%
Intelligent Agents	Emergent	22	10%	**18**	1 / 5%	21 / 95%	0 / 0%	0 / 0%
Control / Feedback	Emergent	22	10%	**18**	12 / 54%	5 / 23%	2 / 9%	3 / 14%
Success Factors	Boyd	18	8%	**20**	18 / 100%	0 / 0%	0 / 0%	0 / 0%
Entity Modeling	Emergent	18	8%	**20**	4 / 22%	11 / 61%	0 / 0%	3 / 17%
Science & Engr Process	Boyd	15	7%	**22**	15 / 100%	0 / 0%	0 / 0%	0 / 0%
Moral Conflict	Boyd	14	6%	**23**	14 / 100%	0 / 0%	0 / 0%	0 / 0%
Complex Adaptive Systems	Emergent	13	6%	**24**	7 / 54%	4 / 30%	1 / 8%	1 / 8%
OODA Loop “Sketch”	Boyd	11	5%	**25**	10 / 91%	0 / 0%	0 / 0%	1 / 9%
Gödel Integration	Boyd	8	4%	**26**	8 / 100%	0 / 0%	0 / 0%	0 / 0%
Cognitive, Info, and Physical Domains	Emergent	6	3%	**27**	3 / 50%	0 / 0%	3 / 50%	0 / 0%

Researcher note: For each category, domain with highest count and percentage is highlighted for emphasis.

Observed OODA Loop Idea Diffusion Trends.

OODA Loop Idea Trend: Wide Variety/Distribution of OODA Loop Ideas

One trend that is evident is that there are a lot of different OODA Loop ideas. Of the 27 categories analyzed by the researcher, only the top 5 (Competition, Fast Transients, Decision Making, Conceptual Spiral, and Information Processing) had over 50% of the literature consistently exhibiting the specified attribute. This is displayed in the data as well. The matrix (in Appendix B) used to collect the coded data looks like the blast from a shotgun, with data spread far and wide. This diversity is a tribute to the versatility of the OODA Loop construct which various adopters use and describe in vastly different (and sometimes contradictory) ways. Different adopters are using OODA Loops differently.

Observed Diffusion Trends in the Literature.

In accordance with the qualitative data analysis methodology outlined in Chapter III, 224 OODA literature documents were identified, analyzed, coded, and categorized. Documentation of the results of the analysis can be found in *APPENDIX B: Matrix for Qualitative Data Analysis of OODA Loop Ideas*. The OODA literature breakout by year, number of documents per year, and types of documents is shown in and is reflected in Figure 26 and Figure 27.

Table 12. Breakout of the OODA Literature by Year

Year	# of Documents	Document Breakout
Boyd (1976 x 2, 1986, 1987 x 2, 1992, 1996)	**7 documents**	1 paper, 6 presentations
1992	**3 documents**	2 papers, 1 book
1993	**3 documents**	2 papers, 1 book
1994	**5 documents**	2 papers, 1 book chapter, 1 journal article, 1 thesis
1995	**11 documents**	3 papers, 1 book, 1 journal article, 1 doctrine reference, 1 presentation, 2 thesis, 1 project, 1 speech
1996	**21 documents**	16 papers, 3 doctrine references, 1 presentation, 1 thesis
1997	**16 documents**	6 papers, 1 journal article, 1 magazine article, 1 doctrine reference, 1 presentation, 5 thesis, 1 project
1998	**16 documents**	10 papers, 1 journal article, 1 doctrine references, 2 thesis, 2 web commentary
1999	**23 documents**	11 papers, 1 book, 2 journal articles, 4 doctrine references, 2 thesis, 3 web commentary
2000	**33 documents**	25 papers, 1 doctrine reference, 1 presentation, 4 thesis, 2 web commentary
2001	**32 documents**	23 papers, 2 books, 1 magazine article, 2 doctrine references, 1 presentation, 2 web commentary, 1 speech
2002	**32 documents**	16 papers, 3 books, 3 journal articles, 2 doctrine references, 4 presentations, 2 thesis, 2 web commentary
2003	**29 documents**	10 papers, 3 journal articles, 1 magazine article, 3 doctrine references, 6 presentations, 6 web commentary

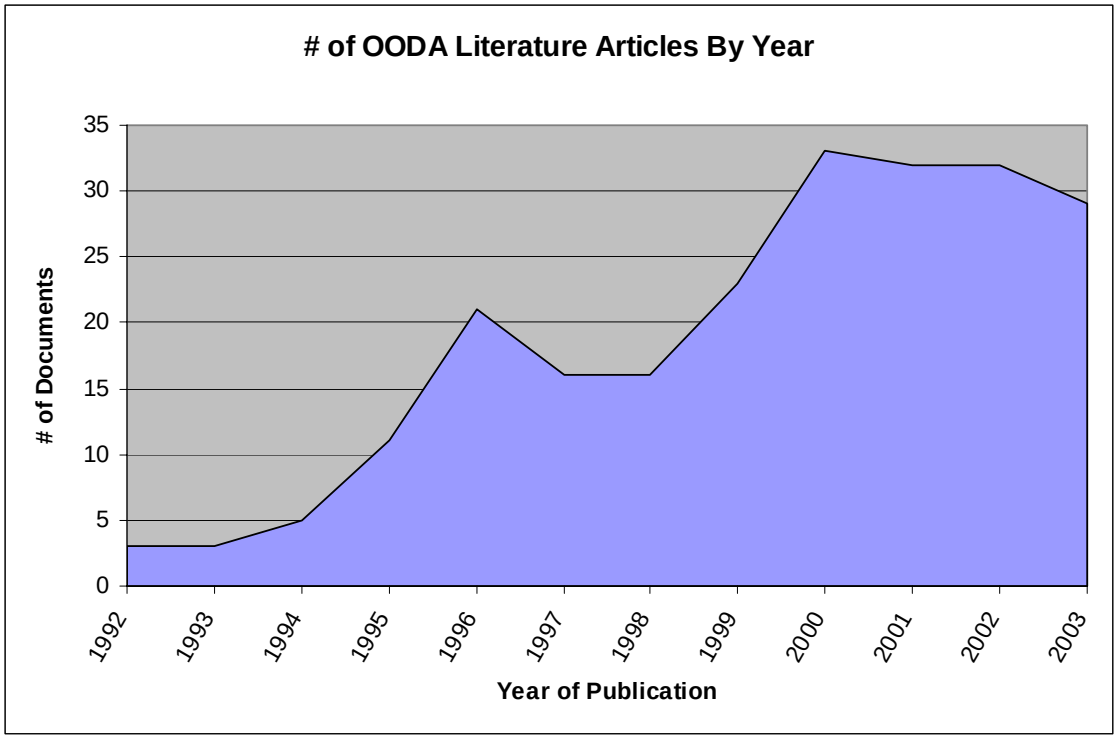


Figure 26. Number of OODA-related Documents Captured in Qualitative Data Analysis

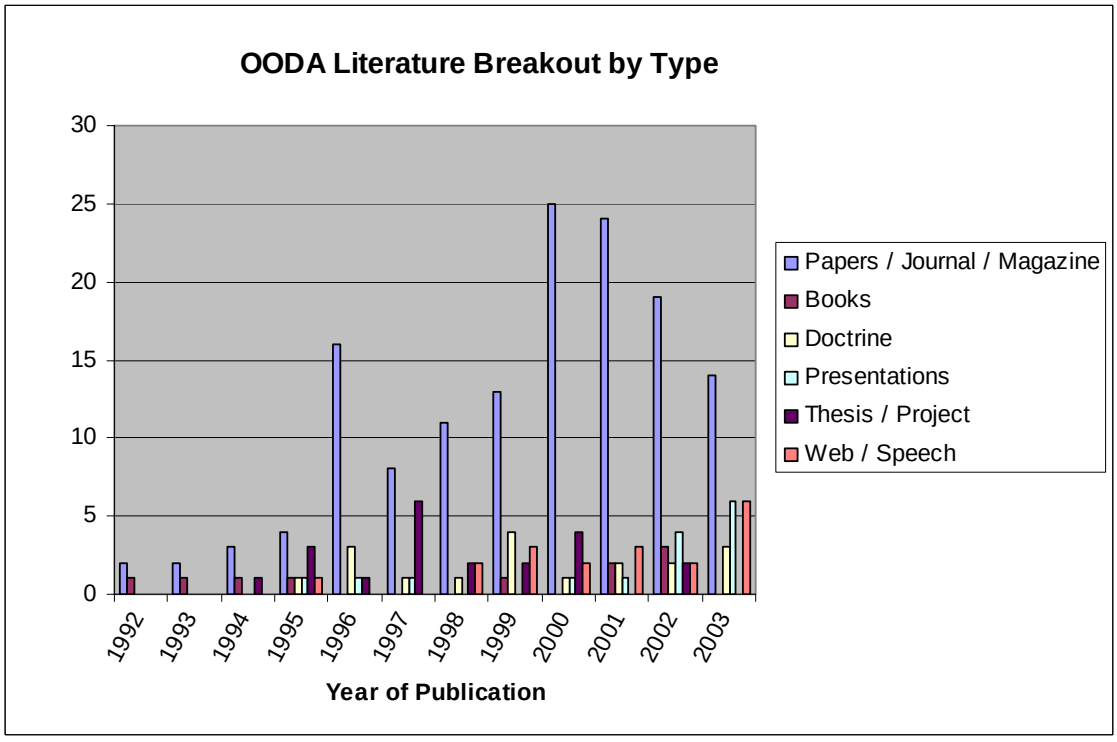


Figure 27. Literature Broken Down by Number of Document Type Per Year

Literature Trend: Increase in OODA Literature Over Time

One observed trend was that the amount of captured OODA literature per year tended to increase over time. A possible explanation for this trend could come from the effects of diffusion of innovation. For example, the spike in 1996 can be partly explained by a conference (Air Force 2025) where participants were encouraged submit papers concerning future Air Force direction. This conference alone was responsible for eight papers containing OODA Loop references. The literature increase in the last decade could be indicative that OODA Loop ideas are in the very beginnings of a diffusion of innovation S-curve.

An alternate explanation for the increase in literature over time could come from the method of literature capture. At the beginning of the decade, the Internet explosion was just beginning. Publications made in the early part of the decade might not necessarily be found on the web. Also, by design, the Google search engine tends to prioritize more recent publications over older ones. However, this rationale for literature increases does not seem to be supported. As a reminder, the research made use of the methodology practice of "reachback", that is, backtracking any OODA Loop references in identified literature. If there were a lot of publications in the early 1990s containing OODA Loop references, then they should have been found via backtracking references from the mid-1990s. This did not occur often during the course of this research. However, there were instances when "reachback" found pre-1992 literature (that could not be incorporated due to set research boundaries). So, by some means, this methodology appeared to be effective in finding relevant literature. The data supports the

claim that the last decade has seen a great increase in interest and/or adoption of OODA Loop ideas as evidenced by references in the literature.

Literature Trend: Incorporation of OODA Loop Ideas into Military Doctrine

Another observed trend is the steady and continuing use and adoption of OODA Loop ideas in "doctrine" publications. Doctrinal publications are viewed by the researcher to include official military doctrine documents, publications from official government warfighting concept development agencies, official military training materials, and reports to Congress. In each of the last nine years, OODA Loop ideas have been incorporated into at least one new military doctrine publication. In the last five years, the average is a little over twice that. OODA Loop idea incorporation occurred in joint and all service doctrines. Table 13 on the following page displays some doctrinal work that reflects the influence of OODA Loop idea adoption.

Table 13. Doctrinal Publications Reflecting OODA Loop Ideas

Doctrine Publication	Year	Support Reference
Army Field Manual (FM), 100-5 (*Operations*)	1986	
Marine Corps Fleet Marine Force Manual Number 1 (*Warfighting*)	1989	
Air Force Manual 1–1 (Essay C: Human Factors in War)	1992	(Schechtman, 1996)
Cornerstones of Information Warfare (Intro by CSAF Fogleman and SECAF Widnall)	1995	
Navy Doctrine Publication 6 (*Command and Control*)	1995	(Polk, 1999)
Army Field Manual 100-6 (*Information Operations*)	1996	
Joint Publication 3-13.1 (*Joint Doctrine for Command and Control Warfare (C2W))*	1996	
Marine Corps Doctrinal Publication (MCDP 6) (*Command and Control*)	1996	
Concept for Future Joint Operations -- Expanding Joint Vision 2010	1997	
Air Force Doctrine Document 2-1.2 (*Strategic Attack*)	1998	(Tighe, 1999)
Air Force Doctrine Document 2-5 (*Information Operations*)	1998	
Network Centric Warfare -- Developing and Leveraging Information Superiority (from DoD C4ISR Cooperative Research Program)	1999	(Alberts, 1999)
Defense Science Board Summer Study Task Force on 21st Century Defense Technology Strategies	1999	
Air Force Doctrine Document 2-5.3 (*Psychological Operations*)	1999	
A Concept Framework for Joint Interactive Planning (Draft from USACOM J-92 Concepts Division)	1999	(Weir, 1999)
Enabling the Joint Vision	2000	
Understanding Information Age Warfare (from DoD C4ISR Cooperative Research Program)	2001	(Alberts, 2001)
Protecting the Homeland -- Report of the Defense Science Board Task Force on Defensive Information Operations	2001	
Network Centric Warfare -- Department of Defense Report to Congress	2001	
Network Centric Warfare (Presentation from DoD C4ISR Cooperative Research Program)	2002	(Garstka, 2002)
Effects Based Operations -- Applying Network Centric Warfare in Peace, Crisis, and War (from DoD C4ISR Cooperative Research Program)	2002	(Smith, 2002)
Army Field Manual (FM 6-0) *(Mission Command: Command and Control of Army Forces)*	2003	
Air Force Information Operations Basics Course	2003	
Making the Joint Vision Happen	2003	(Money, 2003)

In closing the discussion of observed literature trends, one might notice that there is a slight dip in OODA Loop literature in the last two years. This can be partially attributed to researcher constraints. OODA Loop literature was mostly collected in the first half of 2003 in order to meet research schedules, so it is possible that OODA Loop literature that was introduced in mid-to-late 2003 was not included.

Summary of OODA Loop Idea Diffusion.

OODA Loop ideas adoption and diffusion appears to have increased in the last decade, as indicated through a qualitative data analysis of 224 OODA literature documents. OODA Loop ideas have steadily been incorporated into military doctrine, especially in the areas of maneuver warfare, command and control, decision-making, and fast transients. The OODA Loop is also playing a prominent role in new and developing warfare strategies such as information warfare, network centric warfare, and effects based operations. In addition, there is evidence that the military is using the OODA Loop in all of the contexts found in Table 14 and Table 15 below.

Table 14. Boyd's OODA Loop Idea Themes

Boyd OODA Idea Theme	**Examples**
Conceptual Spiral	Mind-time-space; dialectic engine; target for information warfare
Integration of Gödel's Incompleteness Theorem, Heisenberg's Uncertainty Principle, and the Second Law on Entropy	"One cannot determine the nature and character of a system within itself and, furthermore, any attempts to do so will lead to greater disorder and confusion"; warfare strategies to isolate or turn adversary inward to cause confusion, friction, paralysis, etc.
Competition	Survival; warfare; life
Fast Transient Theory	Getting inside adversary decision loop
Success Factors	*Variety, rapidity, harmony, and initiative*

(cont…)

Table 14. Boyd's OODA Loop Idea Themes continued

Emphasis on Human Aspects in Warfare	Implicit communications; shared mindset; "Schwerpunkt"; trust; common experience and training; commander's intent
Maneuver Conflict	Definition for maneuver conflict
Moral Conflict	Win "hearts and minds"; 4th generation warfare
Systems Thinking	"Organic whole"; "overload the system"; open and closed systems; physical, mental, or moral systems (all three in warfare)
Interaction and Isolation	Physical, mental, & moral interaction or isolation (isolate enemy and maintain own interactions)
Orientation	"Interactive process of many-sided implicit cross-referencing projections, empathies, correlations, and rejections that is shaped by and shapes the interplay of genetic heritage, cultural tradition, previous experiences, and unfolding circumstances" (Boyd, 1987a); target of information warfare; sensemaking in warfare
Command and Control Loop	Command and control process
Decision Making	Decision loop; decision cycle; decision superiority
Information Processing	Cycle of entropy; channels of information; information superiority
Science & Engineering Process	Cycle of observations, analyses/synthesis, hypothesis/design, and testing
OODA Loop "Sketch"	*The Essence of Winning and Losing* (Boyd, 1996)

OODA Loop ideas have changed or re-invented over time by various adopters. Adopters have found the OODA Loop broadly applicable, and thus useful, in a various mission areas. Figure 15 on the next page shows some of the various ways the military is using OODA Loop ideas in different contexts.

Table 15. Emergent OODA Loop Idea Themes

Emergent OODA Idea Theme	Examples
C4ISR Architecture	System of systems; global grid; cyberspace
Operations Cycles	ATO cycle; intelligence cycle
Military Strategy/Doctrine	Information warfare; network centric warfare; effects based operations
Data Fusion	Sensor integration; system integration
Intelligent Agents	Software agents; autonomous systems
Cognitive Engineering	Situational awareness; perception; PSYOPS; information warfare
Linked to Data, Information, Knowledge, and Wisdom hierarchy	Epistemology; knowledge management
Control/Feedback Loops	Control systems; cybernetics
Entity Modeling	Simulations of individuals & nation state
Complex Adaptive Systems	Self-organizing, learning, intelligent entities
Occurring in Cognitive, Information, and Physical Domains	OODA Loops in all three domains; information/communication between domains

The next section will discuss how the emergent themes from Table 15 constitute evolution in Boyd's OODA Loop ideas.

Part III: Evolution of OODA Loop Ideas in the Literature

This section will attempt to assess the investigative question, *"How have OODA Loop ideas evolved over time?"* In this section, the researcher constructs an OODA Loop idea timeline to show how OODA Loop themes have changed over time. Additionally, diffusion of innovation theory is used to assess how OODA Loop idea themes to assess the way they have evolved and been re-invented.

OODA Loop Idea Evolution Timeline.

As a way of providing an overall assessment of OODA Loop ideas in the literature and how they have changed in their diffusion over time, the research has

constructed an OODA Loop diffusion timeline. The timeline (shown in Figure 28 on the next page) displays the previously described “Boyd” and “emergent” OODA Loop idea themes in relation to the year at which they show up in the literature (beginning of the idea theme lines up with approximate position on the timeline).

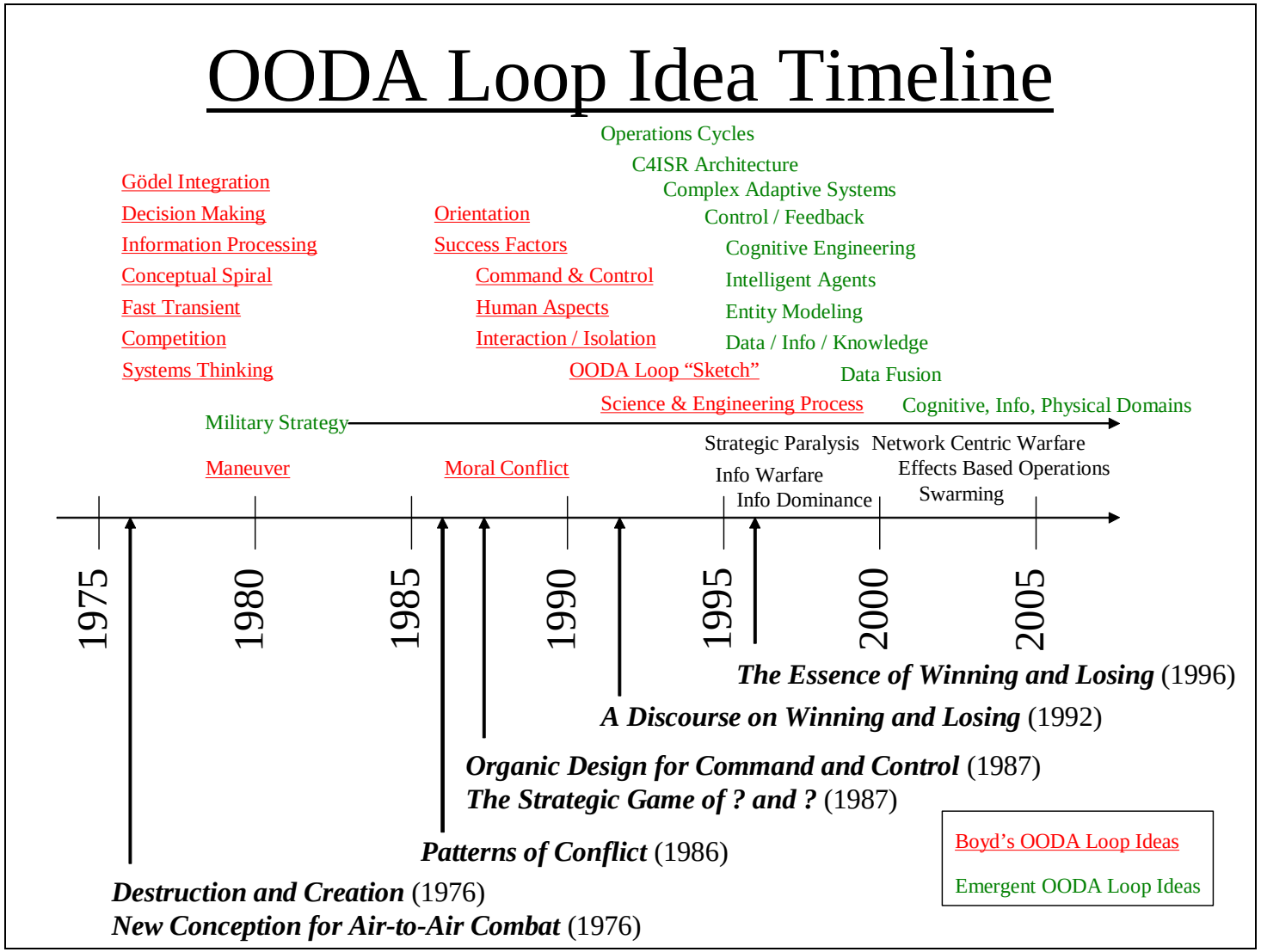


Figure 28. OODA Loop Idea Timeline

This timeline rendering can relay some idea about order of idea theme diffusion (which idea appeared first, second, etc.) and the progression of evolution. The timeline shows frequent emergence of OODA Loop ideas since 1992, occurring most frequently in 1995-1996.

OODA Loop Idea Trend: Increasing Use of Ideas in Technical Contexts

Another observed trend that is evident is that in more recent years (the last half of the decade) there appears to be an increase in the number of documents reflecting depictions of the OODA Loop in technical implementations. These technical implementations seemed to manifest themselves in three ways (as displayed in Table 11).

First, the OODA Loop was used to describe computer system physical architecture (i.e. sensors, networked computers, system of systems, C4ISR systems, firewalls, etc.). These architectures were often described as assets to either be defended or attacked from cyberspace (depending on which side of the information attack you were on). Note that the "C4ISR architecture" category has a majority (78% of usage) of its references containing both human (users of the C4ISR system) and computer (system architecture) OODA Loop use.

Second, the OODA Loop was used to describe information cycle times or information flows. This type of usage might manifest itself in descriptions of computer system information processing, system interoperability, sensor to shooter times, or data fusion in terms of OODA Loops. This type of usage is indicated in the slim majority (45% of usage) in the "Information Processing" category and a tie (50% of usage) in the "OODA Loop in the Cognitive, Information, and Physical Domain" category, both of which used OODA Loops to depict information flows in both human beings and

computer systems (and sometimes between them). This trend is also shown in the strong majority (81% of usage) of the "Data Fusion" category that primarily used OODA Loops to depict the integration and management of information in computer systems.

Third, the OODA Loop was used as a model for describing or programming intelligent behavior in computer systems. This manifested itself in intelligent agent design, descriptions of autonomous systems, and references to artificial intelligence. This trend is shown in the strong majority of OODA Loop usage in computer contexts for the categories of "Intelligent Agents" (95% of usage) and "Entity Modeling" (61% of usage).

OODA Loop Idea Trend: Divide Between "Competition" & "Information Processing Model"

One perceived emergent trend in OODA Loop ideas is there appears to be a fundamental division in how the OODA Loop is viewed and utilized by various adopters. One side of this divide contains "OODA Loop ideas used to achieve competitive advantage". Boyd was a warrior and couched his OODA Loop ideas in very Darwinist terms. To Boyd, the endgame for OODA Loop usage was the achievement of competitive advantage against an adversary and/or an "improved capacity for independent action" (Boyd, 1976a). This summarizes a majority of OODA Loop use in the literature, especially in the military community. This type of OODA Loop use is indicated by the "Competition" category in which 74% of analyzed literature documents fell. However, other documents depict OODA Loop ideas whose applications have nothing to do with conflict or competition. This side of the divide contains "OODA Loop ideas used as an information processing model". These usages tend to be in 1.) technical arenas such as data fusion, intelligent agents, entity modeling, etc., 2,) cognitive research,

and 3.) information references (i.e. data/information/knowledge hierarchy, knowledge management, information engineering, etc.). In these areas, speed and maneuverability are not as important as information management, integration of data, or functionality of intelligent behavior.

Summary of OODA Loop Idea Evolution.

Emergent OODA Loop idea themes have appeared frequently in the literature of the last decade. Most emergent themes are of a technical nature. Within these technical applications, it appears as if the OODA Loop is being used more, and independently, as an "information processing model" rather than as a method to achieve "competitive advantage".

Chapter Summary

This chapter has provided the results from the qualitative data analysis of both Boyd's works and the OODA Loop literature. The researcher used those findings along with Diffusion of Innovation theory to make some judgments and observations of OODA Loop idea diffusion and evolution. In the process, the first three researcher investigative questions were answered. The next chapter will use these results to propose an OODA Loop conceptual framework for collectively considering OODA Loop ideas (last researcher investigative question), summarize researcher findings, and propose future research.

V. Conclusions and Recommendations

Introduction

This research performed an analysis of the diffusion of Col John Boyd's OODA Loop ideas over the last quarter century. OODA Loop literature from the last decade was used to assess recent diffusion trends and evolution of ideas. This effort was undertaken in an attempt get a "big picture" description of different ideas present in the literature and overall exhibited trends and relationships. In the last chapter, the researcher presented perceived OODA Loop idea themes, diffusion and evolution for each theme, and overall observed literature and idea trends. These results were used by the researcher to construct a conceptual framework for collectively considering OODA Loop ideas, which is shown in the next section.

Conceptual Framework for OODA Loop Ideas

The researcher proposed conceptual framework is an attempt to answer the last investigative question (#4): *What kind of a conceptual framework could be used to structure OODA Loop ideas found in the literature?* The proposed framework is intended to provide structure for OODA Loop idea themes identified in the literature during the course in this research. The goal of the proposed framework is to assist in making sense of the wide diversity of OODA Loop ideas manifested in the literature. In order to be useful, a framework for OODA Loop ideas in the literature should simplify inherent complexity of concepts and find common ground within existing diversity of ideas. It should be broad enough to include the wide variety of OODA Loop ideas found

in the literature. It also must be specific enough to provide structure for explanations and provide boundaries for applicability.

The "OODA Loop Conceptual Framework" draws from three main themes that run throughout the OODA Loop literature: **Information**, **Systems**, and **Process**. These are three lenses through which every OODA Loop idea can be viewed. As will be discussed below, the researcher puts forward the conclusion that 1.) information is the fuel for the OODA Loop, 2.) a system (or system of systems) acts as the host for the OODA Loop, and 3.) process (or processing) is the activity of the OODA Loop.

"Information".

Information is a reoccurring theme within Boyd's work and within the OODA literature. The OODA Loop always seems to appear in ideas and applications dealing with information: information processing, information warfare, data/information/ knowledge hierarchy, information fusion, etc. Information is also a common denominator between human beings and computers (as they both process information). Within the literature, information is generally associated with OODA Loop process of orientation, Boyd's most emphasized phase of the OODA Loop. In addition, according to Boyd, all observations, decisions, and actions are steered by orientation (and thus by information). The researcher puts forward the idea that information acts as the fuel for the OODA Loop. That is, information is the lifeblood of the OODA Loop that powers the cognitive engine, scientific process, Gödel's integration, etc. Also, as Boyd illustrated many times, good and timely information is necessary for maintaining competitive advantage. Whether analog or digital, information is required for system processing. Indeed, the analysis from the previous chapter appears to show that within

the context of the researcher conceptual framework, the OODA Loop construct seems equally able to handle ideas in the literature that treats "information as a quantity" (hard science digital realm) as well as "information as a quality" (soft science human realm).

"Systems".

As described in Chapter IV's OODA Loop idea themes, Boyd used "systems thinking" in his OODA Loop theories. Boyd described people as "open systems", having free will, and the drive to compete for survival and independent action. Boyd described computers as "closed systems". In addition, complex adaptive systems and C4ISR systems architecture were emergent OODA Loop idea themes from the research. In testing the validity of the conclusion that the OODA Loop is a suitable "systems" model for ideas in the literature, the OODA Loop appears able to meet all of the descriptive characteristics of a generic "system" (Hoffer, 2001) found in Table 16:

Table 16. Attributes of a System

Attributes of a "System"	Relation to OODA Loop Ideas in the Literature
Components	Observe, Orient, Decide, Act, and Time act as the components in an individual entity OODA system.
Interrelated Components	Observations are interrelated to Orientation; Orientations are interrelated to Observations, Decisions, and Actions; Decisions are interrelated to Actions; Actions are interrelated to Observations. Multiple systems can be interrelated together as systems of systems.
A Boundary	The boundary for a human OODA Loop would be the human mind. A computer OODA Loop would consist of the boundaries of its software and hardware.
A Purpose	Purpose is inferred through the use of Decide (i.e. if a decision is made, there must be some purpose behind it). Computers are given purpose by their human designers (i.e. they are purposefully designed to operate a specific way).
An Environment	This can be shown via physical, information, cognitive domains and environments.

(cont…)

Table 16. Attributes of a System continued

Interfaces	Points of contact with the physical world (Observe & Act).
Input	Inputs can be seen as Observations into the OODA Loop.
Output	Outputs can be seen as Actions stemming from the OODA Loop.
Constraints	Boyd describes a constrained view of reality (due to "mismatches"); Observation constraints; Orientation constraints; Decision Constraints; Action Constraints; Temporal Constraints. Computer OODA Loops are constrained by their hardware and software design.

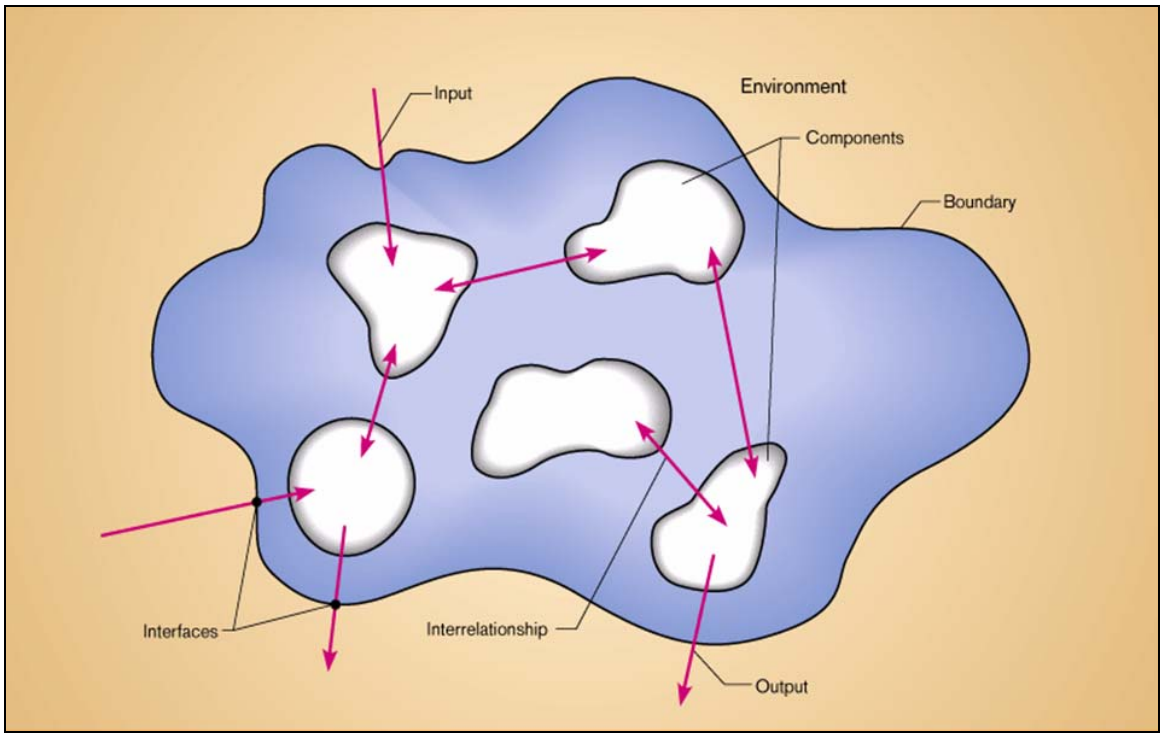


Figure 29. A General Depiction of a System (Hoffer, et al., 2001)

In this sense, an individual could be seen as an "information system". An organization could be seen as an "information system". A computer could be seen as an "information system". Computers are deterministic and perform according to the decisions made by their hardware and software designers. Another feature of systems is their scalability, a trait of OODA Loop ideas in the literature (e.g. OODA Loops applied to individuals,

organizations, nations, etc.). In this vein, the researcher puts forward the idea that a system (or system of systems) of human or computer information processors could be seen as the physical embodiment, or "host", for the OODA Loop ideas in the literature.

"Process".

A generic definition for a process is "a series of actions, changes, or functions that bring about a result". The OODA Loop is repeatedly described as a "process" in the OODA literature. The components of the OODA Loop (Observation, Orientation, Decision, and Action) are also described as complex processes in their own right (Whitaker, 1996). The researcher puts forward the idea that processing is the activity of the OODA Loop ideas in the literature. That is, OODA Loop processing is what allows a system to make use of information to interact with its environment, achieve competitive advantage, etc.

OODA Loop Ideas in the Literature: "Systems Information Processing".

According to this conceptual framework, an OODA Loop occurs where all three attributes intersect: where a system processes information. This would seem to match descriptions of information processing, intelligent systems, and complex adaptive systems descriptions provided in Chapter IV. In an attempt to go outside the OODA literature for some measure of validation for the proposed framework, the researcher investigated information systems processing theory. One theory, dubbed the unified theory of information, described three basic forms of information processing that systems could perform: cognition, communication, and cooperation (Hofkirchner, 2003). According to Hofkirchner, cognition is an intra-system information process,

communication is an inter-system process to transfer information, and cooperation is a process by which systems use information toward a common goal (Hofkirchner, 2003). OODA Loop ideas in the literature seem to correspond with this theory. OODA Loops ideas in the literature have been used to describe cognitive processes (i.e. a conceptual spiral or one's mind-time-space), communication processes (implicit communications, "Schwerpunkt", and C4I architecture communication links), and cooperation processes (command and control loop process).

A rendering of the researcher's proposed "OODA Loop Conceptual Framework" is offered on the next page in Figure 30. Figure 30 shows the researcher premise that Information, Systems, and Process are all interrelated with OODA Loop ideas existing at their intersection. The OODA Loop idea themes/categories outlined in the previous chapter are displayed around the Conceptual Framework. OODA Loop idea themes are positioned close to a Conceptual Framework attribute where there is an obvious relationship (i.e. "information warfare" with Information or "systems thinking" with System). However, in the researcher's mind, all OODA Loop ideas/categories are dependent in some form on all three Conceptual Framework attributes: Information, System, and Process.

OODA LOOP CONCEPTUAL FRAMEWORK FOR IDEAS IN THE LITERATURE

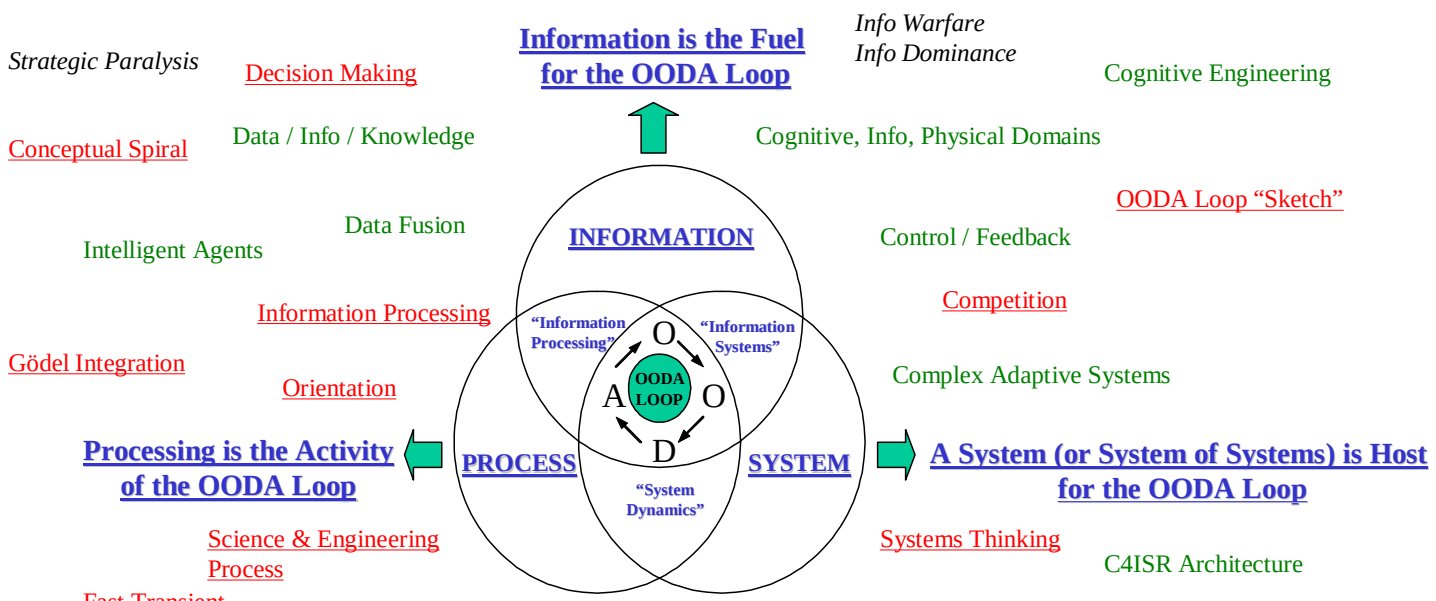


Figure 30. Proposed OODA Loop Conceptual Framework for OODA Ideas in the Literature

Summary of OODA Loop Conceptual Framework.

To recap, the researcher proposed a "systems information processing" conceptual framework that provided three vantage points for viewing and evaluating OODA Loop ideas found in the literature. "Information" was an attribute that described the common fuel powering OODA Loop usage. Information at some level is the material processed to make observations, perform orientations, make decisions, and take actions. "Systems" refers to the physical embodiment that acts as host for the OODA Loop. The system could be open (alive) exhibiting free will or closed (computer) acting in accordance with design specifications. "Process" refers to changes incurred made between input and output. Processing is the activity occurring in the OODA Loop. Taken together, "systems information processing" can be used to describe all OODA Loop ideas in the literature and is consistent with related theory and subject matter.

Limitations

There were many limitations involved in this research. The researcher limited the in-depth analysis of OODA Loop idea diffusion trends and evolution to a sample from the last decade in order to maintain analyzable levels of literature. Even within researcher restrictions, it is most likely that some appropriate OODA Loop literature was overlooked. Conclusions drawn from the qualitative data analysis were limited by the descriptive nature of the study. In addition, coding validation by outside parties and coding reliability measures were limited by time. Also worth noting is that although this analysis was scoped to focus on the DoD, no clear distinction or comparison was made between DoD and non-DoD social systems in the literature. Finally, the researcher recognizes that the conceptual framework constructed during the course of this research

should be viewed as being the result of a limited sample and, as such, open to possible researcher bias.

In light of the research scope and researcher detailed focus specifications, it is important to note that there were many investigative aspects this thesis did not deem to undertake. This research, while assessing diffusion trends of OODA Loop ideas, should not be considered a definitive chronology (i.e., focus was less on diffusion rate and exact diffusion path and more on where OODA Loop innovations have diffused, who are using them, and how they are being used). This research, while it referenced anecdotal, academic, or scientific studies to describe existing support for OODA Loop ideas, did not seek to empirically prove OODA Loop validity or applicability. Also, this research was not meant to be an advocacy of OODA Loop (i.e., researcher is not pushing for greater/faster diffusion), it simply attempted to present and analyze documented phenomena.

Conclusions

OODA Loop ideas appear to provide value to numerous adopters who utilize them in different ways. OODA Loop usage appears to be on the increase and is finding continual use in DoD strategies and doctrine. Some adopters utilize OODA Loops as a means to achieve competitive advantage. Other adopters use the OODA Loop for its ability to model information processes. In either case, the OODA Loop appears to exhibit universal ability to serve as a scalable system and process model. The researcher's "systems information processing" conceptual framework was an attempt to create a "best fit" frame of reference for considering OODA Loop ideas and facilitating future discussions.

Recommendations for Further Research

This research was exploratory in nature and was designed to be an introductory foray into a disorganized collection of OODA Loop ideas. Continued testing of the OODA Loop construct in experimental and simulated settings is recommended to increase empirical support of concepts. Additional research is recommended for the conceptual framework developed by the researcher. Specifically, this framework is offered to members within the information and systems science disciplines for assessment of the OODA Loop construct and its potential value in depictions of information, systems, and process. Also, this researcher offers his proposed OODA Loop conceptual framework to the military for study to see if it is useful in consolidating, integrating, and standardizing aspects of current information superiority doctrine. If nothing else, it is hoped that this research serves to open OODA Loop idea dialogues in both military and civilian communities and facilitate further diffusion and evolution.

APPENDIX A: Defining the "OODA Literature"

Criteria

The researcher has attempted to scope this research mainly by defining the "OODA literature" body, thus outlining and restricting the data for use in the analysis. For the purposes of this research, "OODA literature" can be defined as meeting the following nine criteria:

1. **All "OODA literature" must be in English and have at least some text.** Use of the English language is necessary to facilitate research and avoid translation delays. Also, text must be present for explicit analysis (i.e. a Powerpoint presentation using strictly diagrams and pictures would be disqualified). This criterion seeks to focus researcher effort.
2. **All Boyd authored or presented documents are included in "OODA literature".** This criteria is necessary to obtain original "initial state" innovation conceptions, characterization, and utilizations. These works are also needed to assess Boyd's intent (explicitly stated or implied) for his innovation.
3. **"OODA literature" must explicitly contain any of the following term(s): "OODA", "Observe AND Orient AND Decide AND Act", "Observation AND Orientation AND Decision AND Action", or "Boyd Cycle" (with the "AND" being used in the Boolean sense).** This criterion was needed to eliminate documents that contained OODA-like conceptions, but did not specifically reference the

innovation (OODA Loop) of researcher interest. This criterion was necessary to focus and provide consistency for research.

4. **OODA references must stand for "Observe, Orient, Decide, Act" or "Observation, Orientation, Decision, Action".** This criterion is necessary to eliminate alternate acronyms for OODA like "Object Oriented Database Architecture" that fell outside researcher field of interest.
5. **OODA Literature considered for Idea Diffusion Timeline will be limited to the last 27 years (1976 – 2003).** This starts from the year of Boyd's first publication and continues to the present. This literature will be used to develop an OODA Loop idea diffusion timeline, determining what ideas appeared or were used during a given year. This expansive stretch of time was chosen to capture the entire OODA Loop diffusion window.
6. **OODA Literature considered for Recent Diffusion Trends and Idea Evolution will be limited to the last 11 years (1992 – 2003).** This year limit was chosen for a variety of reasons. First, Boyd made his last contribution to the OODA Loop in 1992 (Boyd, 1992). It might be considered premature to consider an innovation's diffusion before that innovation is completely introduced. Second, 1992 is a year following the first Gulf War (concluding in Feb-Mar of 1991) and will allow for innovation feedback from OODA Loop operational adopters. Lastly, 1992 was one of the initial years of the "Internet explosion". This explosion and the resulting ease of acquiring and sharing information will play a direct impact on the analysis "communication channels" used in OODA Loop innovation diffusion. By restricting OODA literature to post-1991 ("by 1992, the Internet was a major communication factor"), the

researcher can mitigate differences in innovation diffusion by eliminating comparisons of pre- and post-Internet existence communication effects.

7. **"OODA literature" must be an "authored" document.** That is, there must be an author's name attributable to the document in question. The researcher makes the case that a document that is not worth claiming ownership of is probably not worth researching. As such, this criterion eliminates casual references to the OODA loop such as web sites, blogs, etc., focuses researcher efforts on "worthy" documents, and provides consistency for research.
8. **"OODA literature" must be "year-attributable".** That is, there must be a year associated with the date of publication. Those documents that had no publication year were eliminated from consideration. The year of the publication is necessary to properly analyze the diffusion of innovation in the literature in a temporal context. For the purposes of this research, if year of publication is present but ambiguous (as in a web document that has had multiple revisions), the year of the latest revision will be the one considered for research.
9. **"OODA literature" must be able to stand on its own.** A document must be able to be considered outside of the context or environment in which it exists. What this means is that a document must read like a document (with a title, introduction, development, conclusion, etc). A random snippet of information considering the OODA Loop (even if it has an attributable author and year of publication) will not be considered as OODA Literature if it does not read like a document. As such, this criterion eliminates casual references to the OODA loop such as web sites, blogs, etc.,

focuses researcher efforts on “worthy” documents, and provides consistency for research.

APPENDIX B: Matrix for Qualitative Data Analysis of OODA Loop Ideas

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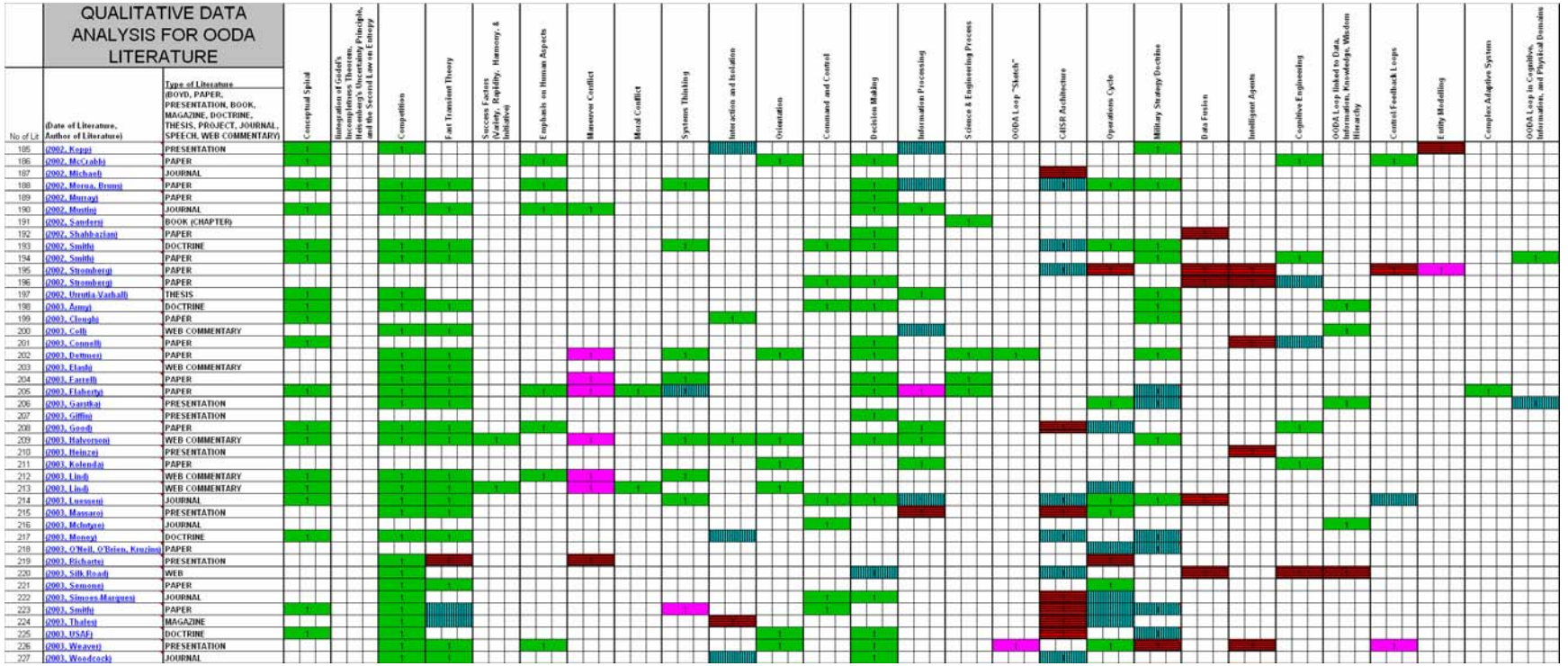
QUALITATIVE DATA ANALYSIS FOR OODA LITERATURE

No of Lit	(Date of Literature, Author of Literature)	Type of Literature @OYD, PAPER, PRESENTATION, BOOK, MAGAZINE, DOCTRINE, THESIS, PROJECT, JOURNAL, SPEECH, WEB COMMENTARY)	Conceptual Spiral	Integration of Godel's Incompleteness Theorem, Heisenberg's Principle, and the Second Law on Entropy	Competition	Fast Transient Theory	Success Factors (Variety, Rapidity, Harmony, & Initiative)	Emphasis on Human Aspects	Maneuver Conflict	Moral Conflict	Systems Thinking	Interaction and Isolation	Orientation	Command and Control	Decision Making	Information Processing	Science & Engineering Process	OODA Loop "Sketch"	C4ISR Architecture	Operations Cycle	Military Strategy Doctrine	Data Fusion	Intelligent Agents	Cognitive Engineering	OODA Loop linked to Data, Information, Knowledge, Wisdom Hierarchy	Control Feedback Loops	Entity Modelling	Complex Adaptive System	OODA Loop in Cognitive, Information, and Physical Domains
1	Boyd's Works (1976-1996)	ESSAY, 6 PRESENTATIONS																										
2	(1992, Cichowski)	PAPER																										
3	(1992, Rononi	BOOK																										
4	(1992, Vincenti	PAPER																										
5	(1993, Burton)	BOOK																										
6	(1993, Paytono	PAPER																										
7	(1993, Vincenti	PAPER																										
8	(1994, Hammondi	PAPER																										
9	(1994, Manni	PAPER																										
10	(1994, McLenderu	BOOK (CHAPTER)																										
11	(1994, Nicholbi	JOURNAL																										
12	(1994, Pinaldi)	THESIS																										
13	(1995, Fadoki	THESIS																										
14	(1995, Fischer)	THESIS																										
15	(1995, Fleming)	PRESENTATION																										
16	(1995, Fogleman, Widnalf)	DOCTRINE																										
17	(1995, Harris)	SPEECH																										
18	(1995, Libicki)	PAPER																										
19	(1995, Stein)	PAPER																										
20	(1995, Szafranski)	PAPER																										
21	(1995, Thompson)	JOURNAL																										
22	(1995, University)	BOOK																										
23	(1995, Wood)	PROJECT																										
24	(1996, Army)	DOCTRINE																										
25	(1996, Atkins)	PAPER																										
26	(1996, Barnett)	PAPER																										
27	(1996, Bansi	PAPER																										
28	(1996, Bradley)	PAPER																										
29	(1996, Bunker)	PAPER																										
30	(1996, Canada)	PAPER																										
31	(1996, Carter)	PAPER																										
32	(1996, Cramer)	PRESENTATION																										
33	(1996, Joint Chiefs)	DOCTRINE																										
34	(1996, Killiani	PAPER																										
35	(1996, Krulak)	DOCTRINE																										
36	(1996, Maethner)	PAPER																										
37	(1996, McCauley-Bell)	PAPER																										
38	(1996, Miller)	PAPER																										
39	(1996, Murphy)	PAPER																										
40	(1996, Ottmani)	PAPER																										
41	(1996, Osborne)	PAPER																										
42	(1996, Ridenour)	PAPER																										
43	(1996, Schechtman)	THESIS																										
44	(1996, Whitaker, Kuperman)	PAPER																										
45	(1997, Chapman)	THESIS																										
46	(1997, Clemente)	THESIS																										
47	(1997, Cox)	PROJECT																										
48	(1997, Crawford)	JOURNAL																										
49	(1997, Endsley)	PAPER																										
50	(1997, Farmer)	PAPER																										
51	(1997, JCS)	DOCTRINE																										
52	(1997, Olsvik)	THESIS																										
53	(1997, Pellegrini)	THESIS																										
54	(1997, Pernichi)	PAPER																										
55	(1997, Plyarsky)	PAPER																										
56	(1997, Romani	PAPER																										
57	(1997, Spinney)	PAPER																										
58	(1997, Spinney)	PRESENTATION																										
59	(1997, Van Riper)	MAGAZINE																										
60	(1997, Whitehead)	THESIS																										
61	(1998, Alfaedlee)	PAPER																										
62	(1998, Beenei	THESIS																										
63	(1998, Bunker)	PAPER																										
64	(1998, Dahl)	THESIS																										
65	(1998, Felker)	PAPER																										
66	(1998, Kuperman)	PAPER																										
67	(1998, Richards)	WEB COMMENTARY																										
68	(1998, Rousei	JOURNAL ABSTRACT																										
69	(1998, Rowe)	PAPER																										
70	(1998, Science)	PAPER																										
71	(1998, Semerdjiev)	PAPER																										
72	(1998, Shalamanev)	PAPER																										
73	(1998, Spinney)	WEB COMMENTARY																										
74	(1998, Stanley)	PAPER																										
75	(1998, USAF)	DOCTRINE																										
76	(1998, Valin)	PAPER																										
77	(1999, Alberts)	DOCTRINE																										
78	(1999, Banei)	PAPER																										
79	(1999, Barnett)	PAPER																										
80	(1999, Beckerman)	PAPER																										
81	(1999, Bedworth)	PAPER																										
82	(1999, Bijkerk)	JOURNAL																										
83	(1999, Defense Science Board)	DOCTRINE																										
84	(1999, Dunlap)	PAPER																										
85	(1999, Editorial)	JOURNAL																										
86	(1999, Gerber)	THESIS																										
87	(1999, Gray)	BOOK																										
88	(1999, Hermes)	PAPER																										
89	(1999, Lee)	PAPER																										
90	(1999, Patajin)	PAPER																										
91	(1999, Polk)	PAPER																										
92	(1999, Regani	WEB COMMENTARY																										

QUALITATIVE DATA ANALYSIS FOR OODA LITERATURE

No of Lit	(Date of Literature, Author of Literature)	Type of Literature @OYD, PAPER, PRESENTATION, BOOK, MAGAZINE, DOCTRINE, THESIS, PROJECT, JOURNAL, SPEECH, WEB COMMENTARY)	Conceptual Spiral	Integration of Godel's Incompleteness Theorem, Heisenberg's Uncertainty Principle, and the Second Law on Entropy	Competition	Fast Transient Theory	Success Factors (Variety, Rapidity, Harmony, & Initiative)	Emphasis on Human Aspects	Maneuver Conflict	Moral Conflict	Systems Thinking	Interaction and Isolation	Orientation	Command and Control	Decision Making	Information Processing	Science & Engineering Process	OODA Loop "Sketch"	C4ISR Architecture	Operations Cycle	Military Strategy Doctrine	Data Fusion	Intelligent Agents	Cognitive Engineering	OODA Loop linked to Data, Information, Knowledge, Wisdom Hierarchy	Control Feedback Loops	Entity Modelling	Complex Adaptive System	OODA Loop in Cognitive, Information, and Physical Domains
93	(1999, Shahbazian)	PAPER																										
94	(1999, Shepgard)	PAPER																										
95	(1999, Spinney)	WEB COMMENTARY																										
96	(1999, Spinney)	WEB COMMENTARY																										
97	(1999, Tighe)	THESIS																										
98	(1999, USAF)	DOCTRINE																										
99	(1999, Wein)	DOCTRINE																										
100	(2000, Bassi	PAPER																										
101	(2000, Bedworth)	PAPER																										
102	(2000, Benzeb	PAPER																										
103	(2000, Blaschi	PAPER																										
104	(2000, Brunstad	PAPER																										
105	(2000, Buddenberg	PAPER																										
106	(2000, Bulleck	THESIS																										
107	(2000, Bulleck	PAPER																										
108	(2000, Canter	PAPER																										
109	(2000, Franke	PAPER																										
110	(2000, Frankel	PAPER																										
111	(2000, Gibb	PAPER																										
112	(2000, Grayhill	PRESENTATION																										
113	(2000, Hagani	PAPER																										
114	(2000, Hammond	WEB COMMENTARY																										
115	(2000, Hickson	PAPER																										
116	(2000, Huggins	THESIS																										
117	(2000, JCS)	DOCTRINE																										
118	(2000, Kruse	PAPER																										
119	(2000, Kuperman	PAPER																										
120	(2000, Luzwick	PAPER																										
121	(2000, Maas	PAPER																										
122	(2000, Marshi	PAPER																										
123	(2000, Maxwell	PAPER																										
124	(2000, McManus	WEB COMMENTARY																										
125	(2000, Moesner	THESIS																										
126	(2000, Murray	PAPER																										
127	(2000, Nunesi	PAPER																										
128	(2000, Plehn	THESIS																										
129	(2000, Rohlfing	PAPER																										
130	(2000, Tighe	PAPER																										
131	(2000, Tomasi	PAPER																										
132	(2000, van der Veerth	PAPER																										
133	(2001, Adams	PAPER																										
134	(2001, Alberts	DOCTRINE																										
135	(2001, Aragon	PRESENTATION																										
136	(2001, Barth	WEB COMMENTARY																										
137	(2001, Belk	PAPER																										
138	(2001, Business Wire	MAGAZINE																										
139	(2001, Curtis	PAPER																										
140	(2001, Danskine	PAPER																										
141	(2001, Darken	PAPER																										
142	(2001, Davis	PAPER (RAND chapter)																										
143	(2001, DoD Science Board	PAPER																										
144	(2001, DoD	DOCTRINE (Congr Report)																										
145	(2001, Dotsik	PAPER																										
146	(2001, Dragon	PAPER																										
147	(2001, Ehrenreich	PAPER																										
148	(2001, Hammond	BOOK																										
149	(2001, Hill	PAPER																										
150	(2001,Hoenigl	WEB COMMENTARY																										
151	(2001, Macklin	PAPER																										
152	(2001, Mellinger	BOOK																										
153	(2001, Mellinger	PAPER																										
154	(2001, Miller, et al.)	PAPER (MITRE)																										
155	(2001, Randalh	PAPER																										
156	(2001, Romei	PAPER																										
157	(2001, Shahbazian	PAPER																										
158	(2001, Shanahan	PAPER																										
159	(2001, Shea	SPEECH																										
160	(2001, Silverman	PAPER																										
161	(2001, Sinsetad	PAPER																										
162	(2001, Smith	PAPER																										
163	(2001, Stone	PAPER																										
164	(2001, Wilson	PAPER																										
165	(2001, Wilson	PAPER																										
166	(2002, Back	THESIS																										
167	(2002, Barth	PRESENTATION																										
168	(2002, Bladon	PAPER																										
169	(2002, Blaschi	PAPER																										
170	(2002, Bulleck	PAPER																										
171	(2002, Burroughs	PAPER																										
172	(2002, Clark	PAPER																										
173	(2002, Clough	PAPER																										
174	(2002, Corami	BOOK																										
175	(2002, Cresch	PRESENTATION																										
176	(2002, Ellison	PAPER																										
177	(2002, Flecky	WEB COMMENTARY																										
178	(2002, Gagnon	PAPER																										
179	(2002, Garstka	DOCTRINE / PRESENTATION																										
180	(2002, Giordano	JOURNAL																										
181	(2002, Hammond	WEB COMMENTARY																										
182	(2002, Heinze	BOOK (CHAPTER)																										
183	(2002, Heinze	PAPER																										
184	(2002, Jansen	PRESENTATION																										


QUALITATIVE DATA ANALYSIS FOR OODA LITERATURE
No of Lit
(Date of Literature, Author of Literature)
Type of Literature (BOYD, PAPER, PRESENTATION, BOOK, MAGAZINE, DOCTRINE, THESIS, PROJECT, JOURNAL, SPEECH, WEB COMMENTARY)
Conceptual Spiral
Integration of Godel's Incompleteness Theorem, Heisenberg Uncertainty Principle, and the Second Law on Entropy
Competition
Fast Transient Theory
Success Factors (Variety, Rapidity, Harmony, & Initiative)
Emphasis on Human Aspects
Maneuver Conflict
Moral Conflict
Systems Thinking
Interaction and Isolation
Orientation
Command and Control
Decision Making
Information Processing
Science & Engineering Process
OODA Loop "Sketch"
C4ISR Architecture
Operations Cycle
Military Strategy Doctrine
Data Fusion
Intelligent Agents
Cognitive Engineering
OODA Loop linked to Data, Information, Knowledge, Wisdom Hierarchy
Control Feedback Loops
Entity Modelling
Complex Adaptive System
OODA Loop in Cognitive, Information, and Physical Domains
185 (2002, Koppi) PRESENTATION
186 (2002, McCrabb) PAPER
187 (2002, Michael) JOURNAL
188 (2002, Morna, Bruni) PAPER
189 (2002, Murray) PAPER
190 (2002, Musting) JOURNAL
191 (2002, Sanders) BOOK (CHAPTER)
192 (2002, Shahbazian) PAPER
193 (2002, Smith) DOCTRINE
194 (2002, Smith) PAPER
195 (2002, Stromberg) PAPER
196 (2002, Stromberg) PAPER
197 (2002, Utrattia-Varhalli) THESIS
198 (2003, Angyi) DOCTRINE
199 (2003, Clough) PAPER
200 (2003, Colli) WEB COMMENTARY
201 (2003, Connelli) PAPER
202 (2003, Dettmer) PAPER
203 (2003, Elashi) WEB COMMENTARY
204 (2003, Farrell) PAPER
205 (2003, Flaherty) PAPER
206 (2003, Garstka) PRESENTATION
207 (2003, Giffin) PRESENTATION
208 (2003, Good) PAPER
209 (2003, Halvorson) WEB COMMENTARY
210 (2003, Heinze) PRESENTATION
211 (2003, Kolenda) PAPER
212 (2003, Lind) WEB COMMENTARY
213 (2003, Lind) WEB COMMENTARY
214 (2003, Luesseni) JOURNAL
215 (2003, Massaro) PRESENTATION
216 (2003, McIntyre) JOURNAL
217 (2003, Money) DOCTRINE
218 (2003, O'Neil, O'Brien, Kruzins) PAPER
219 (2003, Richards) PRESENTATION
220 (2003, Silk Road) WEB
221 (2003, Semone) PAPER
222 (2003, Simons Marquesi) JOURNAL
223 (2003, Smith) PAPER
224 (2003, Thales) MAGAZINE
225 (2003, USAF) DOCTRINE
226 (2003, Weaver) PRESENTATION
227 (2003, Woodcock) JOURNAL

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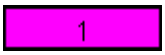
APPENDIX C: Researcher Coding and Categorization

The following coding and categorization specifications were used by the researcher in performing the qualitative data analysis. Coding and categorization specifications were designed according to qualitative data analysis methodology (Miles & Huberman, 1994).

Coding

Within each of the researcher-defined categories (located in the next section), the following coding scheme was used by the researcher to document the context in which an identified OODA Loop idea manifested itself. Specifically, the coding answers the question, "In what domain context was the OODA Loop idea being used?" The various domain alternatives that the researcher had to discern context from were: human, technical/computer, both human and technical/computer, and indeterminate.

-  -- This matrix cell color refers to a human OODA Loop reference (i.e. a human being at some level is doing the observing, orienting, deciding, and acting)
-  -- This matrix cell color refers to technical/computer OODA literature references (i.e. a computer at some level is doing the "observing", "orienting", "deciding", and "acting")

-  -- This matrix cell color refers to OODA literature references in which both human and computer are observing, orienting, deciding, acting.
-  -- This matrix cell color refers to an indeterminate OODA Loop domain reference. This could come as a result of an unclear reference or a generic OODA Loop statement that draws no distinction between human and computer domains.

In closing the coding section, it needs noting that if no OODA Loop references were made pertaining to a specific category, this was documented by leaving the area in the matrix of the corresponding category column in a normal grid condition (uncolored).

Categorization Criteria

The following criteria were used by the researcher to determine whether an OODA Loop literature reference fell into a category or not. These categorization criteria were important in that they provided a measure of consistency in guiding researcher classifications. However, it needs to be noted that not all category criteria required strict explicit word reference (as would be used in a content analysis). In the end, the qualitative judgment of the researcher was required in making final determinations.

"Boyd Idea" Categories.

1. Conceptual Spiral – Literature reference must depict as OODA Loop as a mental process or the way by which a person makes sense of their reality (i.e. one's "mind-space-time" or the "dialectic engine" described in *Destruction and Creation* (Boyd, 1976a)). Words or derivatives to look for: mental, mind, mind-time-space, thinking, reality, analysis/synthesis, conceptual spiral, cognition, etc. Also pertains to references of "getting inside someone's OODA Loop" when this denotes affecting their thinking process.

2. Gödel's incompleteness theorem, Heisenberg's Uncertainty Principle, and the Second Law on entropy – Literature must explicitly reference Boyd's integration of these three theories or the phrase "one cannot determine the nature and character of a system within itself and, furthermore, any attempts to do so will lead to greater disorder and confusion".

3. Competition – Literature reference must denote OODA Loop usage in a competitive context (i.e. whether OODA Loops were being used to defeat an opponent, outmaneuver an adversary, etc.).

4. Fast Transient Theory – Literature reference must refer to superiority achieved by operating at a faster tempo and/or by changing faster than an opponent. Key words to look for: faster, tempo, loop speed, fast transients, etc. Also, look for the phrase "getting inside someone's OODA Loop" when this denotes outpacing their ability to keep up, react, or deal with imposed changes.

5. Success Factors – Literature must explicitly references to all four specific factors: *variety*, *rapidity*, *harmony*, and *initiative.* Usage of these terms does not have be in a list, but their usage within the literature should be in the same area (paragraph) so that the researcher knows these factors are being considered together (and thus attributable to Boyd).

6. Emphasis on Human Aspects – Literature must make a specific effort to emphasize human focus in operations and must some sort of attribution reference to Boyd or OODA Loops in doing so. Key words to look for: implicit, shared mindset, "Schwerpunkt", trust, common experience/training, commander's intent, etc. Also, any use of the Boyd's phrase, "Humans first, ideas second, things third" counts.

7. Maneuver Conflict – Literature must make explicit reference to the word "maneuver" as pertaining to the OODA Loop.

8. Moral Conflict – Literature should make reference to the moral aspects of conflict and Boyd's theories. Any reference to 4th Generation warfare counts.

9. Systems Thinking – Literature should denote Boyd's use of systems terminology. Words to look for: system, organic, whole, organism, connections, relationships, etc. References can include physical, mental, or moral systems.

10. Interaction and Isolation – Literature should show OODA Loop being used to either depict some form of interaction and/or isolation. Utilizations could manifest themselves in a human sense: (i.e disabling a person/organizations ability to observe or orient by separating them from their environment). Utilizations could also show up in technical discussions (i.e. OODA Loop being used in terms of interoperability between computer systems). This category was designed to be broad as it is a Boyd theory aspect

that is often not recognized. References can be made to physical, mental, or moral interaction or isolation.

11. Orientation – Literature must emphasize Boyd's idea that the orientation is the most important phase of the OODA Loop. Use of any part of Boyd's definition: "Orientation is an interactive process of many-sided implicit cross-referencing projections, empathies, correlations, and rejections that is shaped by and shapes the interplay of genetic heritage, cultural tradition, previous experiences, and unfolding circumstances" counts. References to orientation must be explicit and go beyond simple description of orientation as being a phase in the OODA Loop.

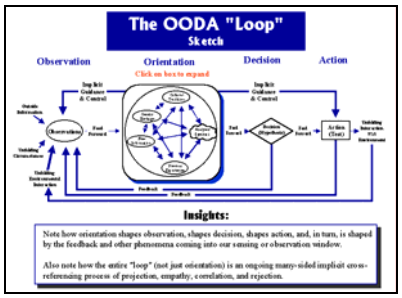
12. Command and Control – Literature must explicitly use one of any of the following terms with regard to the OODA Loop: C2 (or other command acronym), command, and/or command and control.

13. Decision Making – Literature must make explicit reference to the OODA Loop as being a process of decision making. References must going beyond the use of Decision or Decide in a simple description of the OODA Loop. Words to look for: decision making, decision loop, decision cycle, decision process, etc.

14. Information Processing – Literature must make reference to some form of information processing with regard to the OODA Loop. Terms to look for: information process, information overload, information systems, etc.

15. Science & Engineering Process – Literature must make specific reference to the OODA Loop with regard to any process of development, process improvement, problem solving, scientific methodology, etc. Presence of the OODA Loop "sketch" (see criteria #16) does not qualify without further examination of this aspect.

16. OODA Loop "Sketch" – Literature must explicitly show some form of Boyd's OODA Loop "sketch" (Boyd, 1996):



(See Figure 22 in Chapter II for larger version).

"Emergent Idea" Categories.

17. C4ISR Architecture – Literature must use OODA Loops associations with computer and communications hardware as part of C4ISR systems architecture (i.e. computer networks, system of systems, Global Grid, cyberspace, etc.). The key idea is the OODA Loop is pertaining to the hardware or underlying architecture. An example might be if an author described protecting a computer network as "hardening our OODA Loop".

18. Operations Cycles – Literature must make OODA Loop references pertaining to some form of reoccurring operating cycles (i.e ATO cycle, Intelligence cycle, etc.). Also included in this category are descriptions of interlocking OODA Loop cycles occurring at various operational levels (as in tactical, operational, and strategic levels). The key idea for this category is the denotation of the temporal aspect of the OODA Loop (i.e. time to complete a cycle, loop completion time increasing as one goes up through tactical-operational-strategic loops, etc.).

19. Military Strategy/Doctrine – Literature must make reference to the OODA Loop in regard to a specific kind of strategy, warfare, or doctrine (besides maneuver warfare -- see category #7). Strategic paralysis, information warfare, network-centric warfare, effects based operations, information superiority, etc. are all examples.

20. Data Fusion – Literature must make explicit use of the word "fusion" and use the OODA Loop in contexts of data or information fusion.

21. Intelligent Agents – Literature must use the OODA Loop in contexts of intelligent agents, artificial intelligence, autonomous agents, etc. OODA Loop use must pertain to computer software (non-human) references. Key words for this category are: intelligent, agent, autonomy, artificial intelligence, intelligent systems, etc.

22. Cognitive Engineering – Literature must use the OODA Loop to break down various aspects of cognitive functions. An example would be situational awareness being examined as a function of observation and orientation. To be eligible for this category, the document must have cognitive engineering as a primary focus of its content. Key words for this category are: cognitive engineering, situational awareness, perception, etc.

23. OODA Loop linked to Data, Information, Knowledge, and Wisdom hierarchy – Literature must make explicit use of the terms "data", "information", and "knowledge", relate them to the OODA Loop in some way, and relate them to each other in some hierarchical manner. Also, any reference to the OODA Loop as relating to the nature on information (epistemology), information engineering, or knowledge management counts.

24. Control/Feedback Loops – Literature must make explicit reference to OODA Loops and "control loops" or "feedback". This category was used to capture terms that are commonly used in the cybernetics discipline.

25. Entity Modeling – Literature must use the OODA Loop in a modeling or computer simulation to depict the behavior of entities (individuals or organizations). Entity modeling must be the focus of the literature document. Mentions of the OODA Loop being a model itself for human and organizational behavior do not count.

26. Complex Adaptive Systems – Literature must make explicit reference to OODA Loops being related to "complex adaptive systems".

27. OODA Loop occurring in Cognitive, Information, and Physical Domains – Literature must make explicit reference to the OODA Loop occurring in all three of these domains (a diagram is usually required to show the domains).

Closing Note on Researcher Coding and Categorization

In lieu of the fact that this research was an exploratory "big picture" analysis of OODA Loop ideas, a few researcher misjudgments in coding and/or categorization should not skew overall analysis findings. That is, OODA Loop idea trends that were identified by the researcher in Chapter IV were made using a wide "big picture" lens. Overall assessments conducted and conclusions drawn were done at a low level of granularity in which a few stray or erroneous data points should not make a difference. In the end, the researcher matrix in *APPENDIX B: Matrix for Qualitative Data Analysis of OODA Loop Ideas* can be used to clear up any coding or categorization discrepancies.

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Vita

Captain Scott Angerman was born in 1973 in Wurzberg, West Germany to William and Deborah Angerman. He graduated Hanks High School in El Paso, Texas in 1991 and subsequently attended the United States Air Force Academy. He graduated with a Bachelor of Science in Biology in May of 1995.

Upon completing Basic Communications Officer Training at Keesler, AFB, he was assigned to the headquarters of Air Force Operational Test and Evaluation Center (HQ AFOTEC), Kirtland AFB, NM, serving mainly as AFOTEC's Network Ops Officer.

Captain Angerman was then assigned to Ramstein AFB, Germany in March 1999. Soon afterward, during Operation ALLIED FORCE air strikes in the air war over Serbia, he led the USAFE Network Operations and Security Center and later the USAFE Contingency Response Cell. Following the conflict, he held a variety of positions including Chief of USAFE's Command and Control Engineering Branch, USAFE Computer Systems Squadron Executive Officer, and Ramstein Telecommunications Flight Commander. Additionally, he deployed as the Balkan Combined Air Operations Center's Systems Integration Officer and later served as Communications Director for the 3rd Aerospace Expeditionary Task Force, an organization charged with providing Operation ENDURING FREEDOM humanitarian assistance airdrops over Afghanistan.

Captain Angerman was selected for the Information Systems Management program at AFIT in 2002. Upon graduation he will be assigned to the staff of Headquarters Air Force Space Command, Peterson AFB, Colorado.

Capt Angerman married his wife in 1998. Together they have two sons, the last of which was born during this thesis effort.

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14. ABSTRACT

The Observe-Orient-Decide-Act (OODA) Loop ideas of Air Force Colonel John Boyd have impacted the Department of Defense (DoD), influenced military thought, paved the way for operational change, and helped to shape fighting doctrines. A wide variety of OODA Loop ideas and interpretations exist in the literature, but are unorganized and have not undergone holistic study to determine how Boyd's ideas have spread or changed over time. As such, this research analyzed a quarter century (1976-2003) sample of the OODA Loop literature to examine the diffusion and evolution of OODA Loop ideas since Boyd's original conceptualizations. This research used qualitative data analysis to examine OODA Loop ideas in light of innovation diffusion theory. Ideas from Boyd's original OODA Loop theories were compared and contrasted with subsequent literature instances to assess diffusion and evolution of OODA Loop ideas in the DoD. This research concluded with a proposed conceptual framework for collectively considering OODA Loop ideas.

15. SUBJECT TERMS

OODA Loop, Observe-Orient-Decide-Act, Boyd Cycle, Diffusion, Innovation, Evolution, Information, Systems, Processing

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