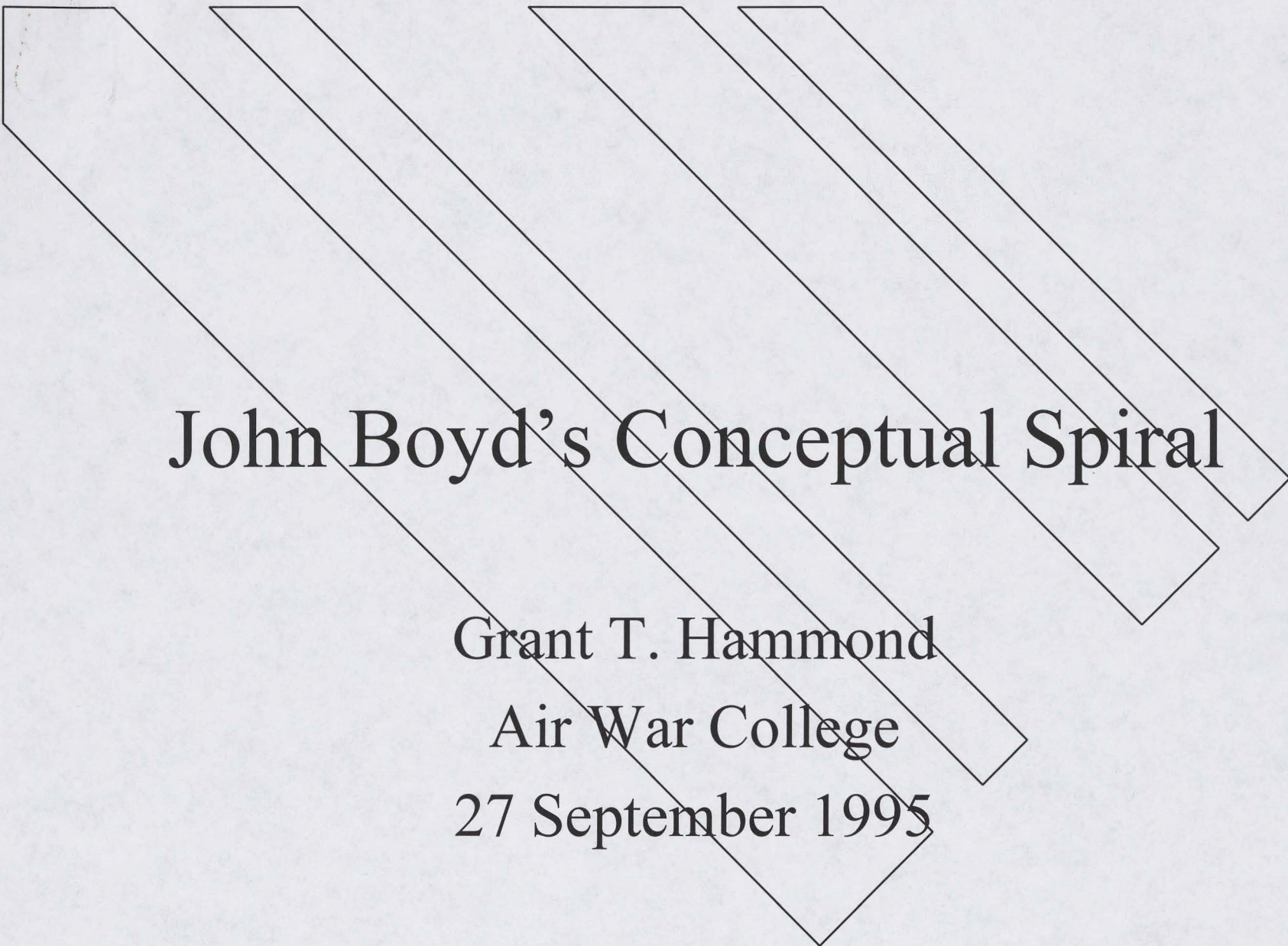




John Boyd's Conceptual Spiral

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Key Questions

- What has the pursuit and practice of science, engineering and technology done for us?
- What is the difference among science, engineering and technology?
- Why are these important?

Definitions

- Science--a self correcting process of observation, hypothesis and test
- Engineering--a self-correcting process of observation, design and test
- Technology--the wherewithal or state of the art produced by the practice of science and engineering

Outstanding Contributors to Science

- Newton (1687)
- Carnot/Kelvin/Clausius/Boltzman (1824/1852/1865/1870s)
- Faraday/Maxwell/Hertz (1831/1865/1888)
- Darwin & Wallace (1838, 1858)
- Mendel (1866)
- Poincare (1890s)
- Planck (1900)
- Einstein (1905/1915)

Outstanding Contributors to Science

- Bohr/ de Broglie/Heisenberg/Schrodinger/ Dirac/et al (1913, 1920s and 30s...)
- Lowenheim & Skolem (1915-1933)
- Godel/Tarski/Church/Turing/ et al (1930s...)
- Claude Shannon (1948)
- Crick & Watson (1953)
- Lorenz/Prigogene/Mandelbrot/Feigenbaum et al 1960s and 1970s...
- Chaitin/Bennett (1965/1985)

Outstanding Contributors to Engineering

- Savery/Newcomen/Watt (1698/1705/1769)
- Pixii/von Jacobi (1832/1838)
- Morse (1837)
- Nieqce/Daguerre/Talbot (1839)
- Gramme/Fontaine (1869/1873)
- Otto (1876)
- Bell (1876)
- Edison (1877/1879)

Outstanding Contributors to Engineering

- Parsons (1884)
- Benz/Daimler (1885/1886)
- Edison/LeRoy/Armat (1890-1896)
- Tesla/Marconi (1893-1895)
- Diesel (1897)
- Wright Brothers (1903)
- Hulmeyer (1904)
- Fleming/DeForest (1904/1907)

Outstanding Contributors to Engineering

- Baird (1926)
- von Ohain (1939)
- Eckert & Machly (1946)
- Bardeen/Brattain/Schockley (1947)
- Ampex (1955)
- Kilby/Noyce (1958/1959)
- Maiman (1960)
- Phillips/Sony (1970/1980)

Question

- In looking at the past via contributions these people have provided the world--
- What can we say about our efforts for now and for the future?

Logical Implications

- The theorems associated with Godel, Lowenheim. Skolem, Tarski, Church, Turing, Chaitin and others reveal that--
- Statements representing a theoretical system for explaining reality are inadequate or incomplete.
- Furthermore, these statements spill beyond any one system and do so in unpredictable ways

Put Another Way

- These theorems reveal that--
- we can neither predict the future migration and evolution of these statements
- nor confine them to any one system
- nor suggest that they fully embrace any such system

Extensions

- Any coherent intellectual or physical system which we evolve to represent large portions of reality will at best do so incompletely and imperfectly
- We cannot create a supersystem that can forecast the kind of systems that will evolve in the future

Extensions

- Furthermore, such a supersystem cannot predict what consequences will flow from systems that we create later on
- We cannot determine or discern the character or nature of such systems with themselves
- It is increasingly difficult and ultimately impossible to interact with and comprehend systems that become more varied unless we use variety to create new understandings

Insights

- The world before us is seemingly orderly and predictable, at least in part, yet increasingly disorderly and unpredictable
- While we can comprehend and predict some portions of an ever changing world that unfolds before us
- Other portions seem forever indistinct and unpredictable
- The more we know, the more we don't know

Questions

- 1) What do science, engineering and technology produce?
- 2) How is this accomplished?
- 3) What is the driving mechanism that keeps the process alive and continuing-- what phenomena sustain and nourish the enterprise of human discovery?
- 4) How do these activities affect us personally as individuals, groups and societies?

1) Change

- What have the combination of science, engineering and technology produced?
- New ideas, new methods, new systems, new processes, new materials, new...
- That is, they produce novelty
- Novelty begets change
- Change is the way we adapt and evolve
 - Sudden or slow, generally uneven
 - Takes time to absorb and integrate

2) Novelty

- The combination of science, engineering and technology produce change via novelty
- Novelty is the product of analysis (reduction, taking things apart) and synthesis (connecting things in different ways)
- Analysis and Synthesis are a feedback loop to comprehend, shape and adapt to the world

3) Mismatches

- If our understanding of the world was perfect, there would be no basis for evolving or creating new ideas, systems or processes
- The presence and production of mismatches are what sustain science, engineering and technology
- The effort to improve our lot is fed by pattern recognition and mismatches

4) Changing Orientation

- Change our understanding of physical universe
- Change the physical reality itself
- Change the way we think about the “fit” between our mental constructs and reality
- Science, engineering and technology change our orientation to match a changing world which we are in fact helping to change

Thus...

- Without the interplay of analysis and synthesis, there is no basis for generating novelty, no way to address mismatches between our image of reality and reality itself, and no process for reshaping our orientation to changing reality
- Novelty, mismatches and reorientation are the fruits of science, engineering and technology that help us to adapt

More Questions

- Why does the world continue to unfold in an irregular, disorderly, unpredictable manner even though some of our best minds try to represent it as being more regular, orderly and predictable?
- Why does such a world, although richer and more robust, continue to remain uncertain, ever-changing and unpredictable?

Features of Our World

- Uncertainty
- Numerical Imprecision
- Quantum Uncertainty
- Entropy
- Irregular Behavior
- Incomprehensibility
- Mutations
- Ambiguity
- Novelty

Underlying Message

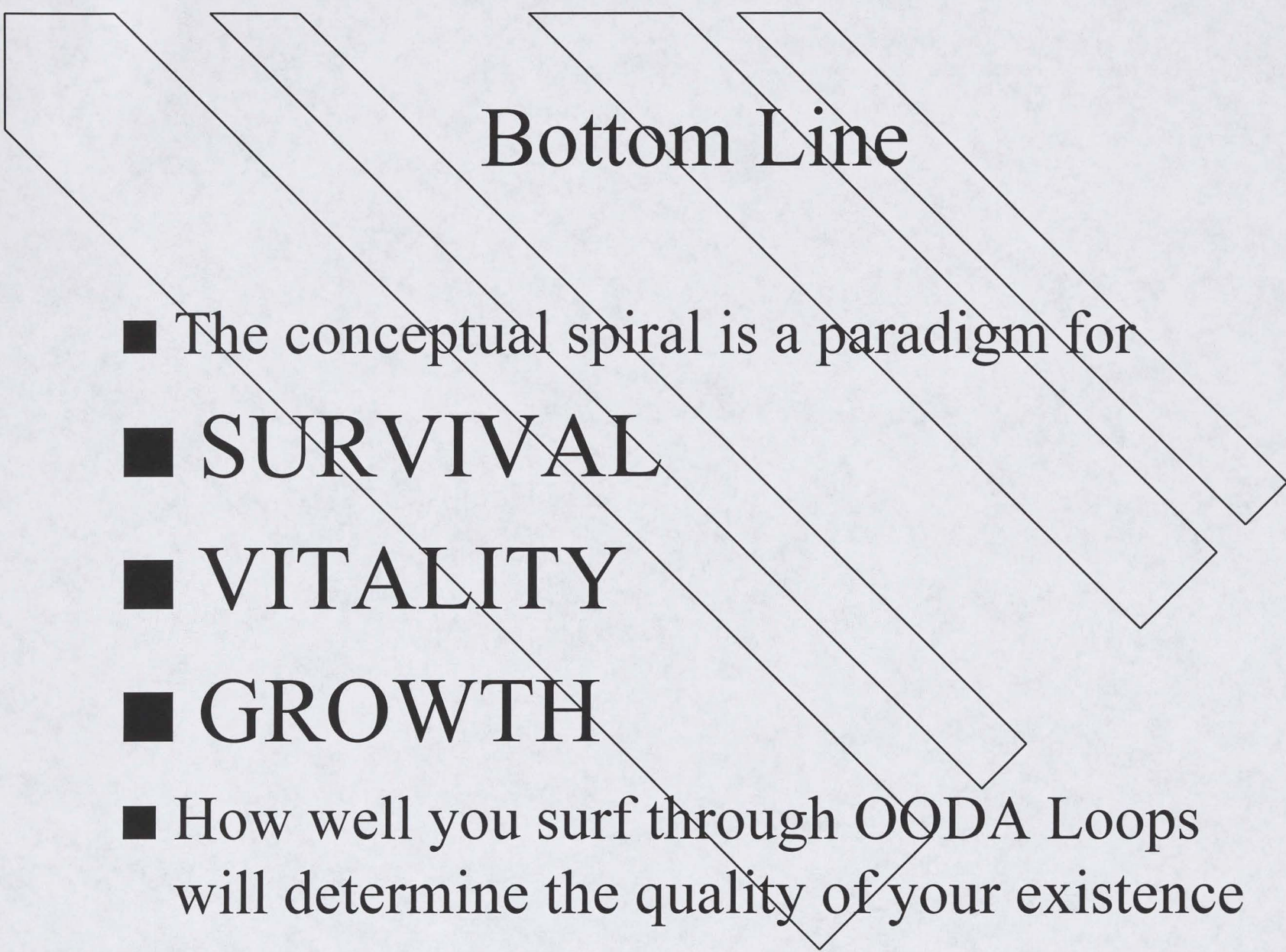
- There is no way out unless we can eliminate these features
- Since we don't know how to do this, we must continue the whirl of reorientation, mismatches, analyses/synthesis over and over again
- This is the basis for trying to comprehend, shape and adapt to an unfolding, evolving reality that is uncertain, ever-changing, and unpredictable

A Conceptual Spiral

Exploration -- Discovery -- Innovation
Thinking -- Doing -- Achieving
Learning -- Unlearning -- Relearning
Comprehending -- Shaping -- Adapting
Insight -- Imagination -- Initiative

Main Point

- “Since survival and growth are directly connected with the uncertain, ever-changing, unpredictable world of winning and losing we will exploit this conceptual spiral of orientation, mismatches, analyses/synthesis, etc..., so we can comprehend, cope with and shape, as well as be shaped by that world and the novelty that arises out of it.”



Bottom Line

- The conceptual spiral is a paradigm for
- SURVIVAL
- VITALITY
- GROWTH
- How well you surf through OODA Loops will determine the quality of your existence

John Boyd

- One of the country's premier strategists
- Col, USAF, fighter pilot (Retired 9/1/75)
- Father of the OODA Loop, EM Theory
- Major player in the design of the F-15
- Chief proponent of the LWF (F-16)
- Leader of the Defense Reform Movement
- "The Briefing"--nearly 1,000 times
- Never published--cited in over 100 books, newspapers, magazines here and abroad

John Boyd

- Largely self taught--no advanced degrees
- Voracious reader--goal in life is to make new connections for illuminating insights
- Enjoys discussions with Nobel Laureates, Institute of Advanced Study, the Santa Fe Institute and others
- Everything he knows flows from studying air to air combat first
- More of an impact on the Army and Marine Corps than the Air Force in many ways

“A Discourse on Winning & Losing”

- Destruction and Creation
- Patterns of Conflict
- An Organic Design for Command & Control
- The Strategic Game of ? and ?
- The Conceptual Spiral
- The Essence of Winning and Losing

Destruction and Creation

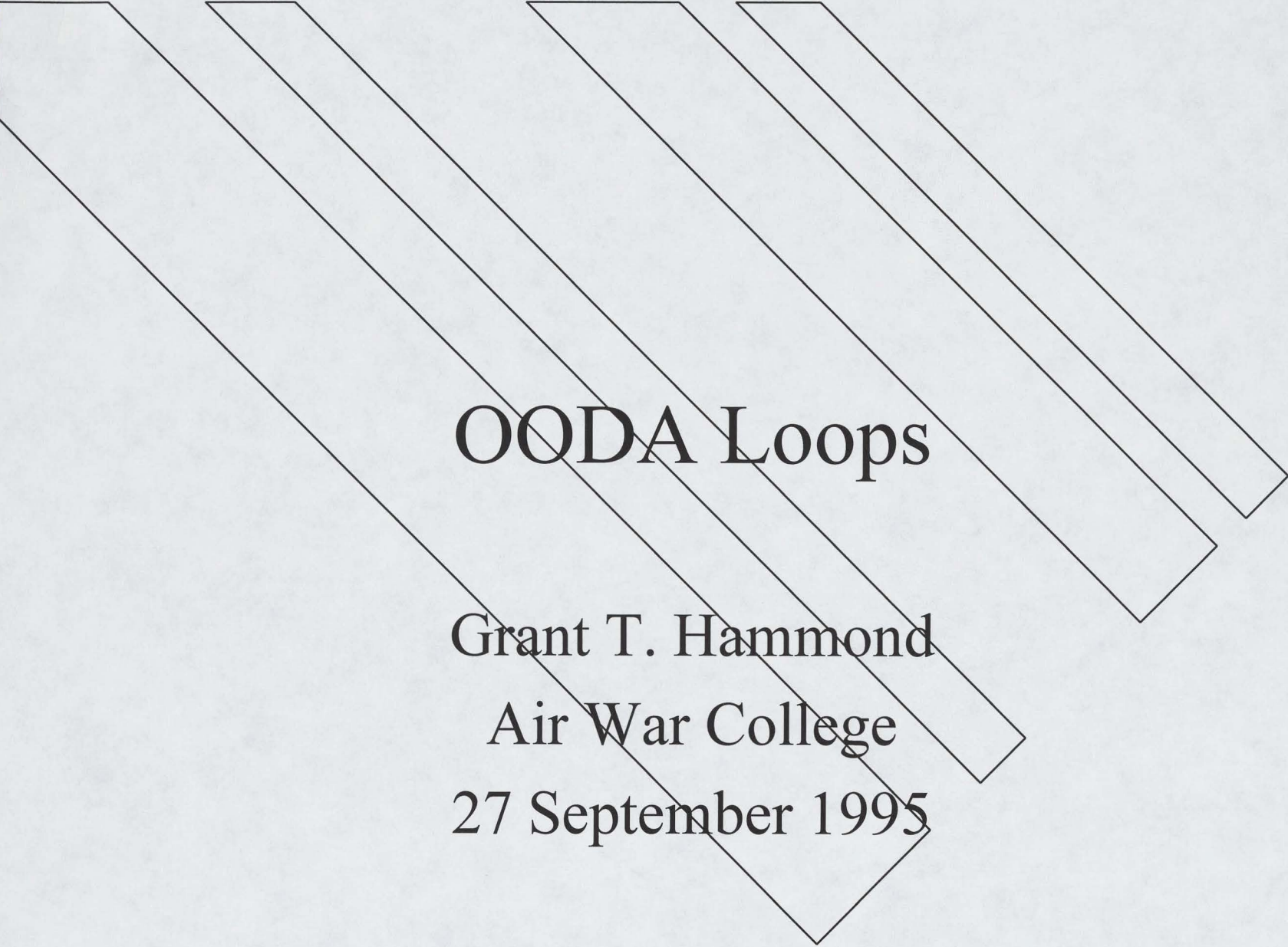
- To keep tabs on the world, processes and ideas, we put tabs on them
- These tabs then substitute as legal tender in the market place of ideas for the reality for which they stand
- From time to time we must revisit the tabs and their implications in order to assess the world and our perception of it anew

Destruction and Creation

- In order to assess the efficacy of a particular existing view, we must destroy it, tear it apart and examine it
- Having taken down the scaffolding of ideas about reality and our view of it, we may erect a new scaffolding, a new view of reality, construct even a new reality itself.
- Before you can create, you must destroy--otherwise you can't think well.

Boyd as Model

- Find another way
- Focus on fundamental questions
- Study doctrines not doctrine
- Use time as the key
- Impact an adversary's perceptions to have him do what you want him to do
- Most importantly, live life as a
- **LOYAL HERETIC**



OODA Loops

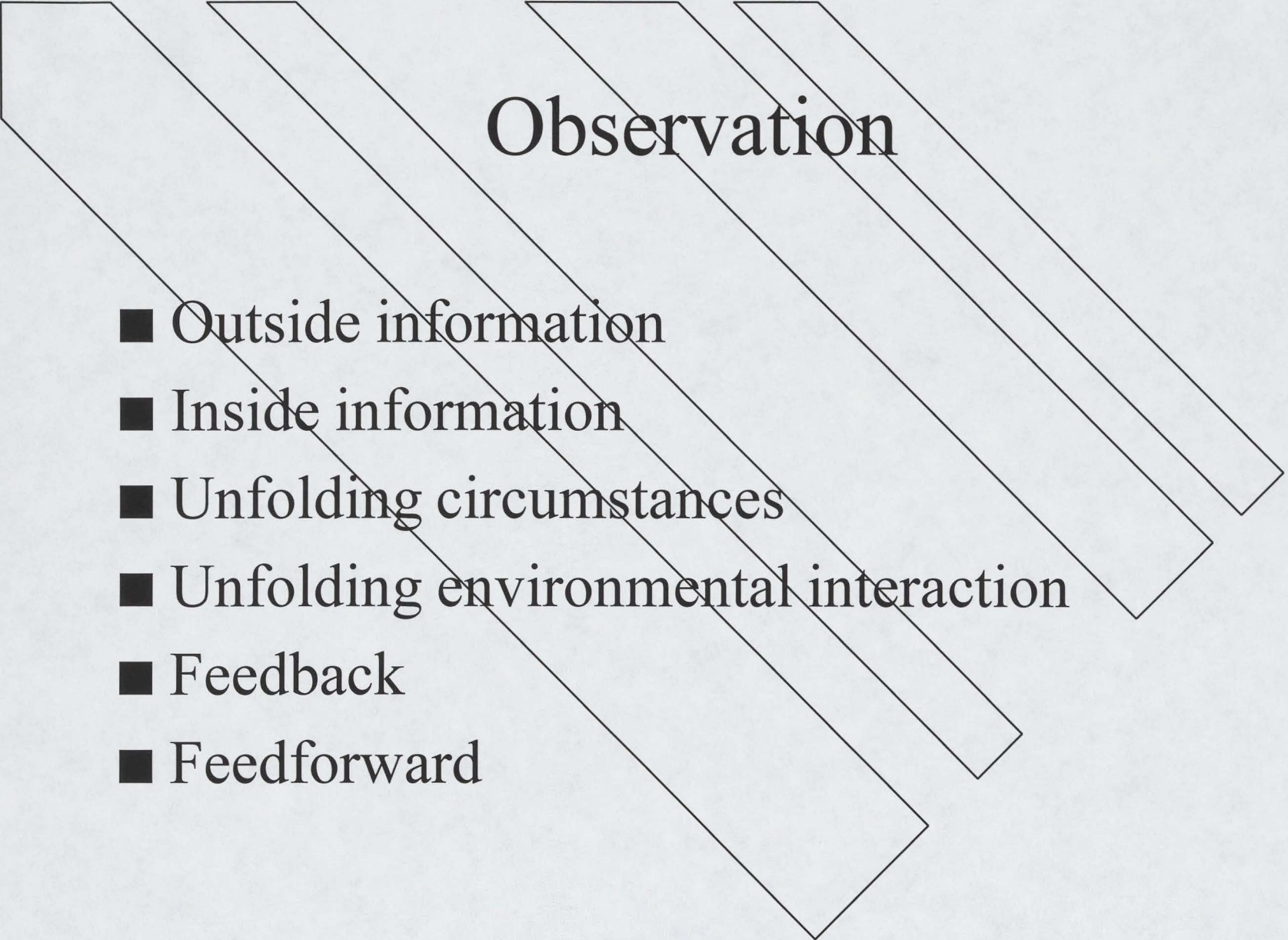
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Observation

- All living organism are sensory beings
- Collect data on
 - the environment
 - themselves
 - the interaction between the two
- Assumptions about guidance and control mechanisms
- Observations feed into orientation

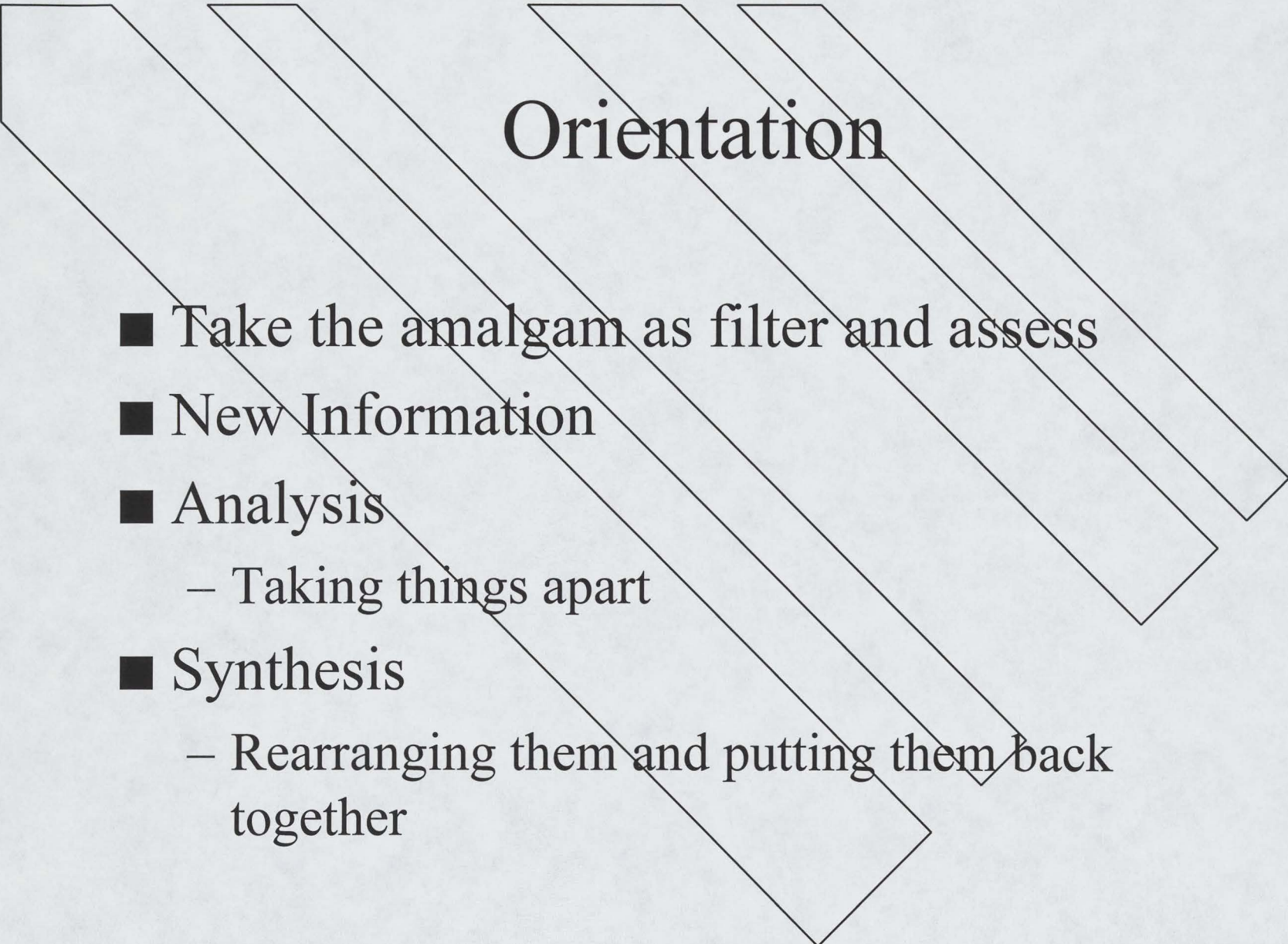


Observation

- Outside information
- Inside information
- Unfolding circumstances
- Unfolding environmental interaction
- Feedback
- Feedforward

Orientation

- Complex amalgam consisting of
 - Genetic heritage
 - Cultural traditions
 - Previous experience
- Each an unavoidable factor in conditioning reactions to circumstances we encounter
- Create new analyses & syntheses
- Inputs which inform decisions



Orientation

- Take the amalgam as filter and assess
- New Information
- Analysis
 - Taking things apart
- Synthesis
 - Rearranging them and putting them back together

Decision

- The product of assessments of our interaction with our environment at t^1
- New data from $t^2...t^n$
- Leads to alternative courses of actions
- Select from an array of choice
 - Maximize, minimize, satisfy, etc..
- Hypothesis about how best to interact with our environment

Action

- Test of the hypothesis we decided upon
- Effort to shape, adapt to and, in turn, be shaped by the environment
- Subjected to unfolding trial of interaction with the environment
- Creates new data and arrangements to observe
- Begins OODA Loop cycle again

OODA Loops

- OODA Loops are continuous cycles of interaction
- A cascade of information and information processing in light of bias, habit and abilities
- Tentative decisions from among many choices
- Action based on this assessment
- Repeat...Repeat... Repeat...

Cycle Time

- How fast or slowly we respond to each aspect of the OODA Loop may determine our survival
- Will determine our ability to prosper and grow
- Is an indication of our vitality and ability to adapt
- Is critical to competition and life itself

Origins of the OODA Loop

- Air to Air combat in Korea
- How could F-86s best MIG-15s which ~~were~~ *could account down*
~~faster~~, had higher ceiling?
- First, see better
- Second, react faster
- Third, know differential capabilities
- Fourth, use these to advantage

Advantages

- Framework is not discipline dependent
- Contextual reality
- “Elasticity of time” concept
- Assess decision maker’s perspectives
- Can change focus and field of view
- Combine data, behavior and structure
- An unending cycle

Cycle Time and Fast Transients

- Led from what we now call “Situational Awareness” to
- Speed with which one could receive, process and react to information flows
- Reaction time--accelerate, decelerate, climb, dive, maneuver sequences
- *partly from* Led to “Energy Maneuverability Theory” and the “Max Maneuver Concept”