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Advanced Modeling & Simulation

# **“Who’s got the grease pencil?!” What Cyber Security can Learn from the Outer Air Battle**

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15<sup>th</sup> ICCRTS  
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U.S. Navy photo by Photographer's Mate Airman Apprentice Antonia Ramos (RELEASED)



U.S. Army photo by Staff Sgt. Lorie Jewell (Released)

# **“Who’s got the grease pencil?!”**

## **What Cyber Security can Learn from the Outer Air Battle**

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- **A Battle of Complex, Adapting, Living Systems**
- **The Outer Air Battle – plan for degradation**
- **Danger of Too Much Information**
- **Conclusion**

# Battle of Complex Adaptive Living Systems

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## The adversary gets a vote



# Battle of Complex Adaptive Living Systems

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## ▪ **Complicated**

- Known/knowable, predictable cause and effect chain
- Inputs/outputs proportional
- Whole equals sum of parts

## ▪ **Complex**

- Multiple interdependent variables
- Changing cause and effect chain
- Inputs and outputs not proportional; whole does not equal sum of the parts

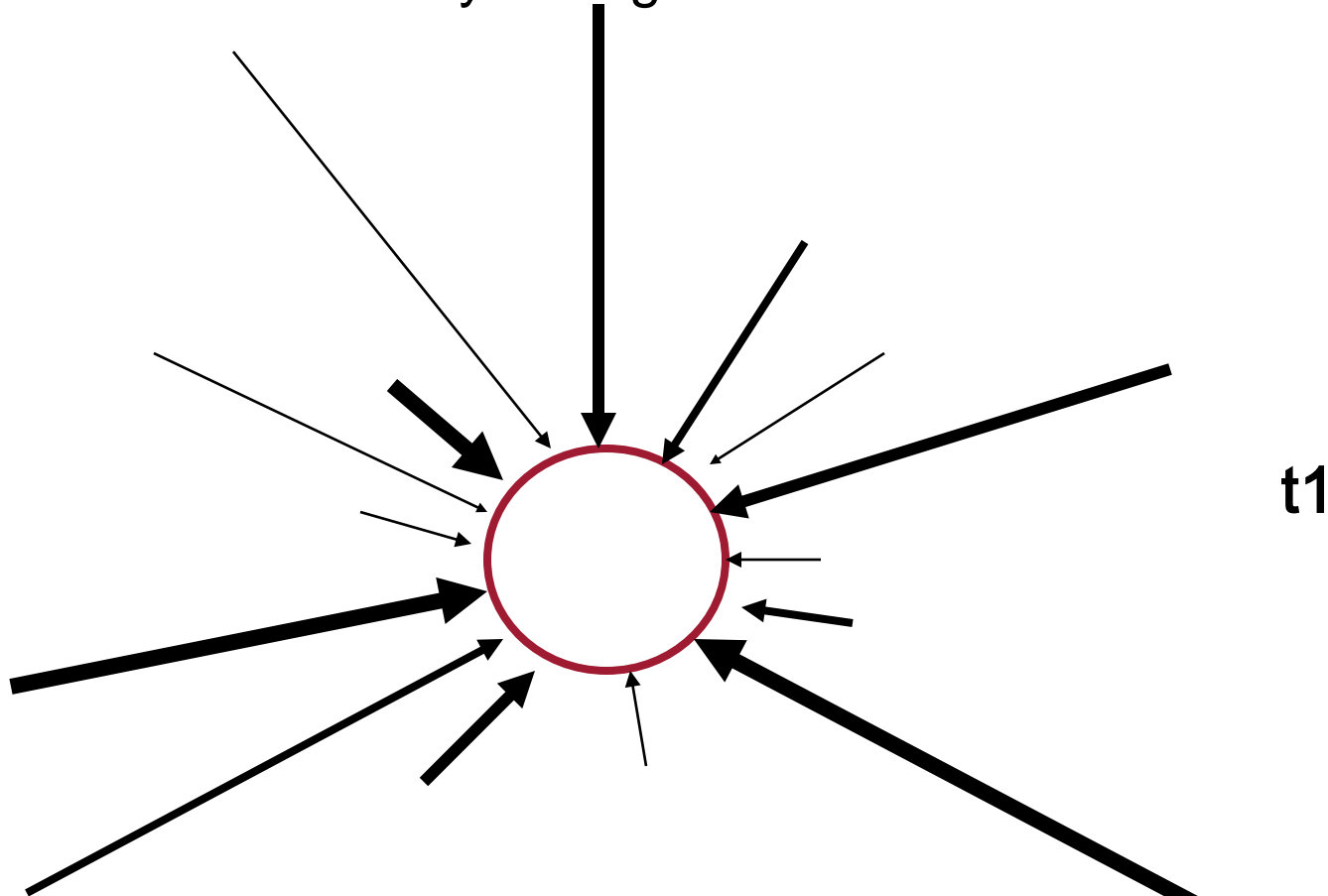
## ▪ **Complex Adaptive System**

- Reacts and evolves independently in ways we cannot entirely predict

# Complexity: Interdependent Variables

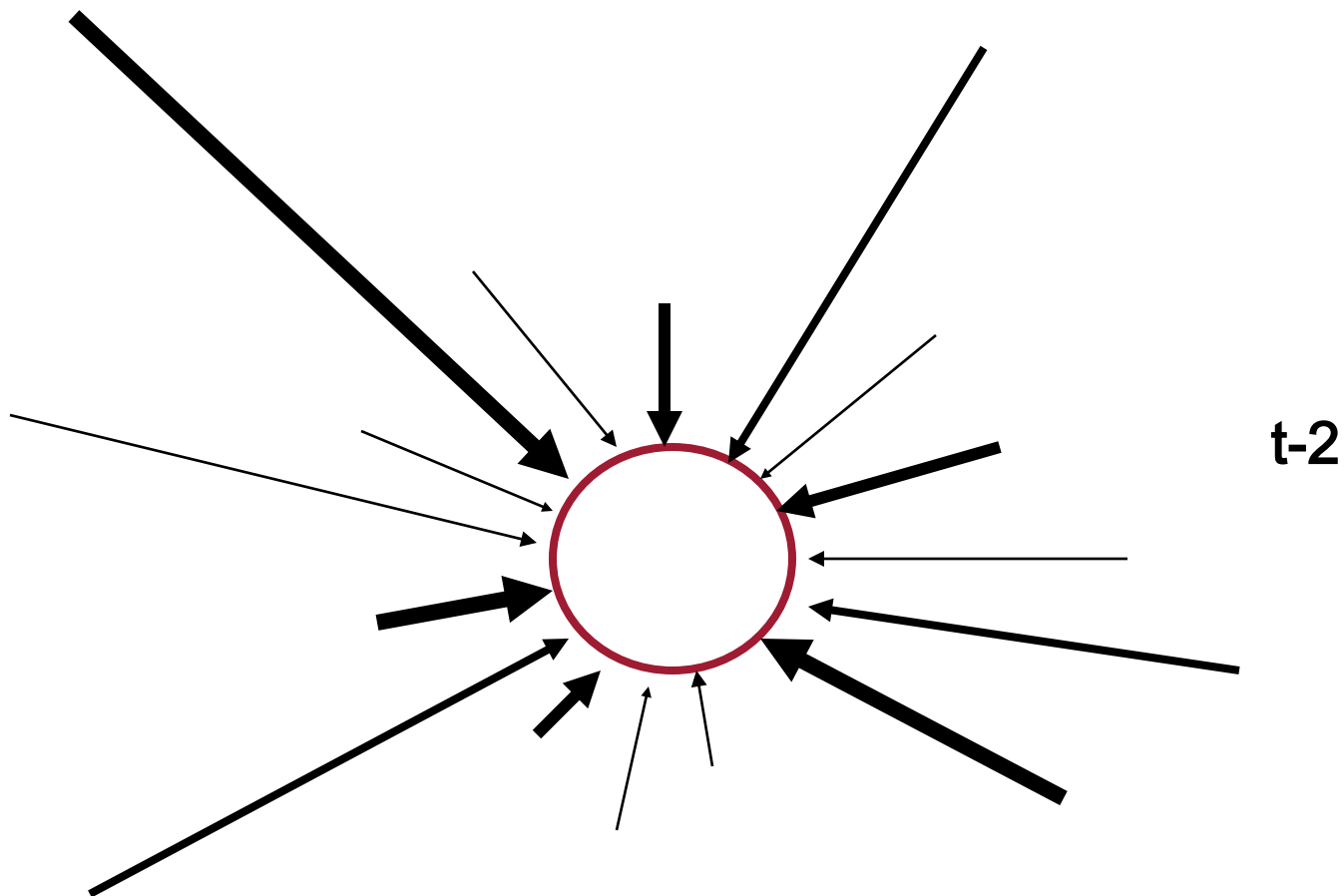
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Large numbers of interdependent variables shape the behavior of each actor but continually change



# Complexity: Interdependent Variables

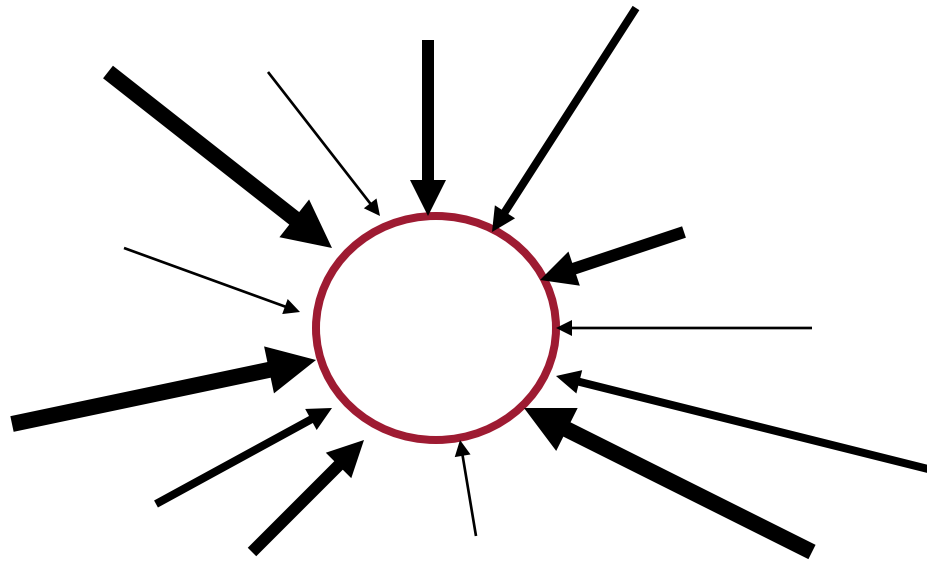
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# Complexity: Interdependent Variables

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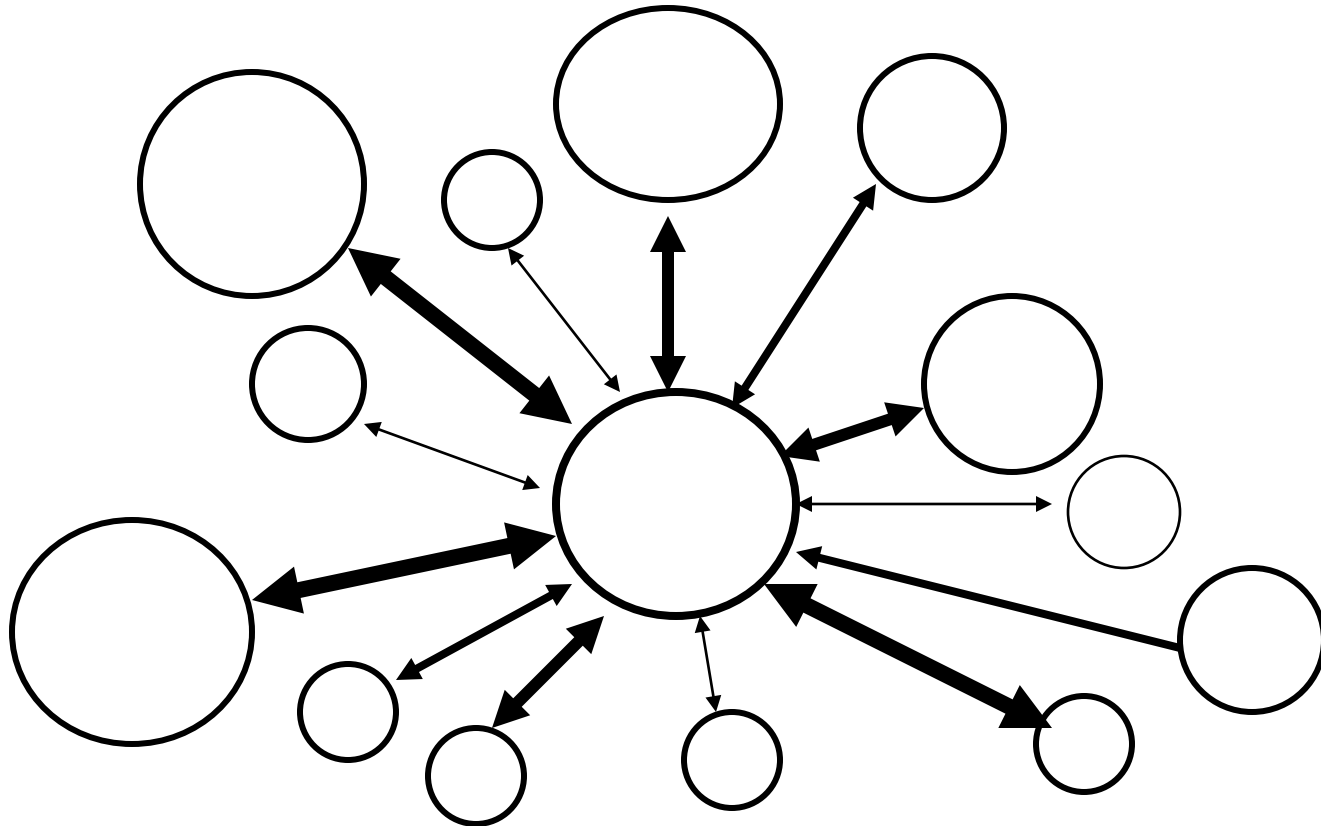


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# Complexity: Interdependent Variables

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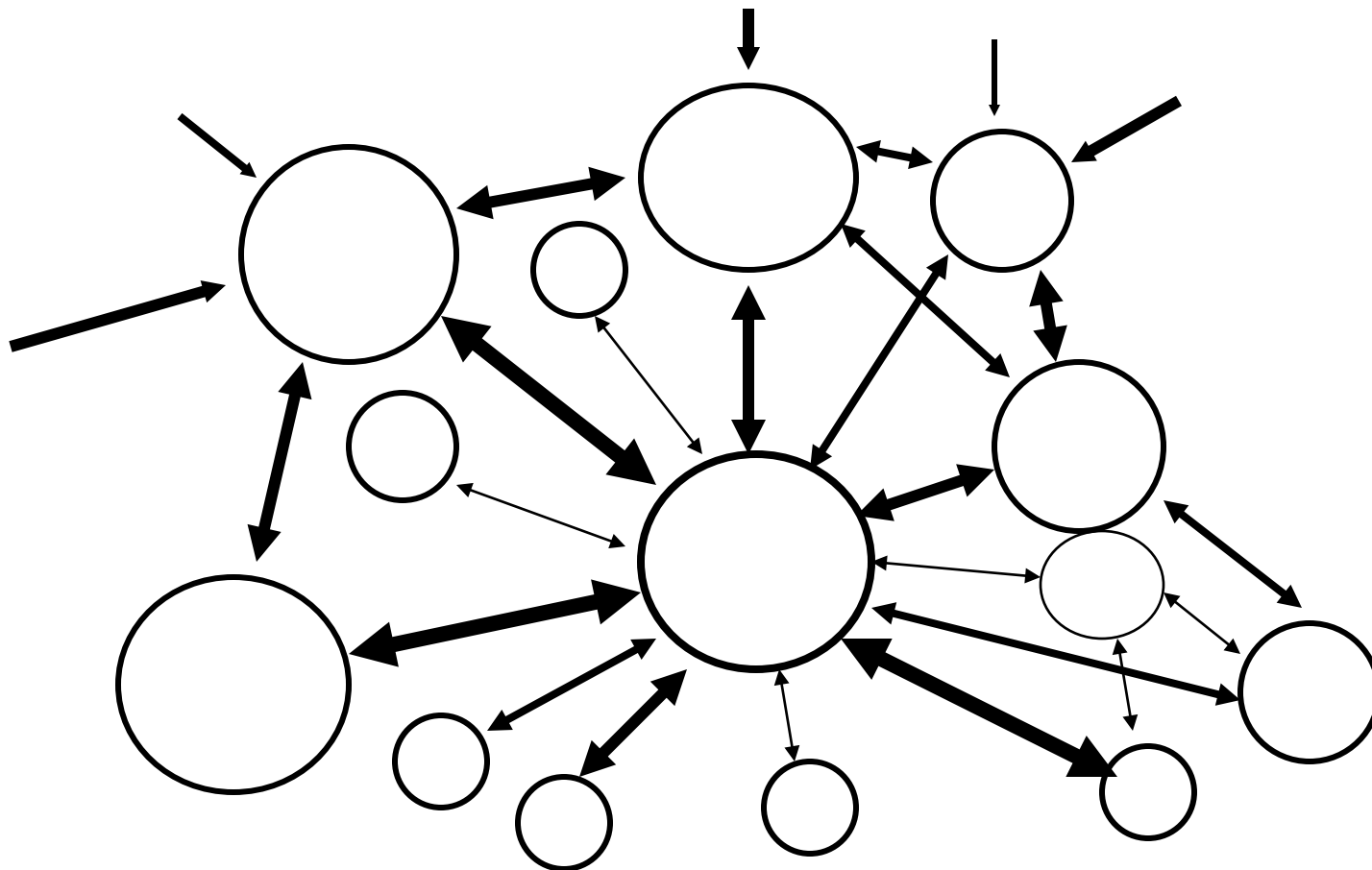
Each variable is two-directional affecting other actors...



# Complexity: Interdependent Variables

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... who in turn co-evolve and affect each other.



# Adaptation Key Traits

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- **Flexibility** – how robust an organization is in adapting to new mission sets at the strategic / operational (higher) level
- **Resilience** – how robust an organization is in adapting to damage to their system
- **Responsiveness** – how robust an organization is in adapting to new mission sets at the operational / tactical (lower) level
- **Agility** – how quickly an organization adapts to a changing environment

# Levels of Adaptation

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- **Action** – how well the system adapts at the tactical level – the point of action.
- **Learning** – how well the system absorbs and adapts to changes in the outer environment.
- **Learning to learn** – how well the system is structured to learn and adapt.
- **Defining success** – how well the system is able to redefine their fitness based on new information / lessons learned.
- **Co-adaptation** – from the system of systems standpoint, how well the disparate organizations are able to co-adapt to improve the fitness of the greater system.

# Adaptive Action

How well the system adapts at the tactical level – the point of action

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U.S. Navy photo by James D. Hamill/Released

# Learning

How well the system absorbs and adapts to changes in the outer environment

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U.S. Navy photo by Photographer's Mate 1st Class Michael W. Pendergrass. (RELEASED)



# Learning to Learn

How well the system is structured to learn and adapt

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U.S. Navy photo by Photographer's Mate 1st Class Mahlon K. Miller. (RELEASED)

# Defining / Redefining Success

How well the system is able to redefine their fitness based on new information / lessons learned

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# Co-Adaptation

How well the disparate organs  
the fitness of the greater sys

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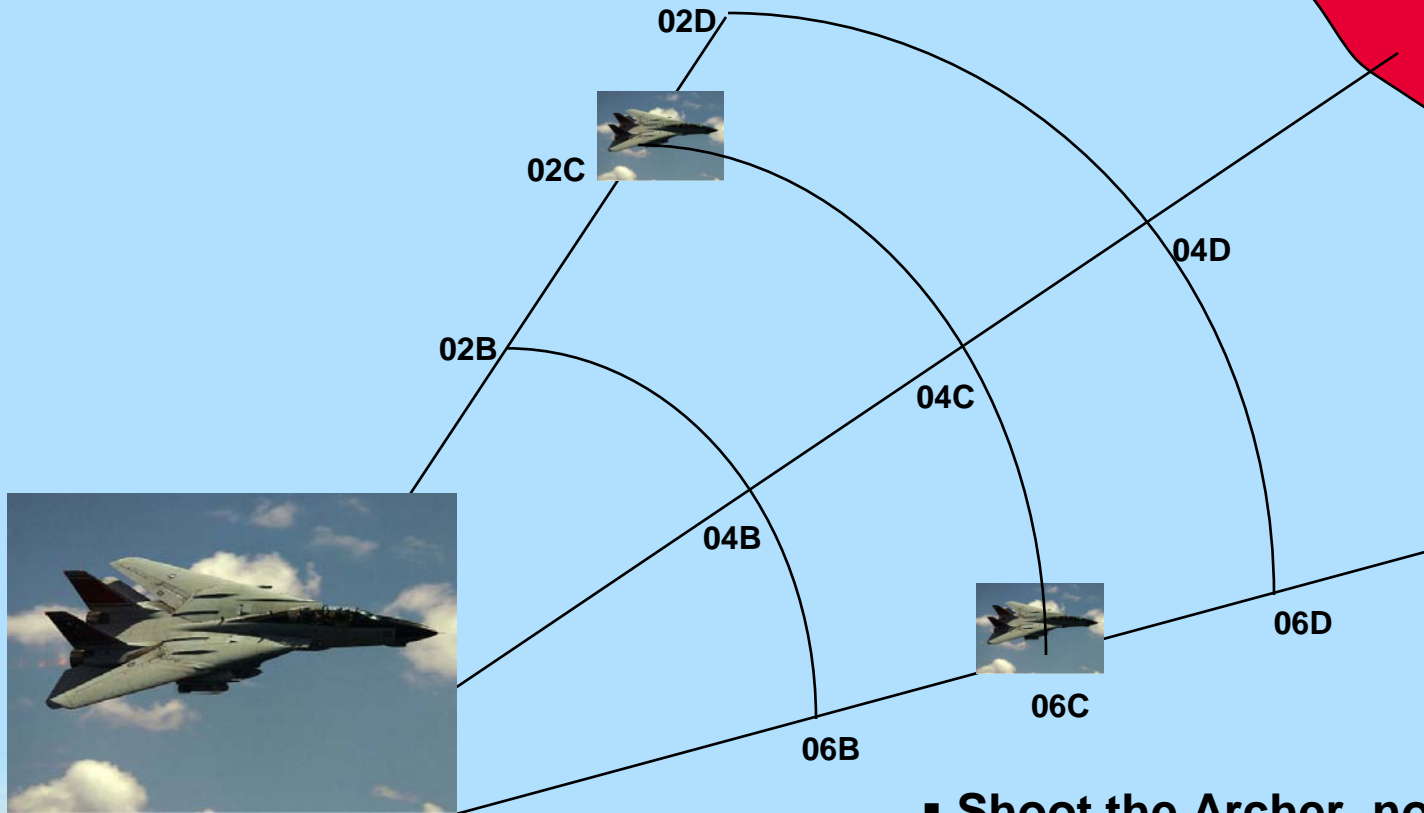
**Complex Adaptive Living Systems may be a  
useful model for real world challenges**

U.S. Navy photo by

Illen III (RELEASED)

# The Outer Air Battle

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U.S. Navy photo by Photographer's Mate 3rd Class Christopher B. Long (RELEASED)

- **Shoot the Archer, not the Arrows**
- **Electrons on the Attack**

**Plan for degradation**



# Danger of Too Much Information

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- **Blurring Levels of War?**
- **GOOOAAAALLLL!!!!!!**  
**(a sports analogy)**

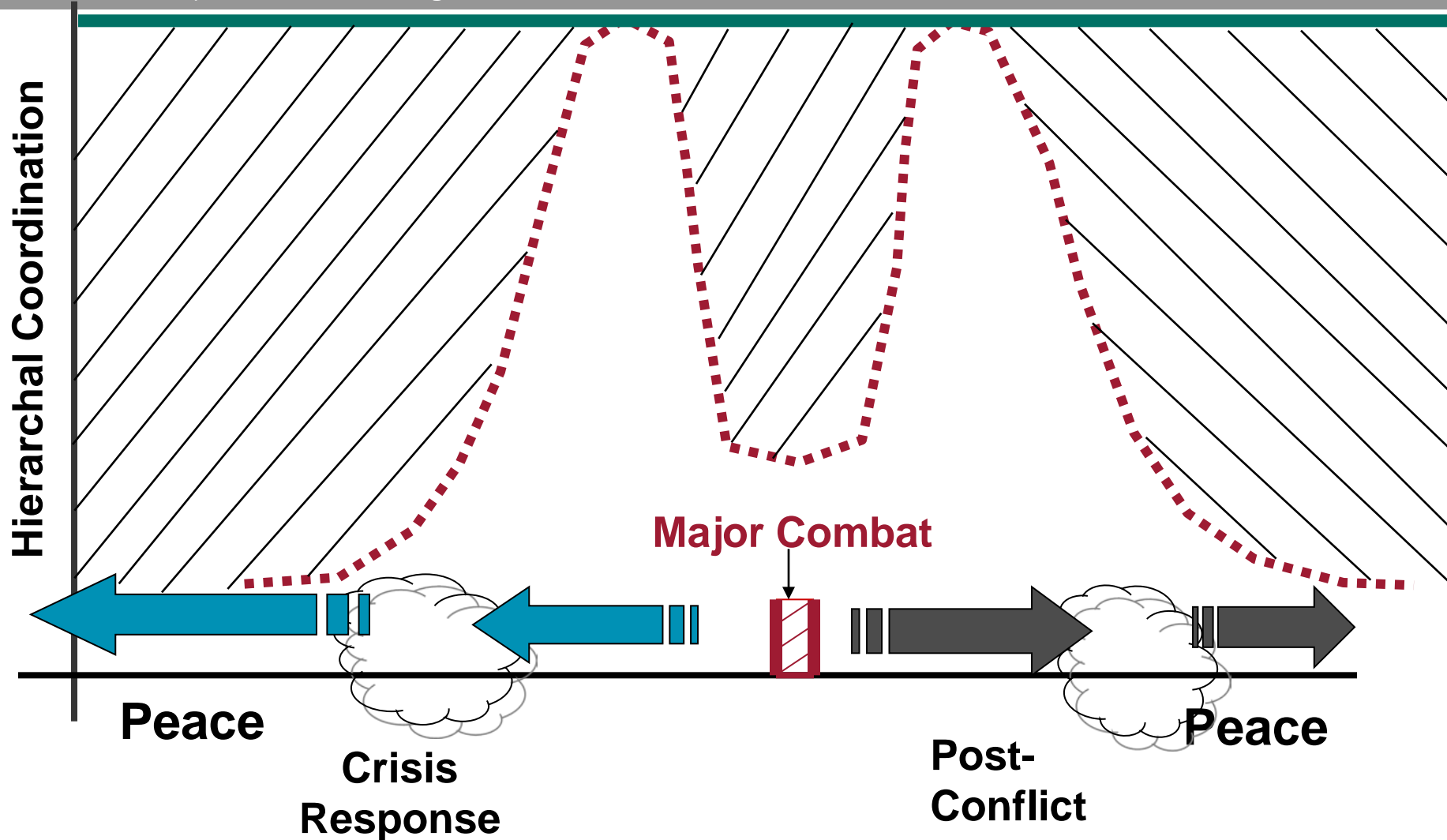


**Emergent functions at different  
scales may need different  
approaches and tools**

Insen Laurel

# Danger of Too Much Information Coordination over Time

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# Conclusion

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- **This is no “black box” solution to complex human challenges**
- **Never forget that your adversary gets a vote**
- **Complex adaptive living systems may be a useful model for real world challenges**
- **Plan for degradation**
- **Hierarchy is not inherently evil ... emergent functions at different scales may need different approaches and tools**



# Questions

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“It's not if the nets go down but when they go down, because the enemy is going to try to take them down. There is no military in the world more vulnerable to losing its nets than the U.S. military because we are so reliant on them for our worldwide operations. We need to create a corps of officers who are comfortable with uncertainty and ensure that they can give commander's intent - broad guidance to their subordinates - so that when, not if, the nets go down, they can continue to operate at good speed, understanding what the commander needs done.”

**Gen. James Mattis**

Commander, U.S. Joint Forces Command

Interview with Vago Muradian

23 May 2010

# Questions

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“We've raised a generation that, for the last nine years of active operations, have never been out of touch with their higher headquarters. What we're going to have to do is train by turning off the radios - as we did in the Cold War, when by pressing that handset key and transmitting, you were endangering yourself to the enemy's strikes on you. We're going to have to get used to turning off the handsets for other reasons: to see if people can operate on their own initiative.”

**Gen. James Mattis**

Commander, U.S. Joint Forces Command

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# Questions

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“To the extent possible, naval forces will deploy and employ redundant systems to maintain command and control of dispersed forces in the face of such threats, and will maintain proficiency in retaining the operational and tactical initiative when communications and information systems are degraded or denied.”

## **Naval Operations Concept 2010**