



JADC2: Getting Down to Work

John Flach, Pete Venero, Sarah Hill, Michael Smith

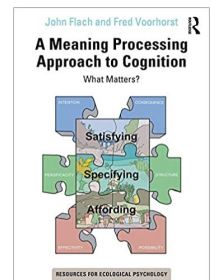
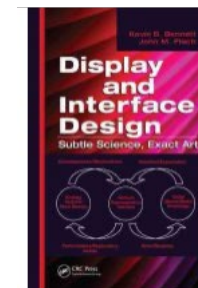
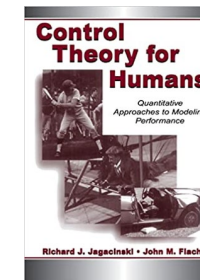
NDIA 2023 HUMAN SYSTEMS CONFERENCE

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Context Matters!

- I have been working in the field of Cognitive Systems Engineering for almost 40 years.
 - Early collaborations with Jens Rasmussen and Kim Vicente
 - Co-authored books on control theory, interface design, applied cognition
- I have had extensive interactions with DoD research community.
 - Collaborated with Rik Warren, Grant McMillan & Gary Riccio (AFRL) to frame an “Active Psychophysics” for assessing pilot performance.
 - Work analysis on SEAD with Gil Kuperman (AFRL).
- I have limited experience with the operational military community.
 - Was observer at JEFEXs at Nellis, AFB (2002 – 2005).
- I have recently been exploring issues of polycentric control related to emergency operations.
 - Innovations in communications systems (AWARE)
 - Review of major incidents (Washington Naval Yard, Uvalde)
 - Interviews and observations during training exercises.



Context Matters: Putting Control into the Hands of Smart Humans

The comic strip consists of five panels. The top row has three panels: 1. A large, boxy airship with yellow sails on a barge. 2. The airship is shown in flight, but the sails are detached and falling away. 3. The airship has crashed into the water, with the sails floating nearby. The bottom row has two panels: 1. A newspaper clipping from the Stark County Democrat, dated July 3, 1907, with the headline 'FLYING MACHINE FIASCO' and sub-headline 'Prof. Langley's Airship Proves a Complete Failure.' 2. A simple line drawing of a biplane on a flat field with a person standing nearby.

AROUND 1900, SAMUEL LANGLEY WAS GRANTED \$70,000 TO DEVELOP A PILOTED AIRPLANE

TWO ATTEMPTS, 7 OCTOBER AND 8 DECEMBER 1903 HAVE THE SAME RESULT....

LANGLEY GIVES UP..

Stark County Democrat.
CANTON, OHIO FRIDAY, JULY 3 1907

FLYING MACHINE FIASCO

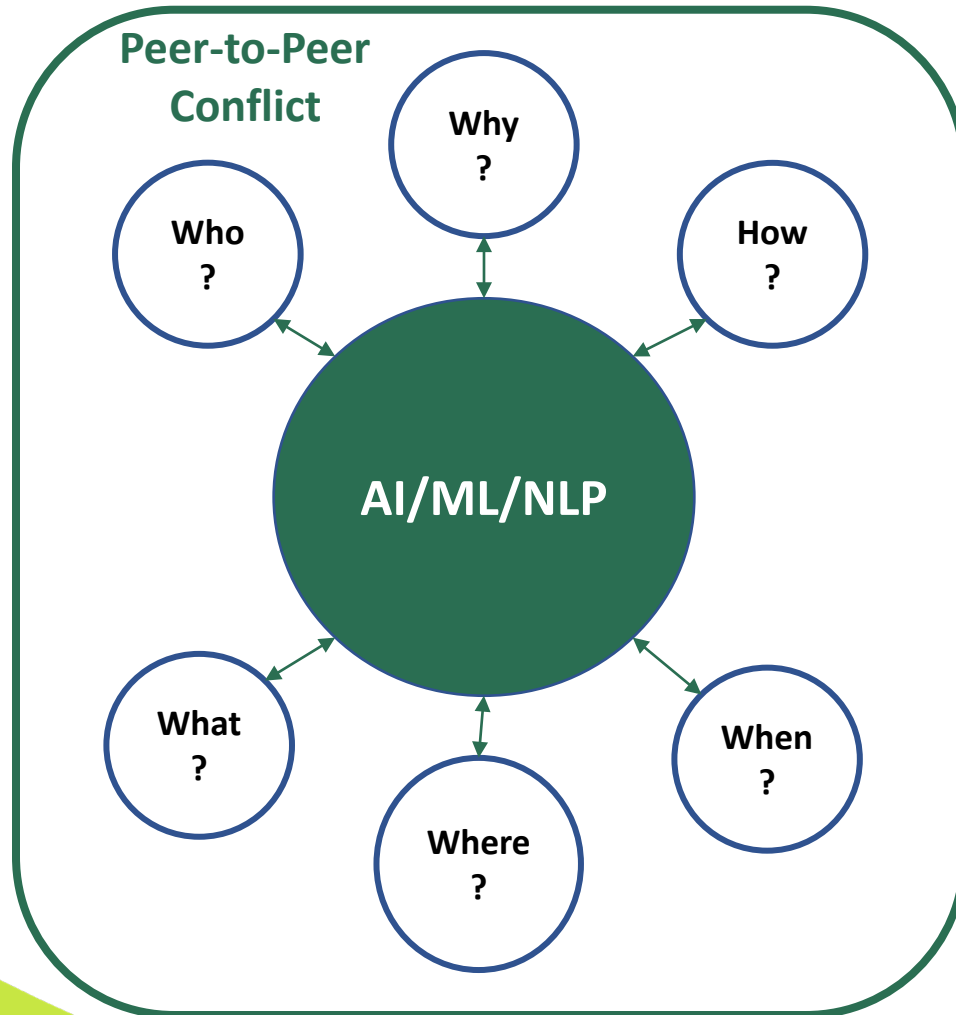
Prof. Langley's Airship Proves a Complete Failure.

Prof. Langley in the Car of the Aero...

NEWSPAPERS REPORT THE FAILURE, AND URGE LANGLEY TO INVEST HIS TIME AND RESOURCES INTO SOMETHING MORE USEFUL. IT WILL TAKE MILLION YEARS BEFORE MAN FLIES...

DEC 17, 1903.... WILLBUR AND ORVILLE WRIGHT MAKE THE FIRST EVER PILOTED FLIGHT

Concerns/Questions???



- Are we approaching **JADC2** in the spirit of **Langley** or in the spirit of the **Wrights**?
- How important is **technological superiority** in determining success in peer-to-peer conflict?
- Are investments in technology coming at the expense of investments in **people**?
- How important is a **systems perspective** to innovation?
- **What does it mean to be "in control" of a complex, distributed organization?**

Hollnagel's Test



Erik Hollnagel



Dave Woods

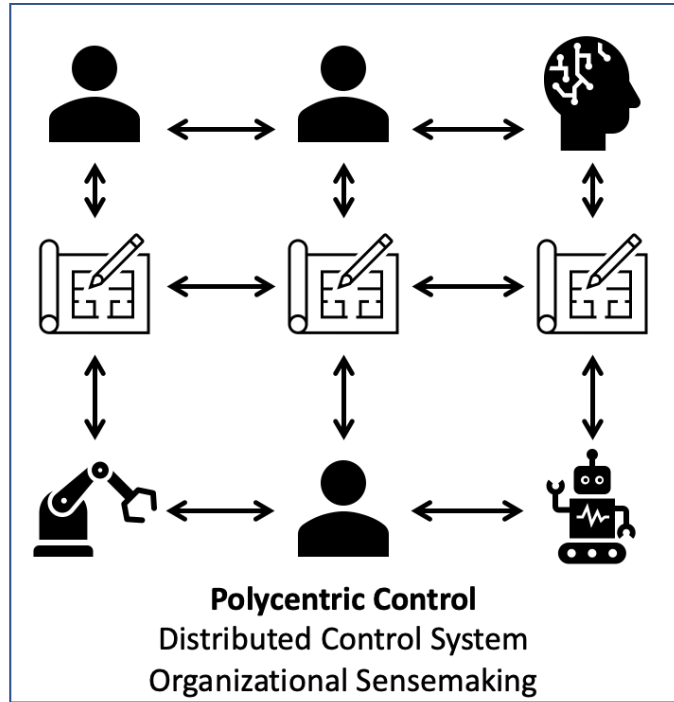
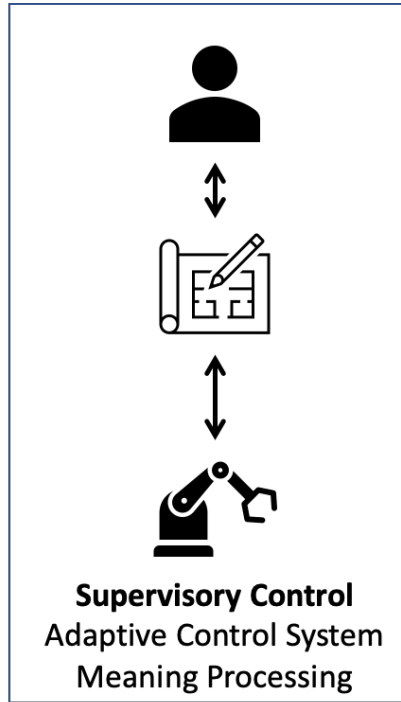
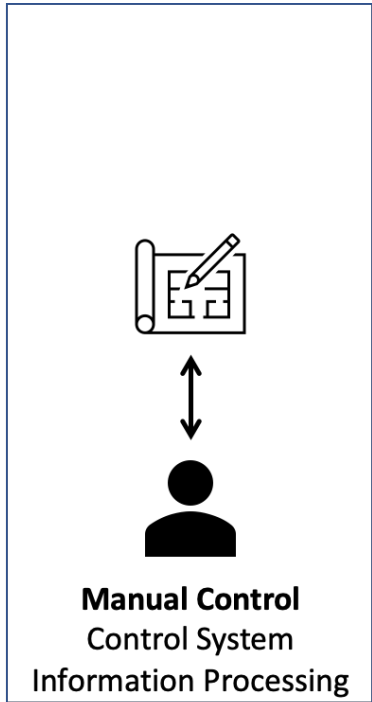
Each technology shift – manual to automated control to multi-layered networks – extends the range of potential control, and in doing so, the joint cognitive system that performs work in context changes as well. For the new joint cognitive system, one then asks the questions of Hollnagel's test:

What does it mean to be 'in control'?

How to amplify control within the new range of possibilities?

(Woods & Branlat 2010, p. xx)

Polycentric Control: Toward Resilient Organizations



“If we do not understand the process of which to make a decision, there is no technology that you’re going to develop that’s going to suddenly turn this tide.”

(Brig. Gen. Jeff Valenzia, JADC2 cross-functional team lead for Air Force Futures, cited in Pomerleau, FEDSCOOP Aug 12, 2022)

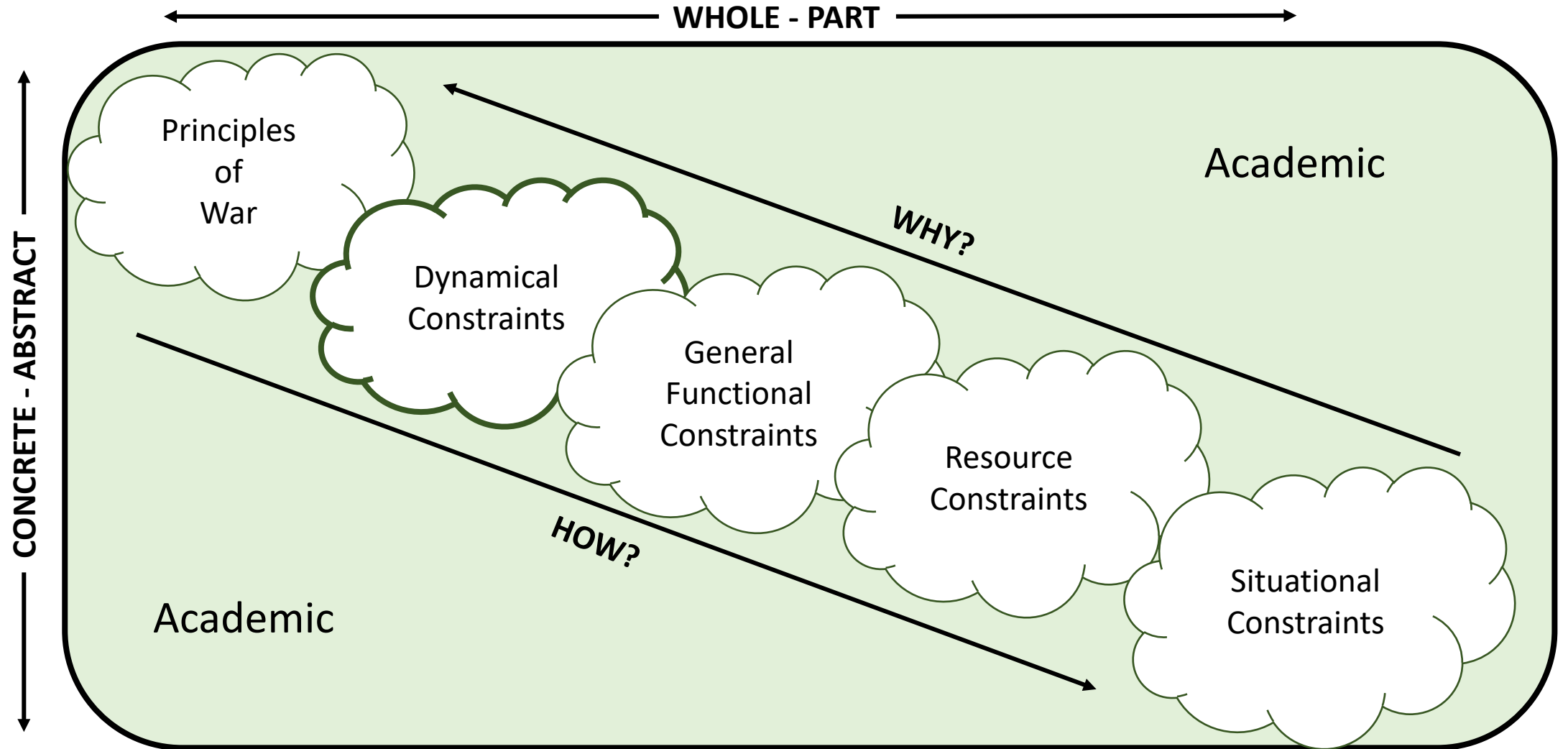


Human Factors Engineering
How well can people follow the plan to accomplish a goal?

Cognitive Systems Engineering
How well can people detect flaws in the plan and make appropriate adaptations in order to achieve a goal?

Resilience Engineering
How well can people collaborate with other semi-autonomous agents and co-adapt their plans and activities to achieve a common goal?

Work Analysis: Abstraction/Decomposition



Dynamical Constraints of Polycentric Control Systems

- **Military Science**
 - **Mission Command** →
 - Command Intent
 - McChrystal - Team of Teams Dynamics
- **Motor Control** – perception-action coupling
 - Berstein; Kugler & Turvey; - coordinative structures
 - EJ Gibson; Runeson; - attunement of smart mechanisms
- **Economics** – limitations of centralized economic planning
 - Hayak – free markets
 - Ostrom – tragedy of the commons; polycentric control
 - Krugman – self-organizing economies
- **Organizational Psychology**
 - Thompson – standardization, planning, mutual adjustment
 - Weick – organizational sensemaking
 - Cooke – team cognition
- **Cognitive Psychology**
 - Klein – Naturalistic Decision Making, Data-frame model
 - Gigerenzer – Ecological Rationality
- **Systems Engineering**
 - Sage – systems of systems, federalism, subsidiarity
 - Rochlin – necessary friction
- **Physics**
 - Bak – Self-organizing criticality in dynamical systems
- **Biology**
 - Kaufman – evolutionary biology

“**Mission Command** is the conduct of military operations through **decentralized execution** based upon mission-type orders. Successful mission command demands that subordinate leaders at all echelons exercise **disciplined initiative** and act aggressively and independently to accomplish the mission”

Martin E. Dempsey,

General, U.S. Army,

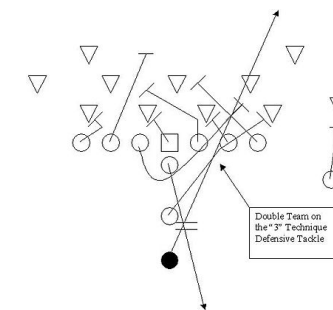
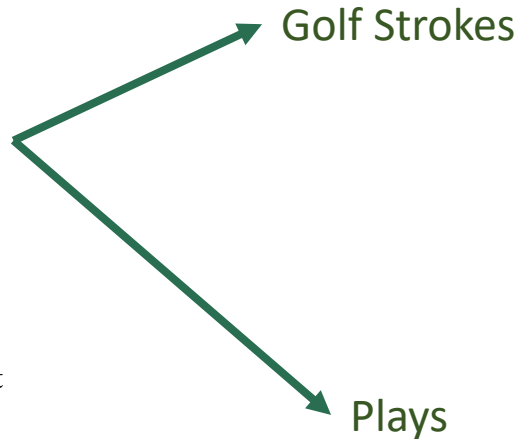
Chairman of the Joint Chiefs of Staff

Several key attributes enable the practical application of mission command. These are understanding, intent, and trust.

- **Understanding** – What changes for Joint Force 2020 is the increasing need for the commander to frequently frame and reframe an environment of ill-structured problems to gain the context of operations by continuously challenging the assumptions both before and after execution.
- **Intent** – [commanders] will be required to clearly translate their intent ... to their subordinates and trust them to perform with responsible initiative in complex, fast-changing, chaotic circumstances.
- **Trust** - building trust with subordinates and partners may be the most important action a commander will perform. Given our projected need for superior speed in competitive cycles of decision-making, it is clear that in Joint Force 2020, *operations will move at the speed of trust.*

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Miller, C. & Parasuraman, R. (2007). Designing for flexible interaction between humans and automation: Delegation interfaces for supervisory control. **Human Factors**, 49(1). 57-75.

Behymer, K.J., Patzek, M.J., Rothwell, C.D., Ruff, H.A.: Initial Evaluation of the Intelligent Multi-UxV Planner with Adaptive Collaborative/Control Technologies (IMPACT). Technical report, AFRL-RH-WP-TR-2016-TBD (in preparation)

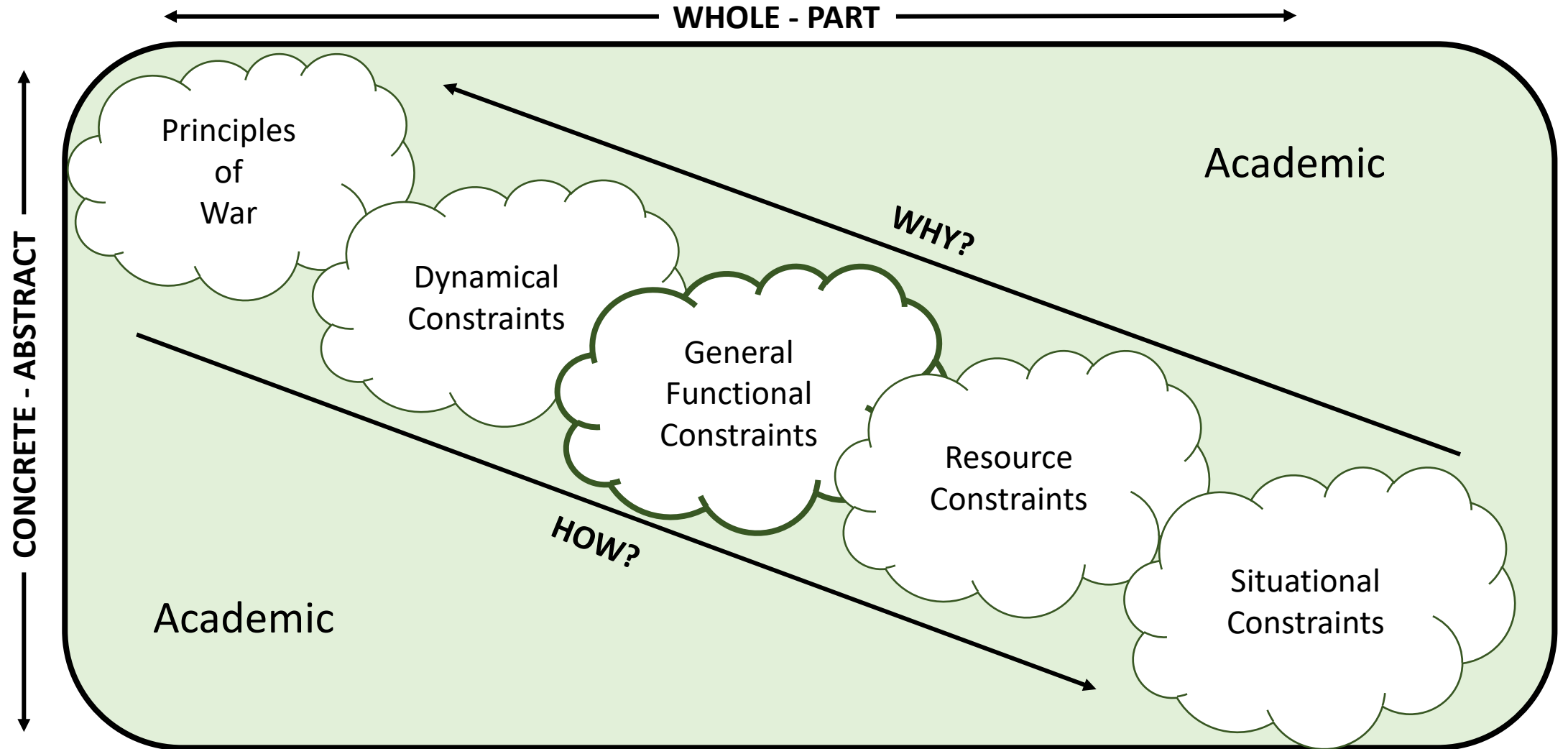
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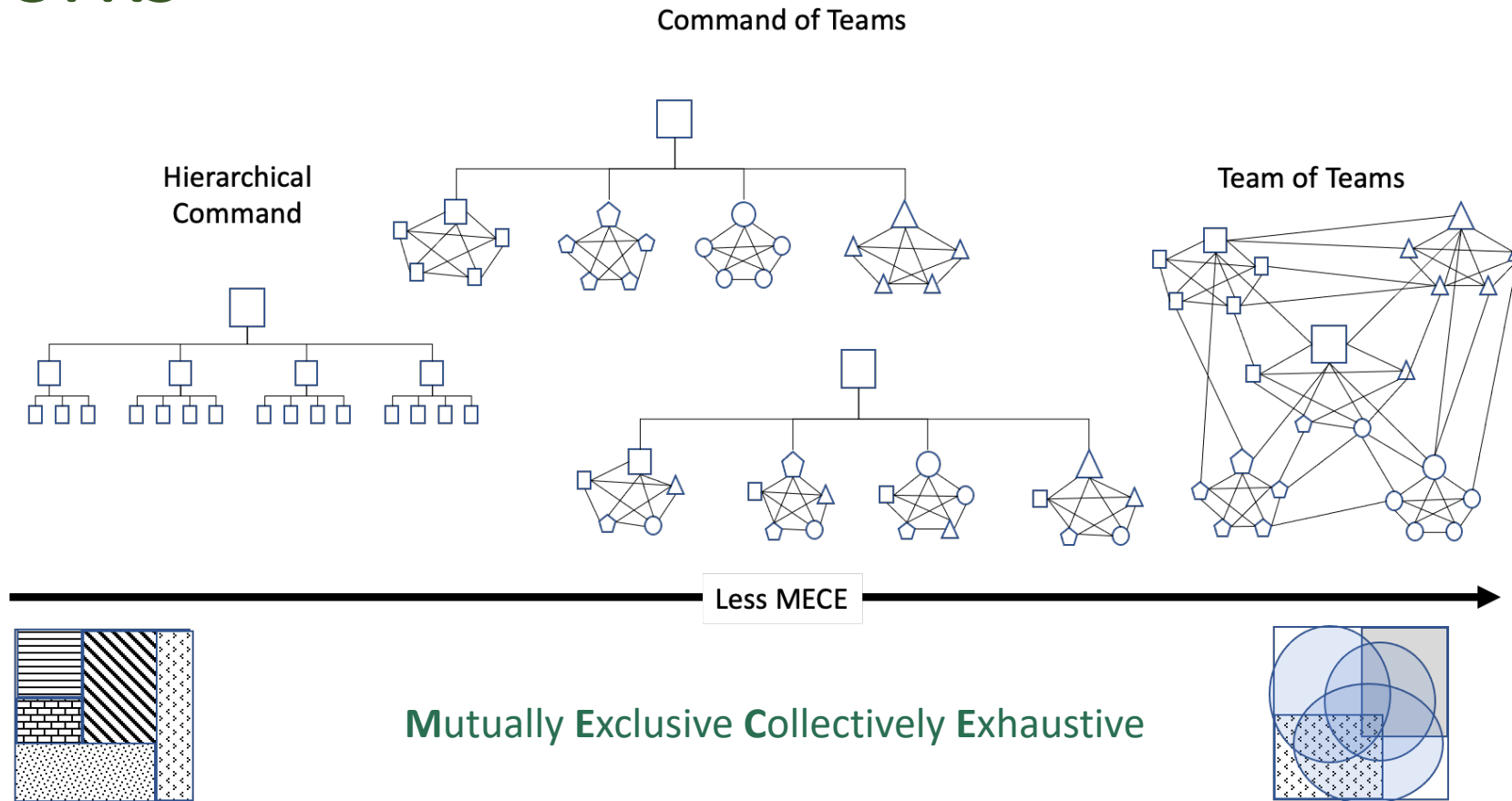
Subsidiarity is the most important of federalism's principles. It means that **power belongs to the lowest possible point within the FOS** engineering team. Handy indicates that a higher order body should not take unto itself those responsibilities which properly belong to a lower order body. Managers are often tempted to subsume their subordinates' decision prerogatives. **Subsidiarity requires, instead, that they enable those subordinates, by training, advice, and support, to make those decisions better.** *Subsidiarity is the reverse of empowerment in that it is not the FOS program manager who is giving away or delegating power. Instead, power is assumed to lie at the lowest point in the organization and should be taken away only by agreement between the engineering professional and project manager(s).*

Sage & Cuppan (2001). On the Systems Engineering and Management of Systems of Systems and Federations of Systems. Information-Knowledge-Systems Management, 2, 325-345.

Work Analysis: Abstraction/Decomposition

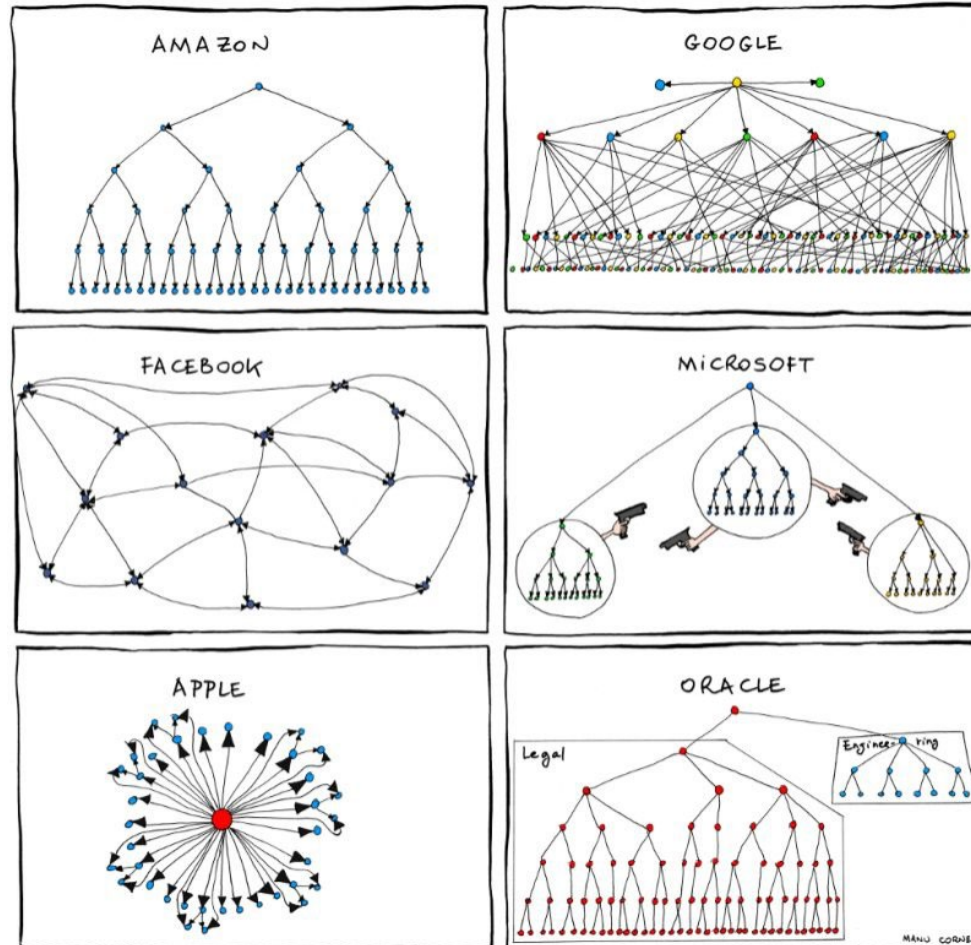


General Functional Constraints: Layered Networks



McChrystal (2015)

General Functional Constraints: Layered Networks



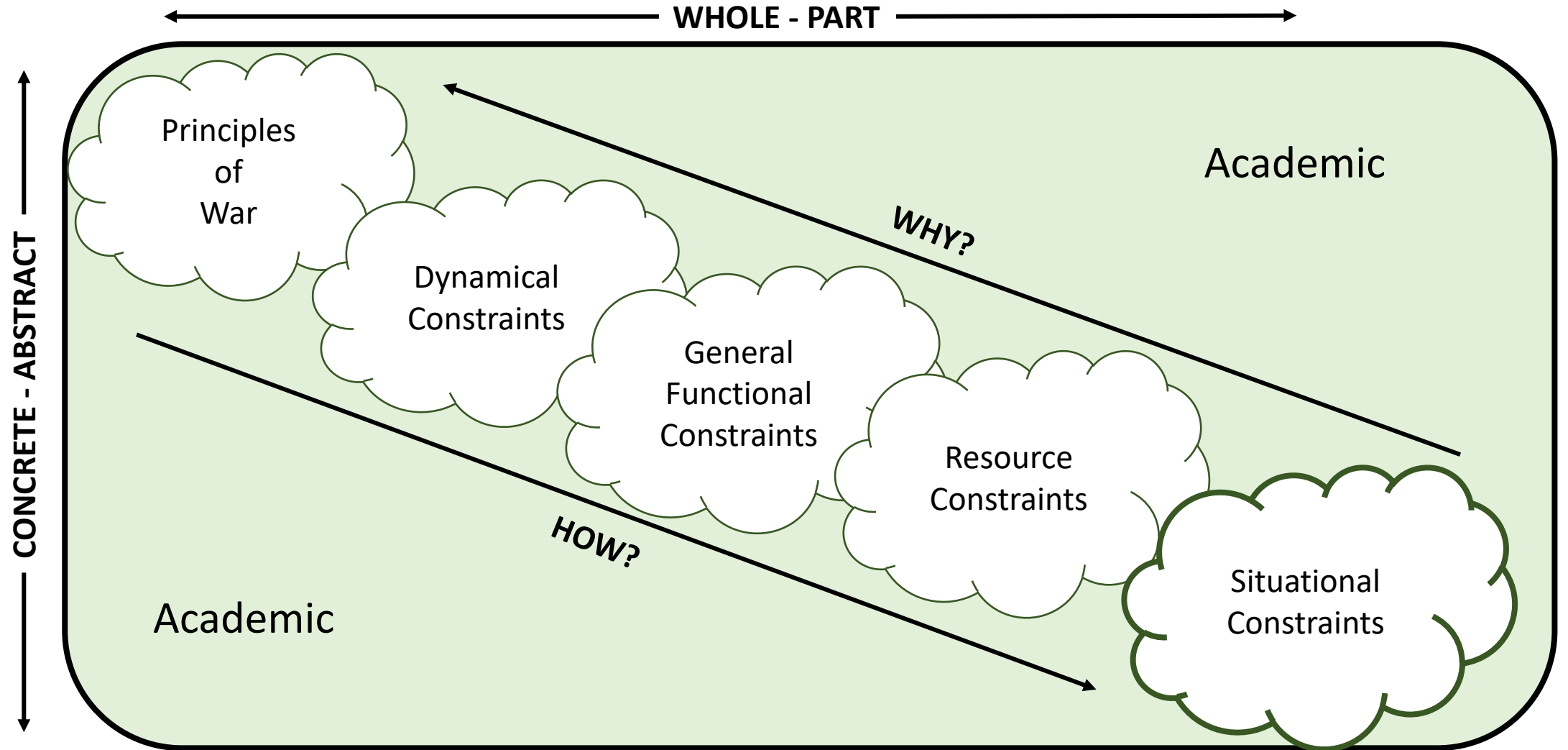
Conway’s Law: “Organizations, who design systems, are constrained to produce designs which are copies of the communication structures of these organizations.”

David Snowden: “Don’t try to break down silos. It never works.”

Sandy Pentland: “When the flow of ideas incorporates a constant stream of outside ideas as well, then the individuals in the community make better decision than they could on their own”

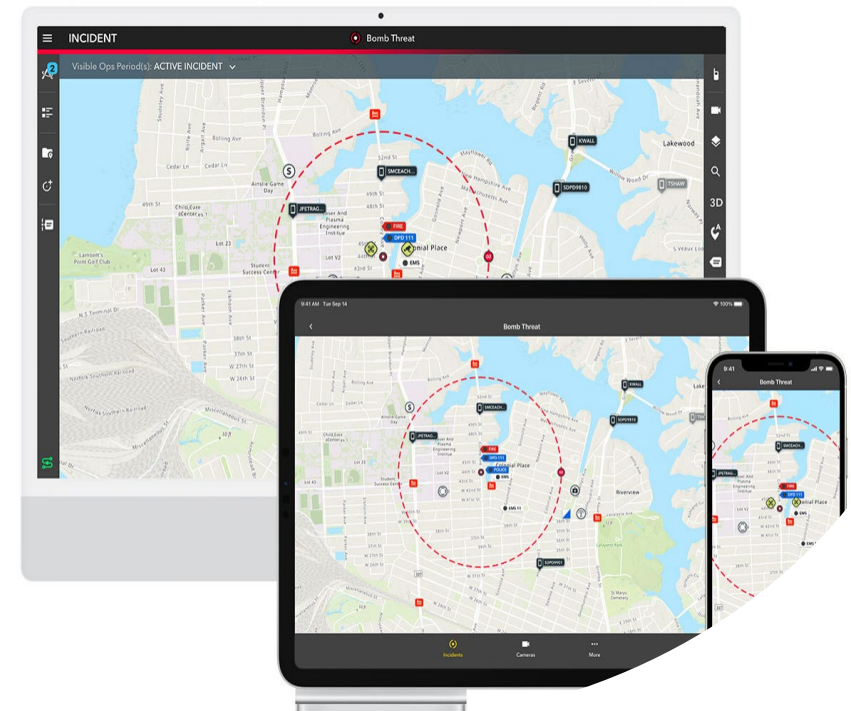
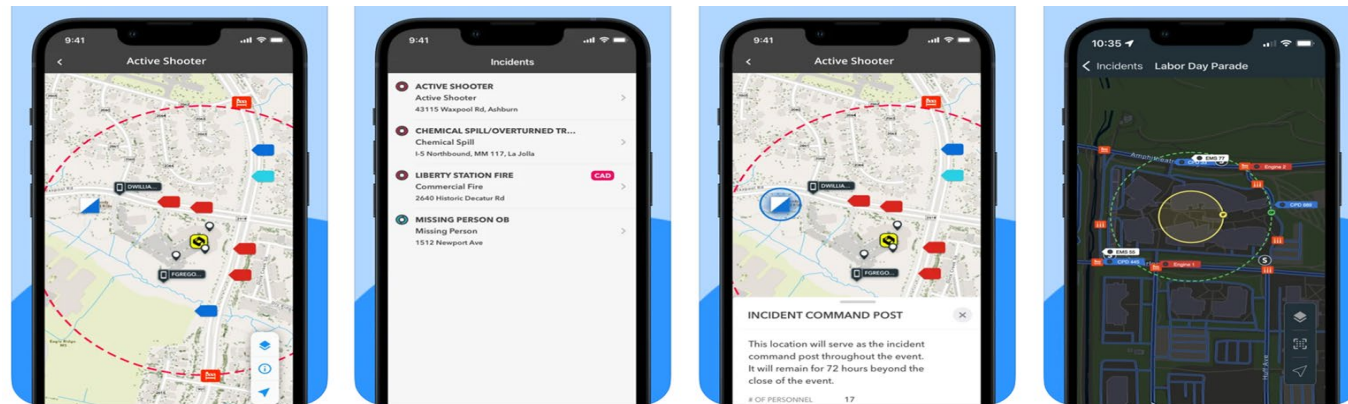
What form of network organization is envisioned for JADC2?

Work Analysis: Abstraction/Decomposition

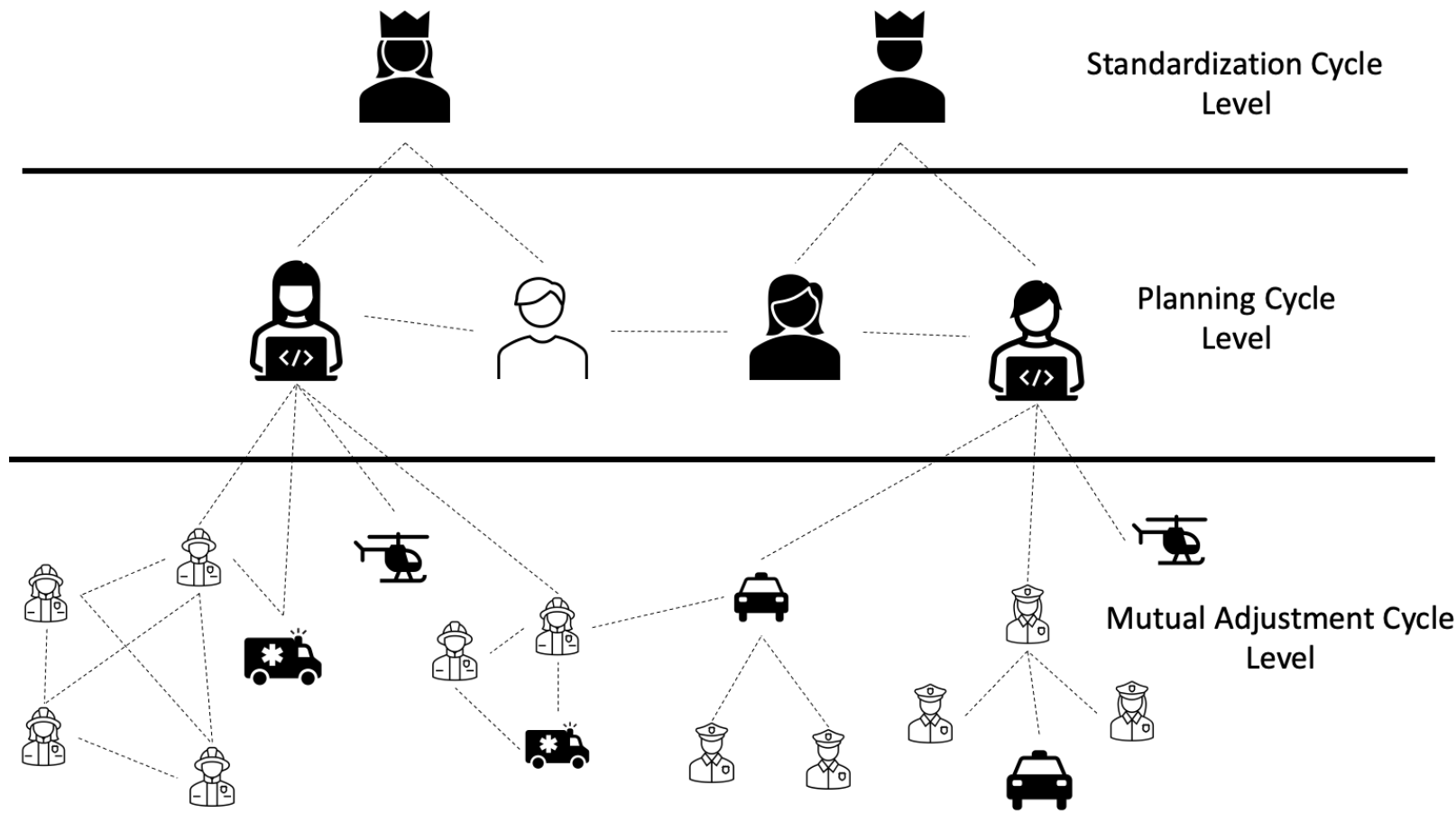


Situational Constraints?

- GlobalFlyte’s “AWARE” for regional emergency command & control
- Washington Naval Yard Mass Shooting
- Uruzgan Helicopter Attack
- Haystack, Medusa, IMPACT, JADPACT



Situational Constraints?



Thompson (1967) *Organizations in Action*

Situational Constraints?



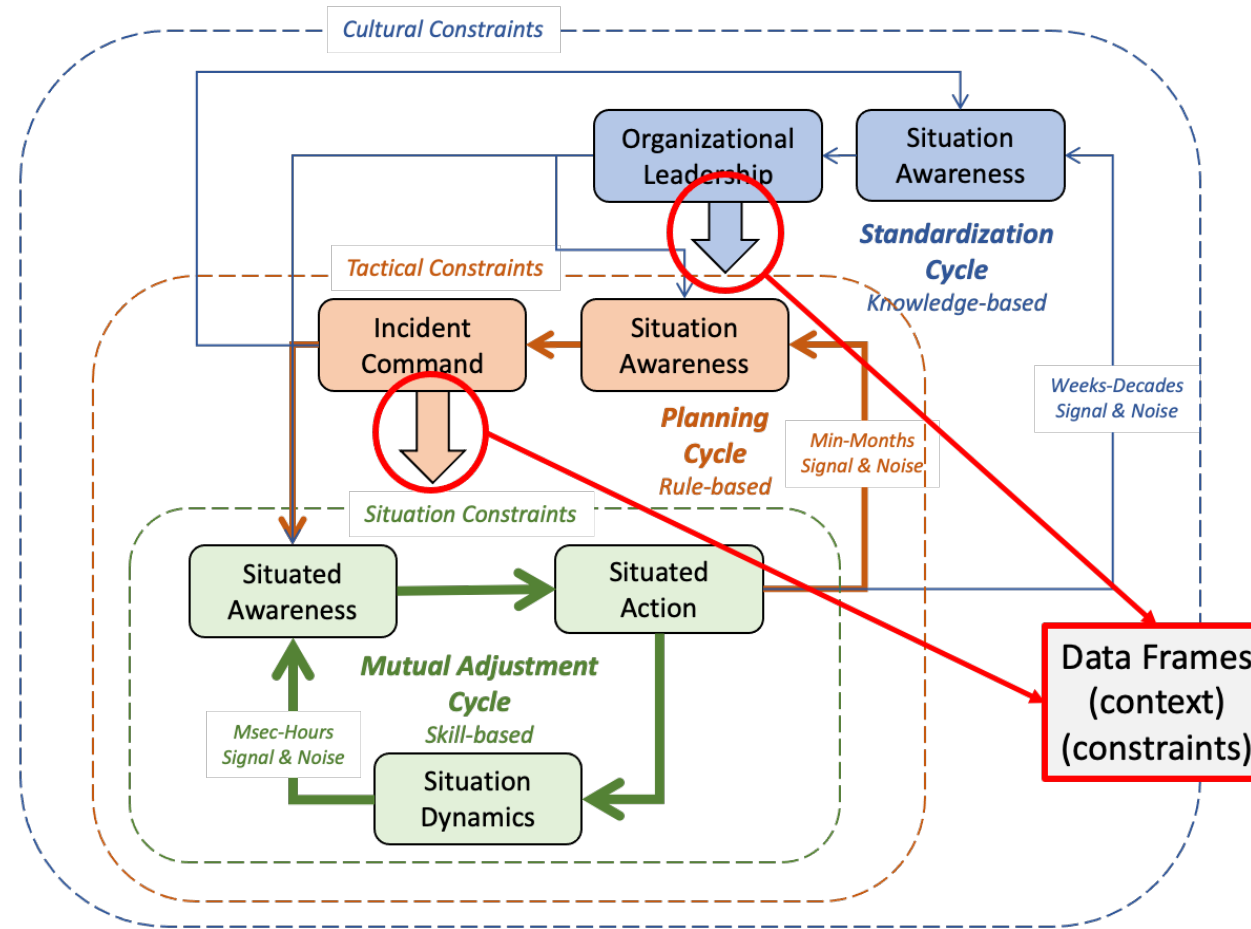
Standardization



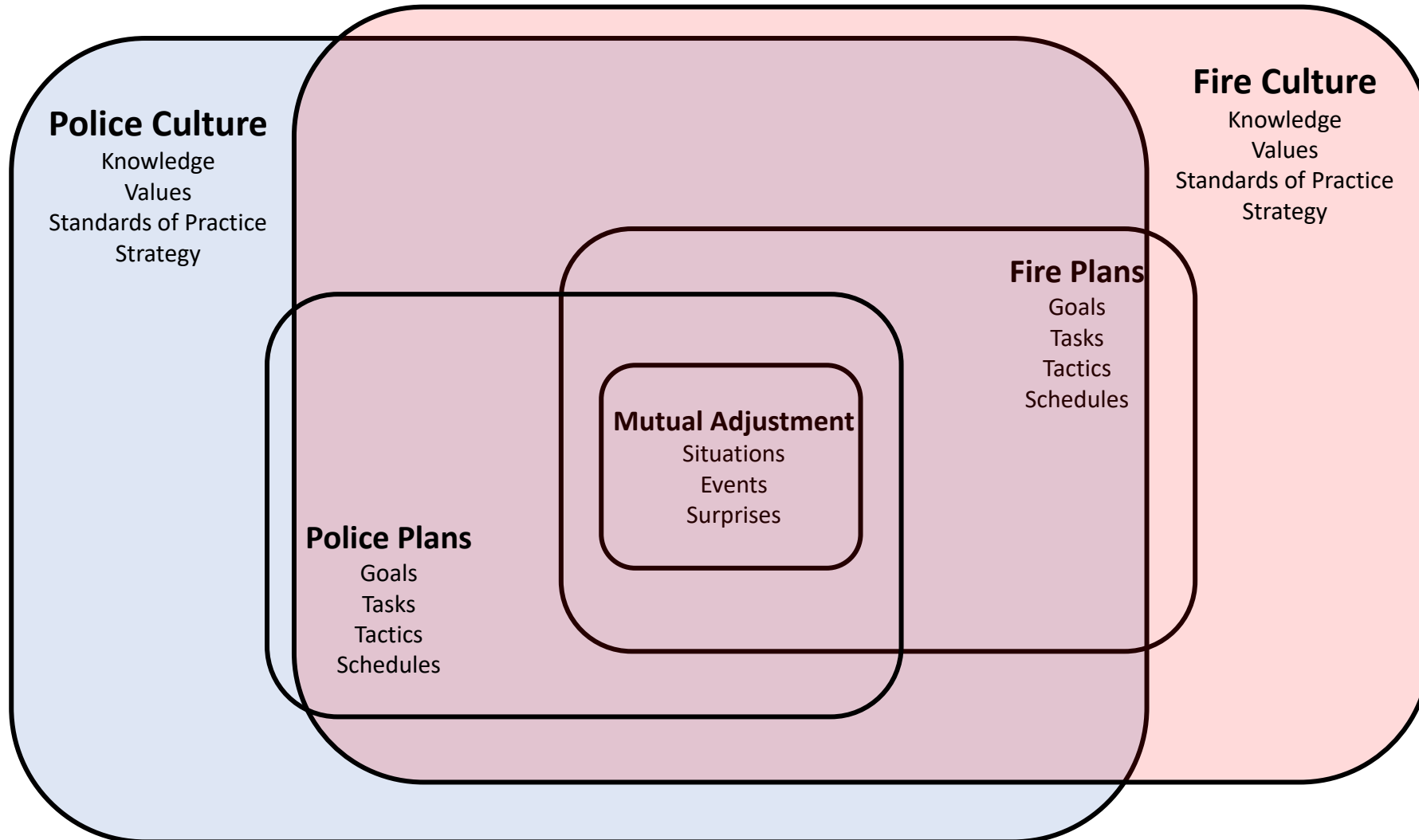
Planning



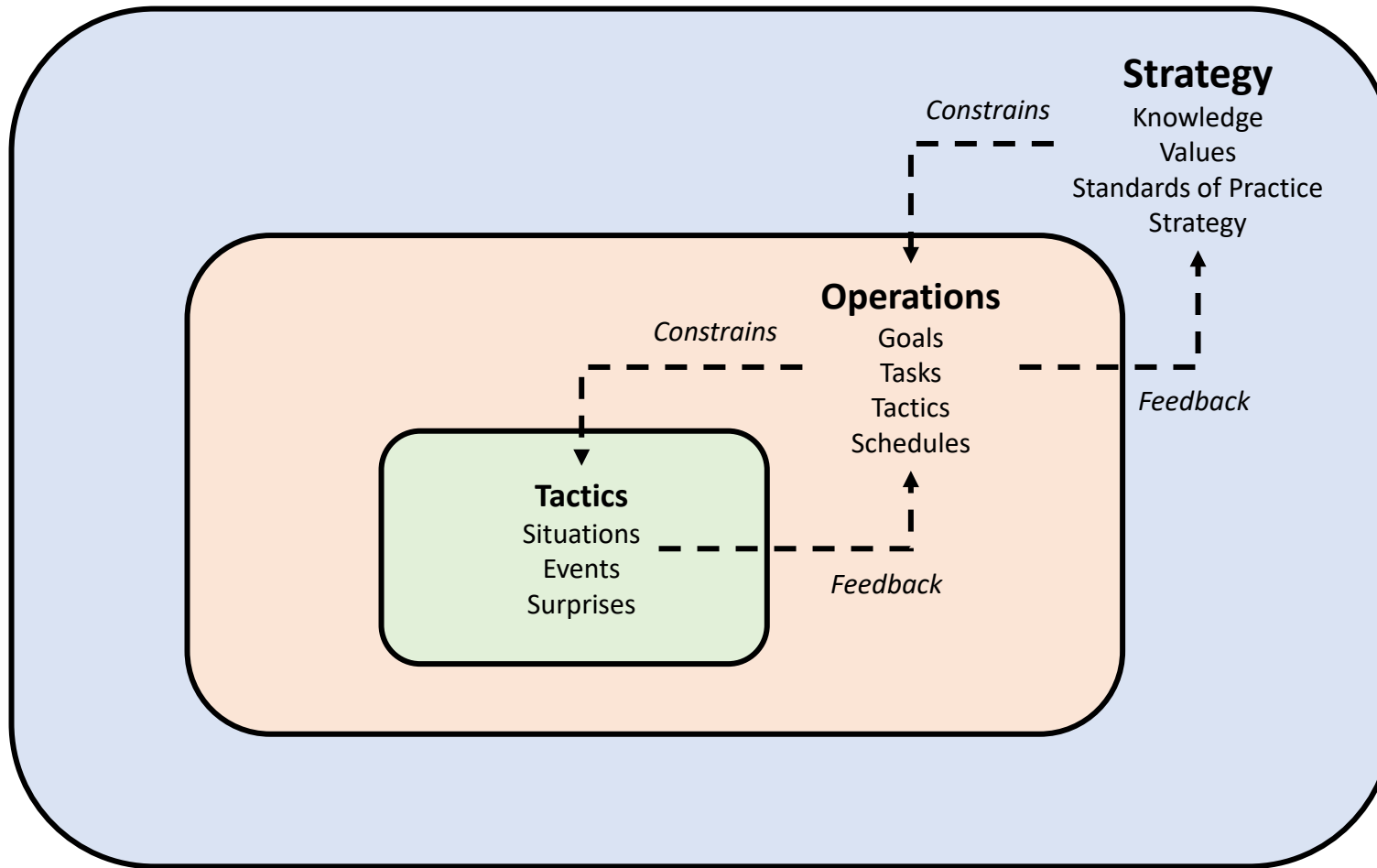
Mutual Adjustment



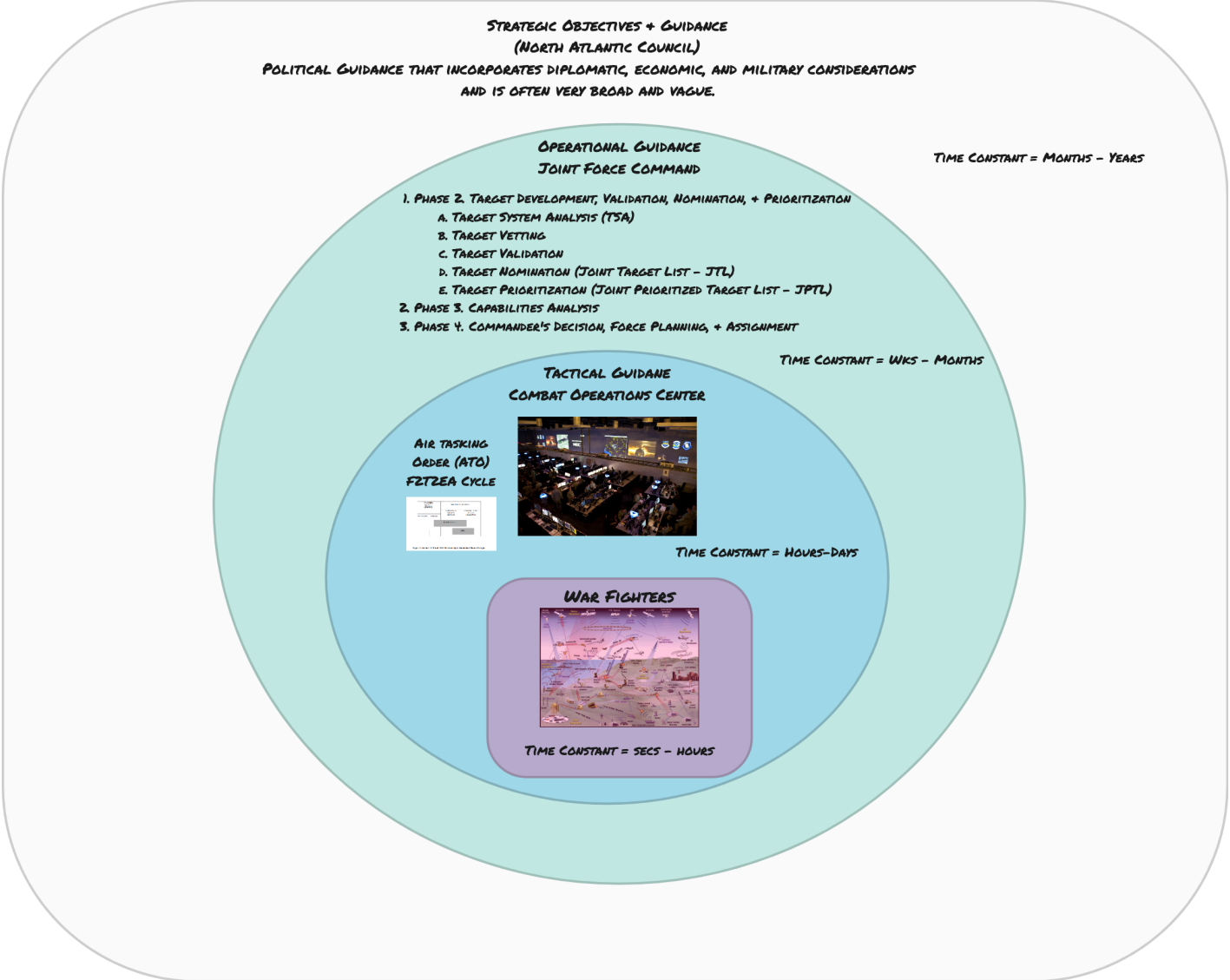
Situational Constraints?



Framing the JADC2 Problem



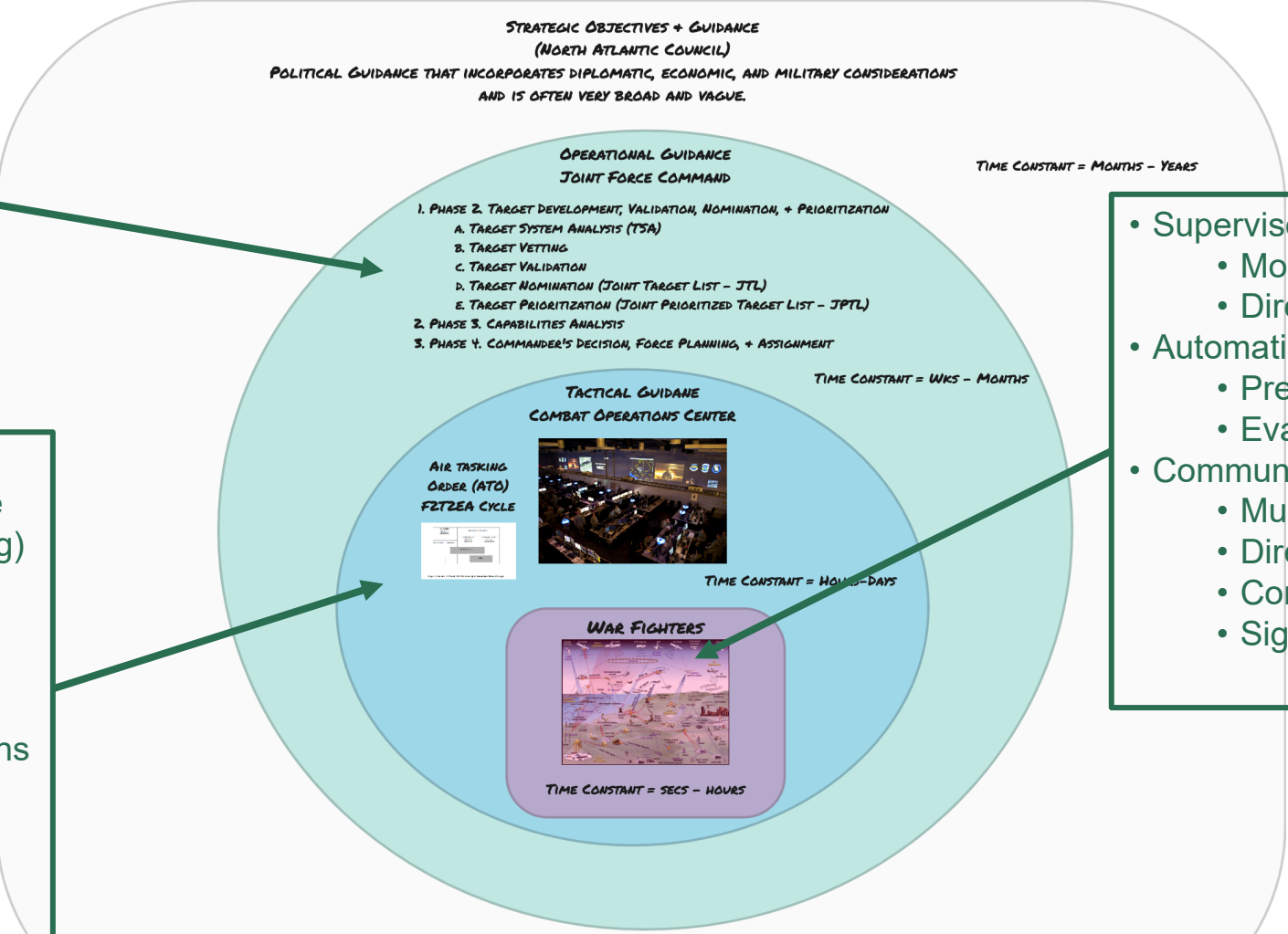
JADC2: Dynamic Targeting



JADC2: Dynamic Targeting

- INTEL
 - Analysis of Big Data
 - Effects-based Targeting
 - Simulation
 - War Gaming
 - Collateral Effects

- Situation Awareness
 - Common Operating Picture
 - Selective Attention (Filtering)
- Play Calling
 - Recommenders
 - Direct Manipulation
- Communications
 - Multi-modal Communications
 - Direct Attention
 - Context Aware
 - Signal/Noise Filtering



- Supervisory Control
 - Monitoring Operator State
 - Direct Attention (Alerting)
- Automatic Control
 - Precision Targeting
 - Evasive Maneuvers
- Communications
 - Multi-modal Communications
 - Direct Attention
 - Context Aware
 - Signal/Noise Filtering

Final Thoughts

- We are in the early stages of Work Analysis and still have a lot to learn about JADC2 systems.
 - Envisioned World Problem
- Work Analysis is never done. You can't wait for a complete work analysis to start generating products/solutions.
 - Work Analysis works best when it's part of an iterative design and development process. (Serious Play, Shrage)
- You can create products without doing Work Analysis.
- **You can't create innovative products/solutions without investing in Work Analysis!**
 - Work Analysis is not a pre-requisite for innovation, but a co-requisite.



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**Thank You for your Attention.
We welcome your feedback.**

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