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Combining AI with M&S to Meet Emerging Military Challenges

Peter Schwartz, PhD

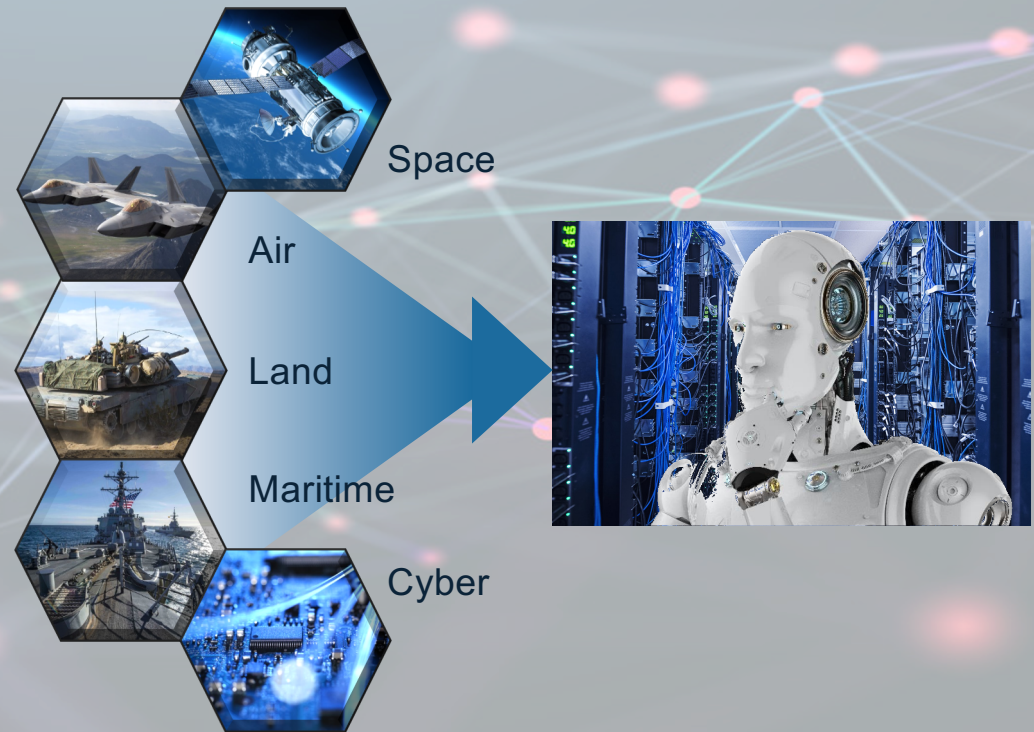
Principal Artificial Intelligence Engineer, MITRE

December 17, 2020

MITRE | SOLVING PROBLEMS
FOR A SAFER WORLD™

BLUF

1. Near-peer adversaries are forcing the U.S. to increase the ***speed and complexity*** of warfare
2. Research is ***combining AI and M&S*** to help meet these demands
3. Many opportunities exist, but so do ***hard problems***

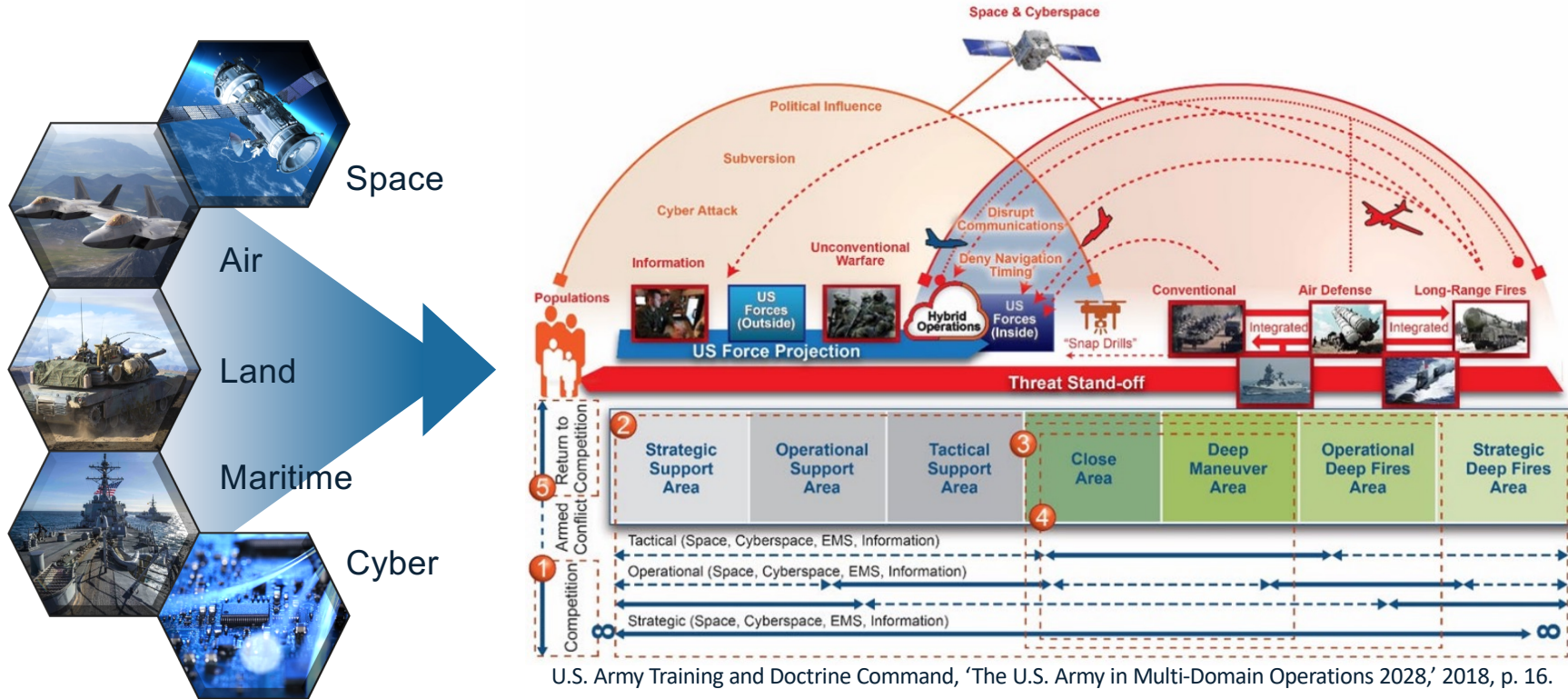


Military Challenges

The Threat: Increased Speed and Complexity of Warfare from Near-Peer Adversaries



The Response: MDO and JADC2



**Multi Domain Operations + Joint All Domain Command & Control =
More options to consider, but less time to consider them**

The Technology: AI/ML and M&S

Artificial Intelligence and Machine Learning (AI/ML)

AI: Program that searches for a solution instead of just following instructions

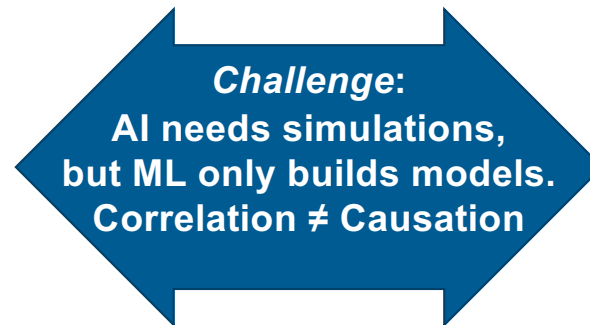
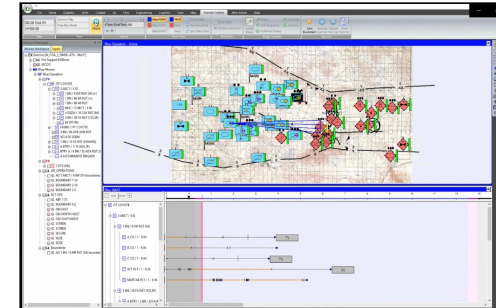
ML: Form of AI that searches for a model that best matches data



Modeling and Simulation (M&S)

Model: Abstraction of reality resulting in the formal specification of a system

Simulation: Execution of a model over time



How can AI/ML and M&S support MDO and JADC2 to deter and win against near-peer adversaries?

Example of AI + M&S: AI COA Recommender (AICR)

Problem: COA Analysis Decision Support



“When maneuver battalion staffs plan operations, they manually analyze terrain and weather to predict enemy courses of action, considering how an enemy commander could most effectively fight. Staffs plan their own friendly course of action against this analysis. The process works much the same as it did 30 years ago.”

- COL Edward Ballanco, January 16, 2019 (<https://warroom.armywarcollege.edu/articles/enemy-analysis-tool-now>)



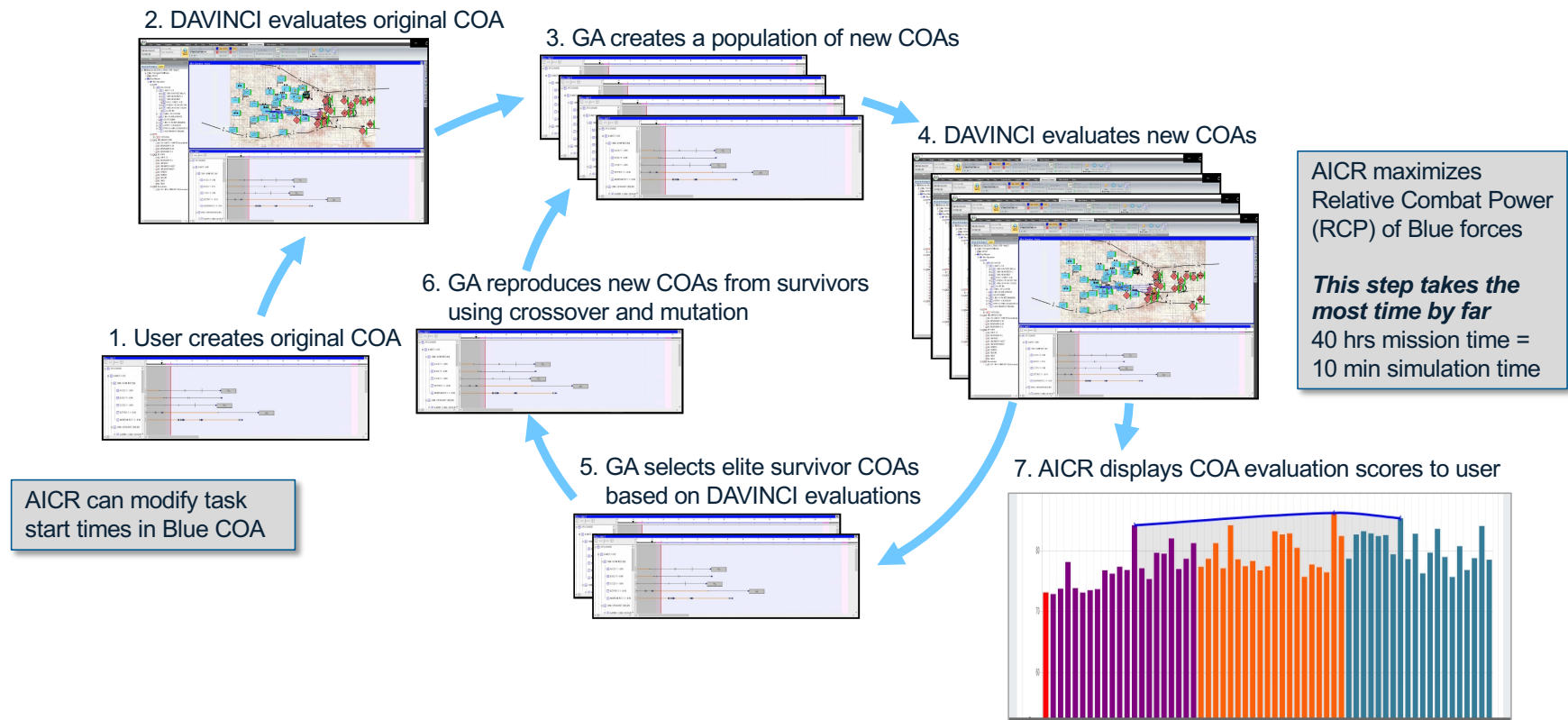
From *How to Master Wargaming*, Center for Army Lessons Learned

Hypothesis: AI can save time, reduce cognitive burden, and improve decision quality

AICR: Genetic Algorithm + Simulation



Use AI and a ground combat simulation (DAVINCI) to recommend improvements to staff-generated Blue COA



AICR Prototype Video



Dashboard

OPN_COTTONMOUTH_IDIOT[URN-Fix]

Explore Live Results

Status: Running AI Simulations

Completed Runs in Population: 2 of 20

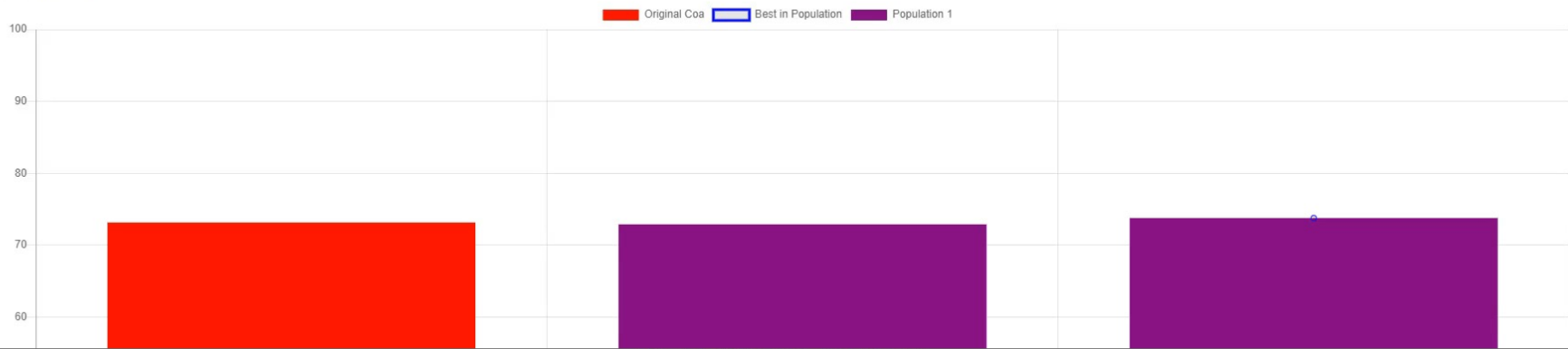
Completed Populations: 0 of 3

5%

Recommendations



Live Metrics



AICR Step 1: Configure



1.a. Configure Algorithm

Advanced Algorithm Settings

Random Number Seed (text or blank):

Population Size:

Max Number of Populations [?]

Population Fittest Value [?]

Selection Size [?]

Mutation Probability (Decimal 0-1)

1.b. Configure Simulation

DXTRS Options

Time Multiplier:
 x Real Time

1 250 500 750 1000

Wargame Timeout:
H+ :00 hours

1.c. Configure Blue COA Options

Add Scheduling Constraints

Start Time Constraints

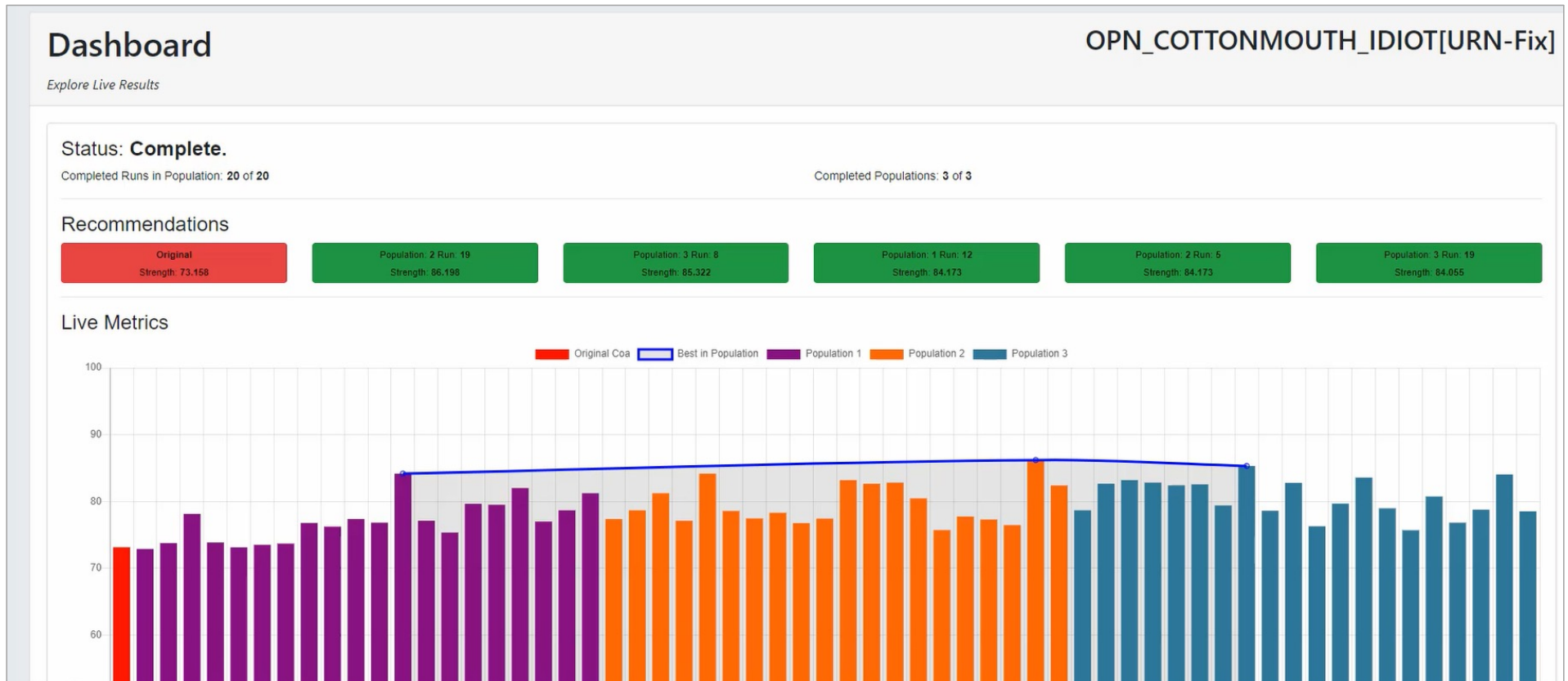
Minimum Start Time: H+04:52
Maximum Start Time: H+10:38

00:00 05:00 10:00 15:00

AICR Step 2: Run



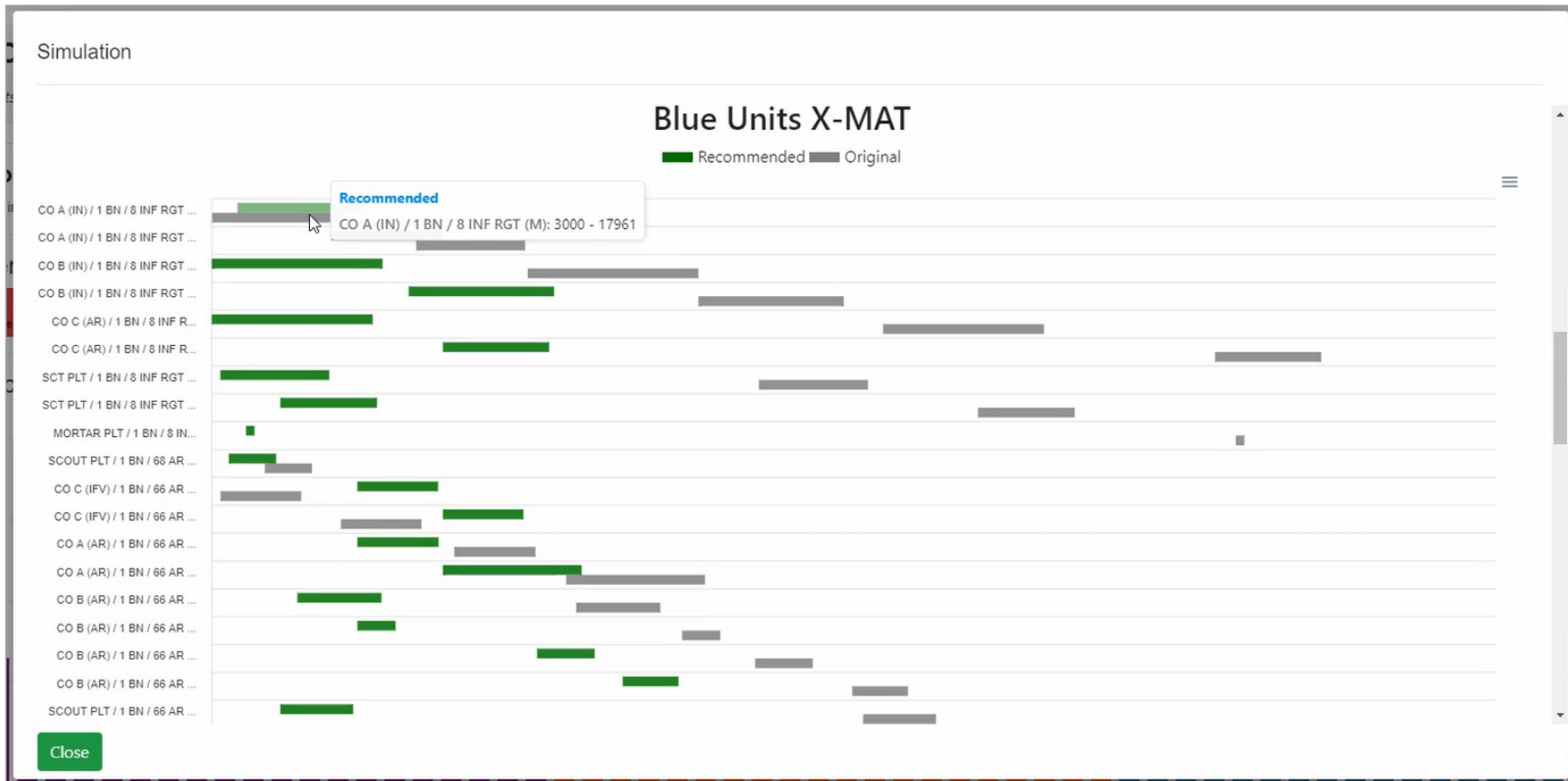
2. View Results across All COAs



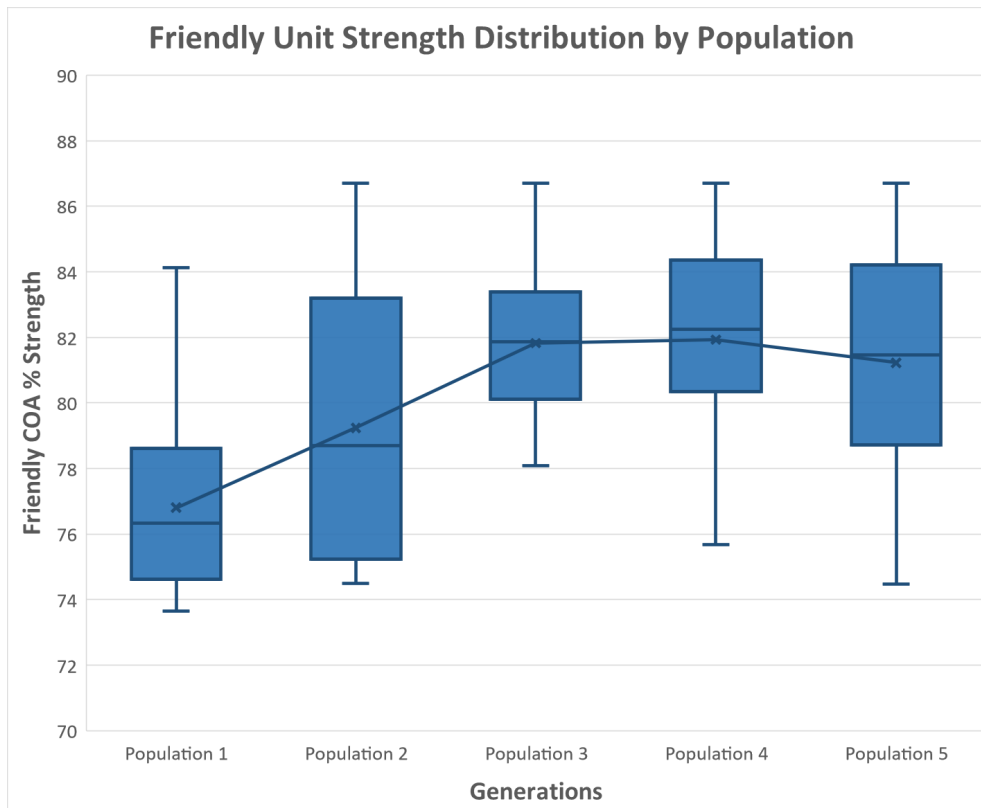
AICR Step 3: Review



3. Review Results within a Single COA



AICR Performance



- **Demonstrated ability to improve simulated mission outcomes significantly**
 - Human expert level in 3 generations
 - But testing is still limited
- **Serial simulation is slow**
 - 1 generation = 3.5 hours
- **Parallel simulation is 20x faster**
 - 1 generation = 10 minutes

Schwartz, et al., 'AI-enabled wargaming in the military decision making process,' *SPIE DCS Conference on Artificial Intelligence and Machine Learning for Multi-Domain Operations Applications II*, 2020.

AICR Future Work



Build on AICR success to extend what AI can modify to go beyond current time and cognitive limits

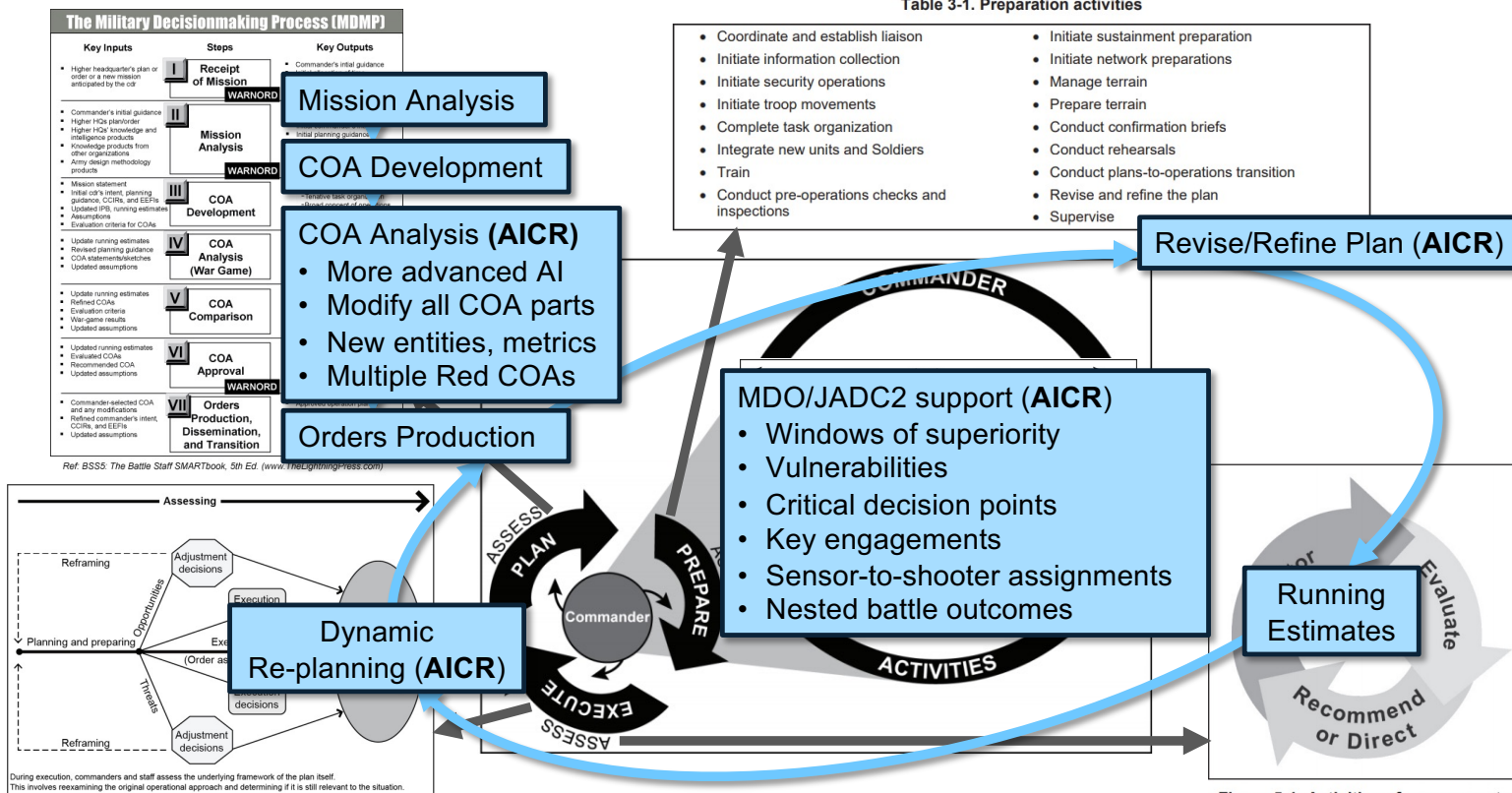


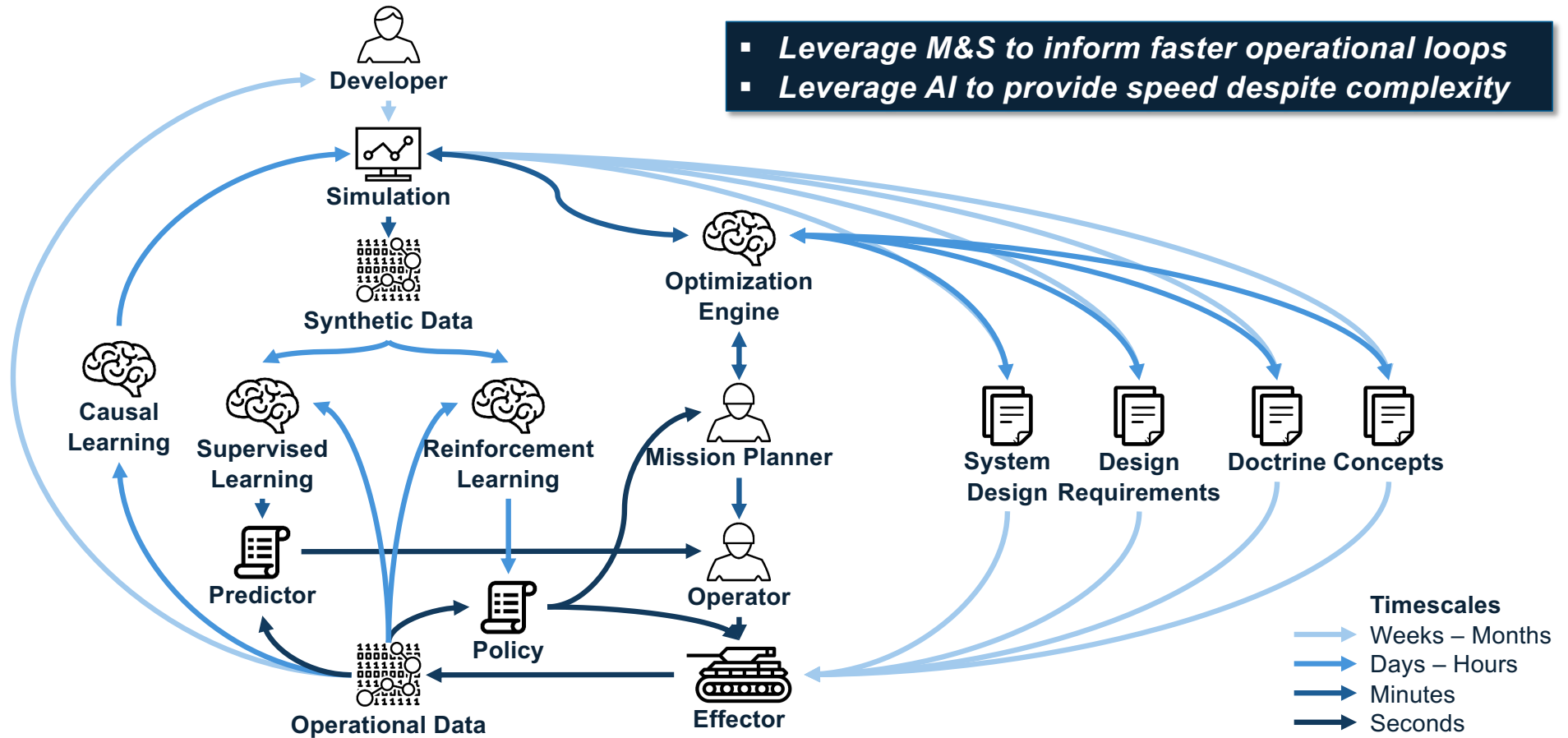
Figure 4-2. Decision making during execution

Figure 5-1. Activities of assessment

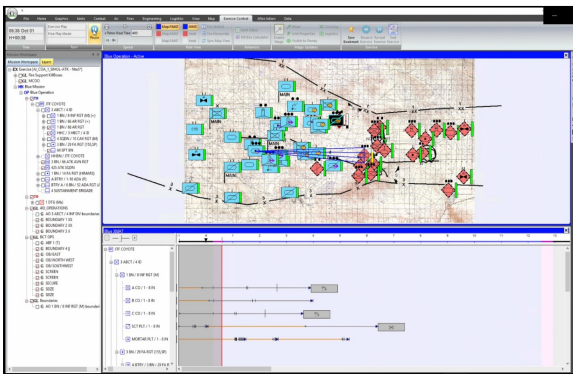
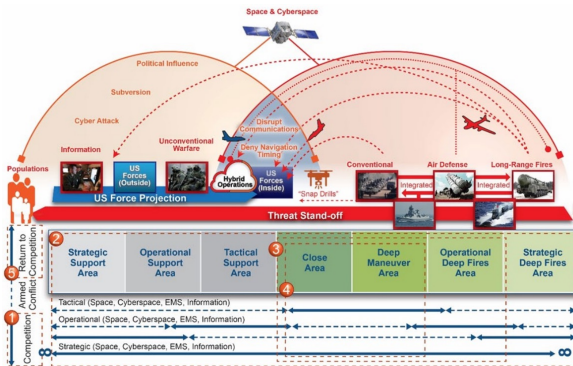
Opportunities & Challenges

How might we use an MDO/JADC2 simulation with AI?

- Leverage M&S to inform faster operational loops
- Leverage AI to provide speed despite complexity



What would we require of an MDO/JADC2 simulation?



1. *Adaptable* for many purposes

- Model all 5 currently defined domains and their interactions
- Increase/decrease the level of fidelity of each domain independently

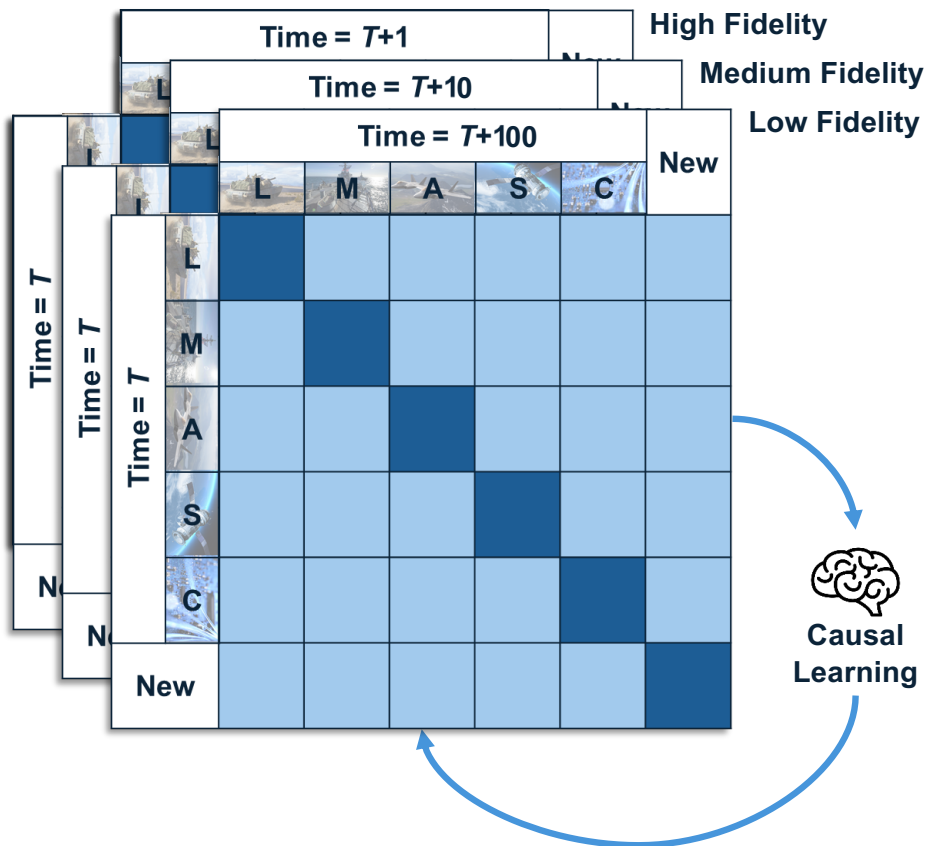
2. *Extensible* to new domains

- Add a new model of an existing domain or a model of an entirely new domain with minimal integration effort
- Develop a new model of an existing domain or a model of an entirely new domain with minimal effort

3. *Interoperable* with AI

- Simulate efficiently (100's to 1,000's x real time)
- Send information to external AI and receive commands from it while simulating

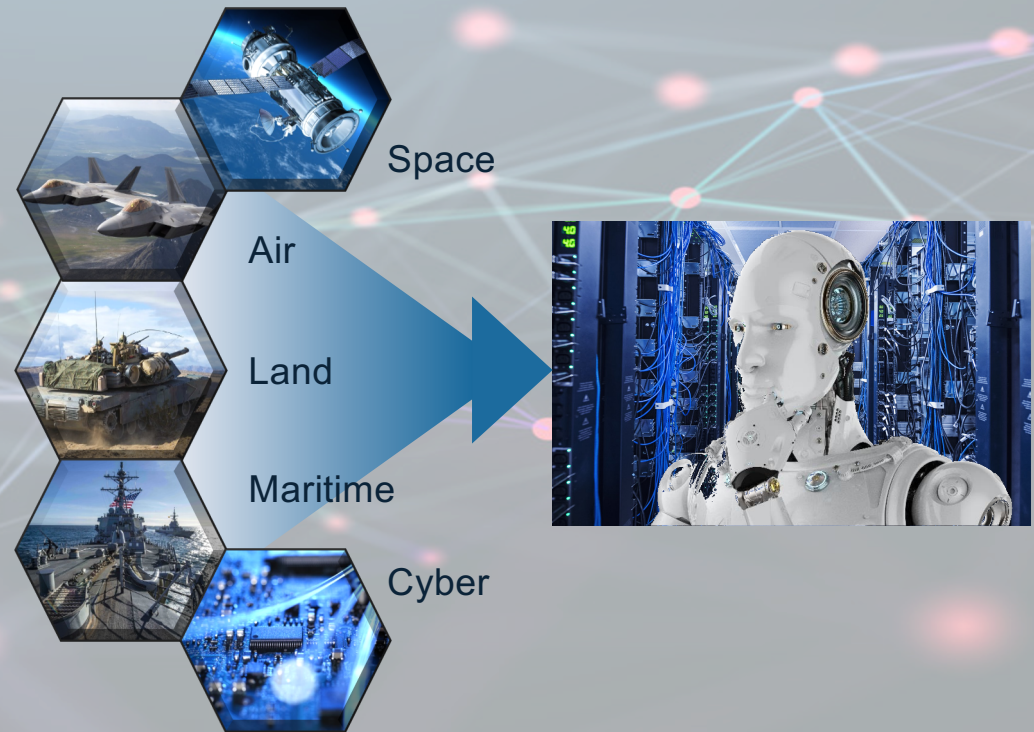
How might we develop such an MDO/JADC2 simulation?



1. **Model each domain** as a set of variables that change over time
2. **Model interactions** between variables in domain 1 and variables in domain 2
3. **Add a new domain** without changing interactions between existing domains
4. **Create faster, lower fidelity models** with surrogate modeling
5. **Develop and improve models** using causal learning

Summary

1. Near-peer adversaries are forcing the U.S. to increase the **speed and complexity** of warfare
 - U.S. response: MDO, JADC2
2. Research is **combining AI and M&S** to help meet these demands
 - AICR supports COA Analysis
3. Many opportunities exist, but so do **hard problems**
 - Could causal learning help develop an MDO/JADC2 simulation?



Questions?

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