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M&S Approach for Quantifying Readiness Impact of Sustainment Investment Scenarios

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Executive Summary

Sustainment for weapon systems involves multiple components that influence readiness outcomes through a complex array of interactions. Military leadership can use simple analytical approaches to yield insights into current metrics (e.g., dashboard for top downtime drivers) or historical trends of a given sustainment structure (e.g., correlative studies between stock sizes and backorders). However, they are inadequate tools for guiding decision-making due to their inability to quantify the impact on readiness.

In this talk, we discuss the power of IDA's end-to-end modeling and simulation (M&S) approach that estimates time-varying readiness outcomes based on real-world data on operations, supply, and maintenance.

These models are designed to faithfully emulate fleet operations at the level of individual components and operational units, as well as to incorporate the multi-echelon inventory system used in military sustainment.

We showcase a notional example in which our M&S approach produces a set of recommended component-level investments and divestments in wholesale supply that would improve the readiness of a weapon system. We also argue for the urgency of increased end-to-end M&S efforts across the Department of Defense to guide the senior leadership in its data-driven decision-making for readiness initiatives.

Modeling and Simulation (M&S) Approach for Quantifying Readiness Impacts of Sustainment Investment Scenarios

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April 2022

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Modeling and Simulation

Han G. Yi & Andrew C. Flack

Aggregate raw data → Calculate key performance metrics → Make assumptions and set scope of study → Conduct study exploring link between $ and readiness → Analyze and interpret results

Handling Raw Sustainment Data

Megan L. Gelsinger

Cross-Cutting Data Analyses

Joseph M. Fabritius II & Kyle E. Remley

IDA has developed multiple analytical techniques to aid readiness and supply chain decision-making

- Combine data from multiple sources to reveal trends and gain insights
- Discover ground truth hidden by stovepiped processes
- Cannot explore "what if" scenarios
- Limited ability to tie decisions to outcomes

- Historical trends can reveal which factors likely drive performance
- Limited ability to make specific or tactical predictions and recommendations

Stay tuned for the next talk!

IDA uses end-to-end simulations to help DOD tie investment decisions to readiness outcomes

End-to-end simulations

- Explicitly model all aspects of sustainment and **make predictions** on how specific investments cause changes in readiness
- Model quality is contingent on data quality
- Heavy initial lift to build the model

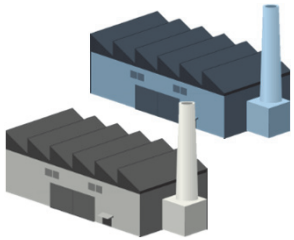
Why end-to-end simulation? Sustainment involves many moving pieces that interact with each other

Operations
Units perform missions

Local supply and maintenance
Replace or repair stock at local location (e.g., base or ship) as able

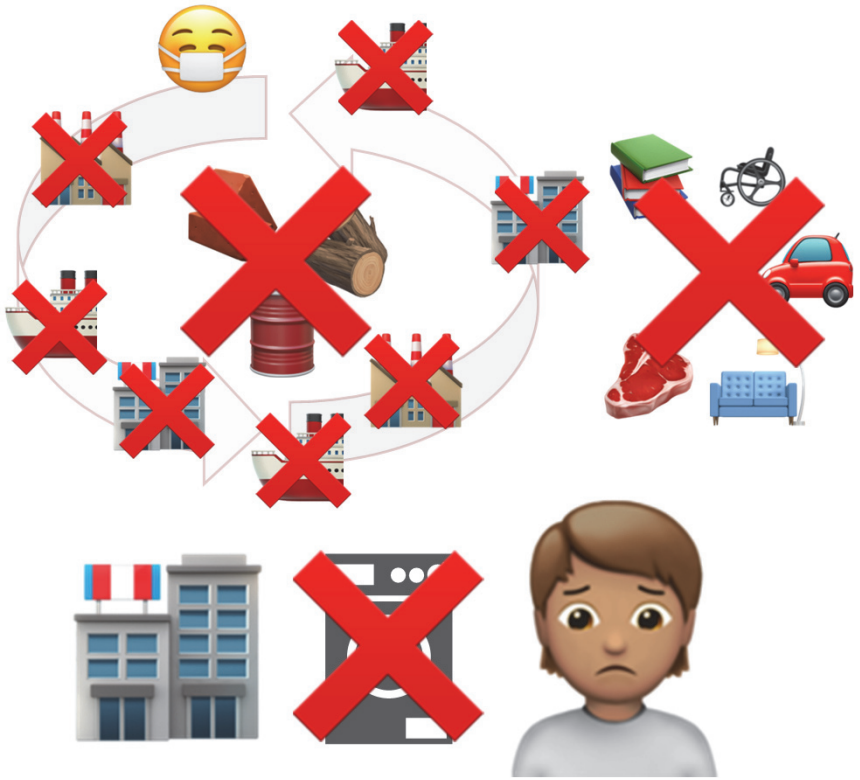
Wholesale
Stock delivery to local sites

Depot-level maintenance
Extensive repair, scheduled upgrade, or maintenance performed off-site



Why end-to-end simulation? Simple non-simulation models can be insightful … until they are not

Analogy: The global supply chain is a delicate, interconnected system with multiple chokepoints



A simple "model" that only focuses on one piece of the system stops being useful once other unmodeled pieces violate implicit assumptions

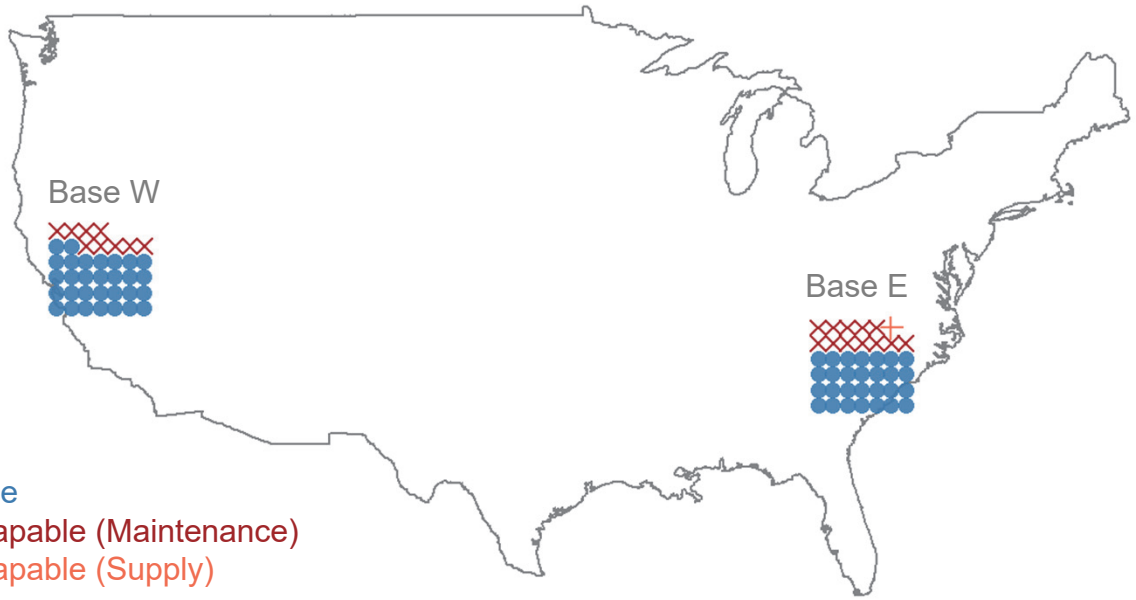
Why end-to-end simulation? Simulation is critical for answering detailed "what-if" questions for the complex and delicate system that is military sustainment

Military sustainment involves thousands of individual parts that are procured, shipped, shipped, and repaired … **and the stakes are high!**

IDA focuses on end-to-end simulation to tie resourcing decisions to expected readiness outcomes

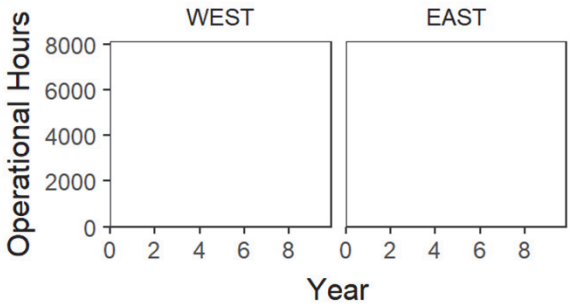
What we do Discrete event simulations emulate operational schedules and project future readiness

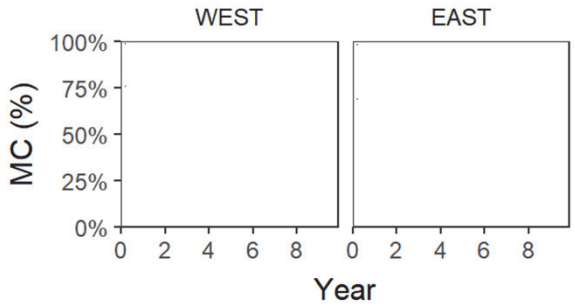
Units conduct missions from their home bases,
accrue operational hours, and experience failures



- Mission-Capable
× Non-Mission-Capable (Maintenance)
+ Non-Mission-Capable (Supply)

We can track how operational profiles and mission
capability change across time and operational units





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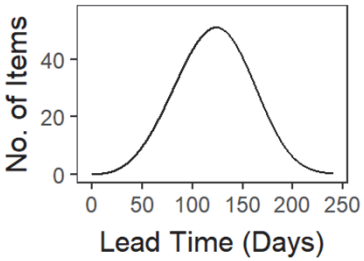
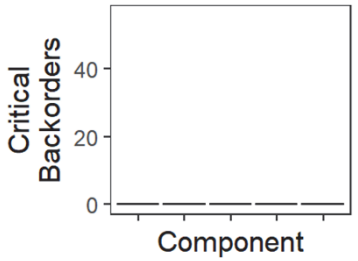
What we do Simulation models individual parts and how they move across the sustainment system

Stock and demand fluctuations are modeled at both wholesale and local sites

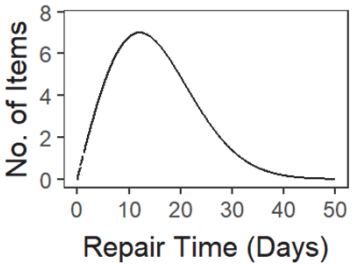
Purchasing lead times are drawn from probability distributions



Some unfulfilled demands render systems non-mission-capable



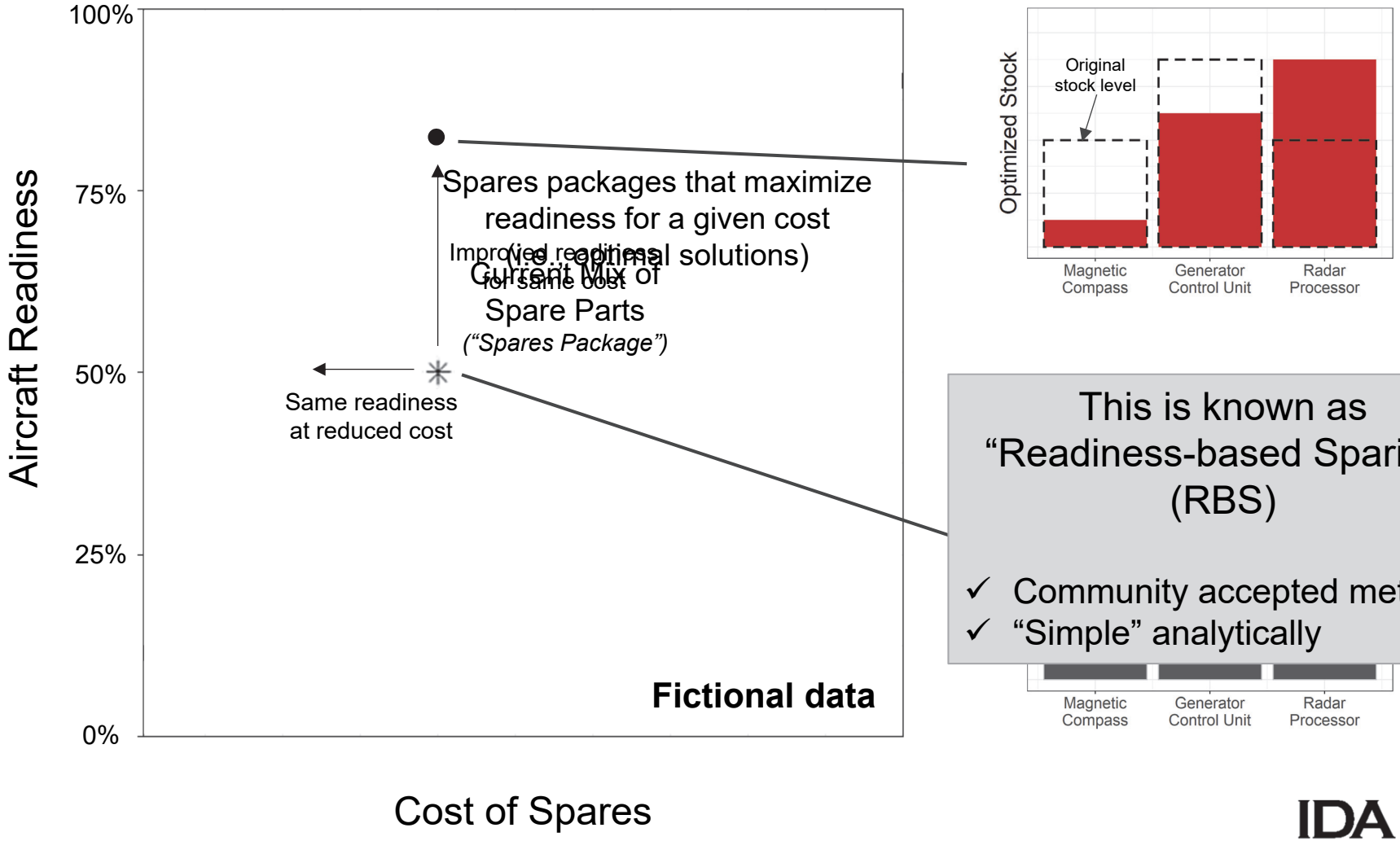
Repair times are also drawn from probability distributions



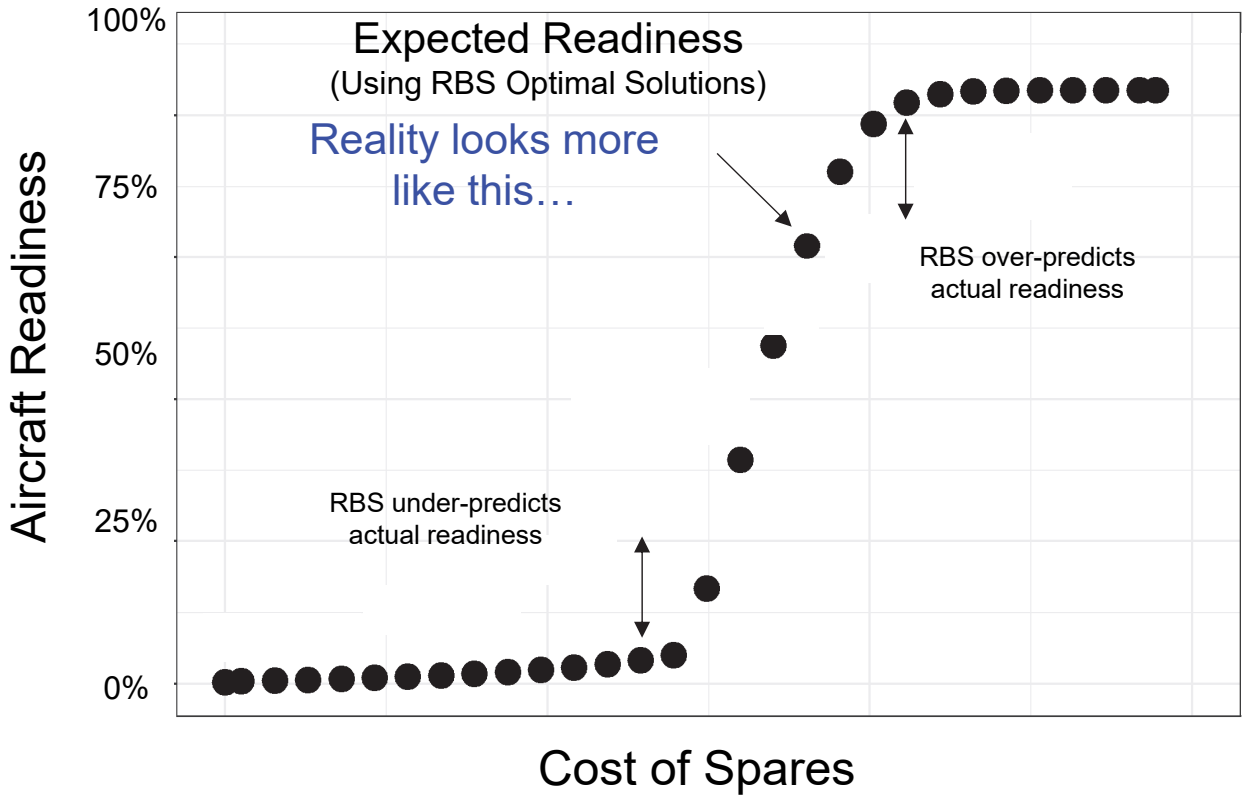
How can we use end-to-end simulation?

Having the wrong **mixture** and **quantities** of spare parts can affect the fleet's ability to perform missions (i.e., "readiness")

There is a mathematical approach for setting spares levels to maximize readiness… no simulation needed



Steady-state assumptions, critical to RBS, may not be valid for complex sustainment systems and real-world operations



Supply system bottlenecks

Feast or famine flight operations

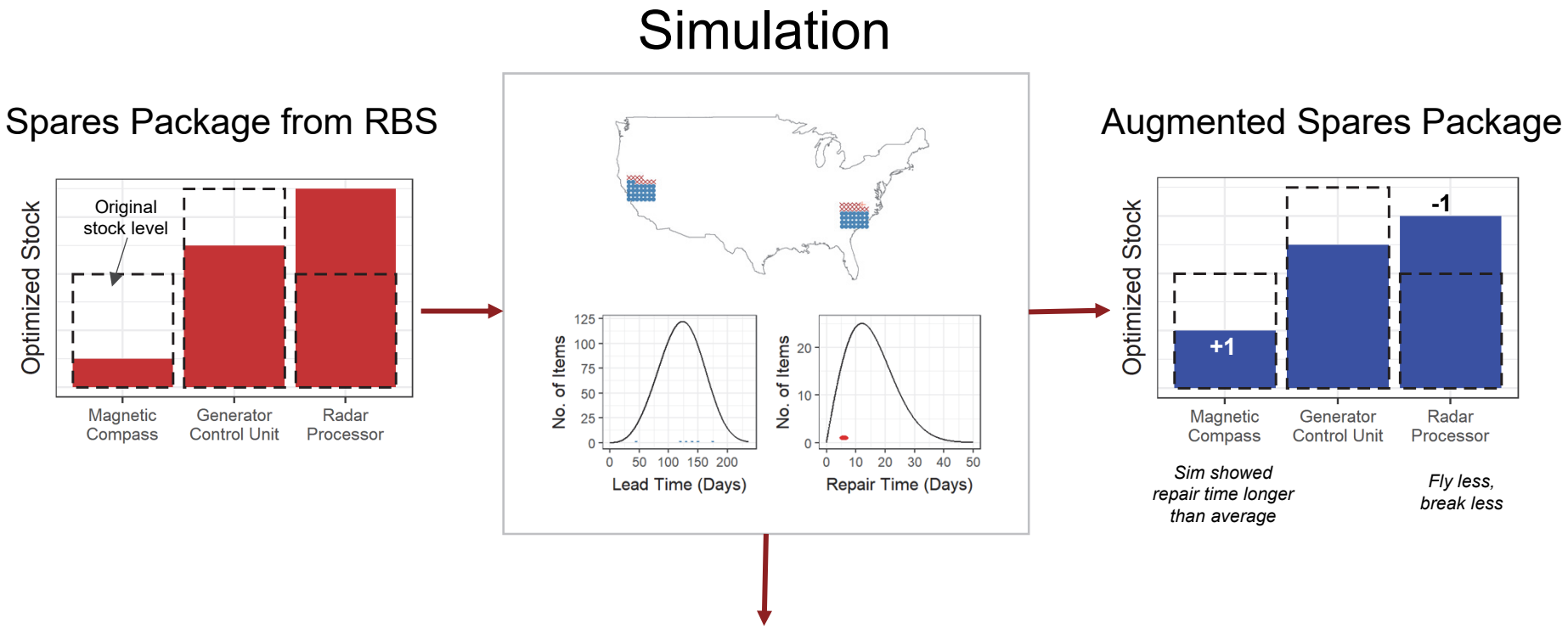
Aircraft added or removed from fleet

Other time varying inputs

RBS alone does not adequately capture real-life variability or time-based changes to inputs

Simulation makes RBS better

"Stress-testing" RBS outputs using **simulation** captures real life variability and offers more detailed component-level insight to improve sparing

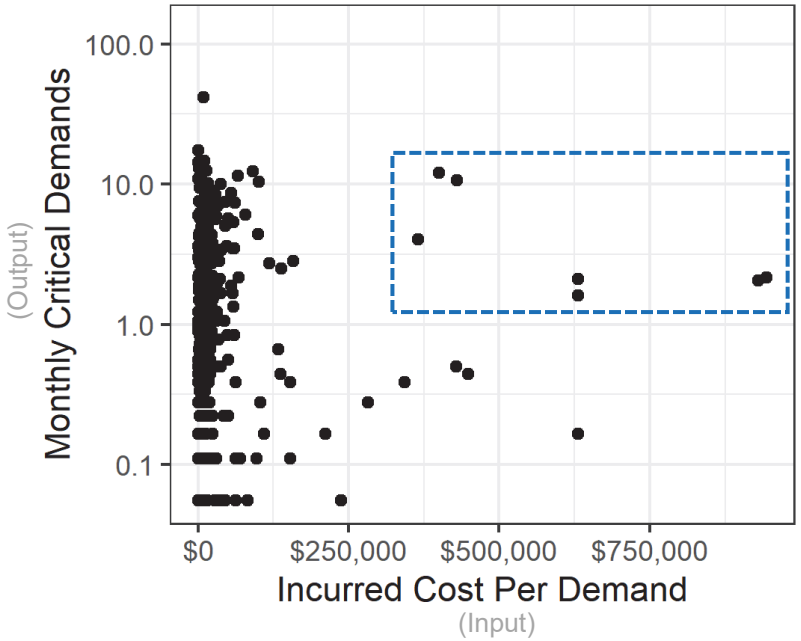


Bonus! Simulation produces numerous **time-varying outputs** that we can use to ask/answer other questions beyond sparing, or to guide further analyses

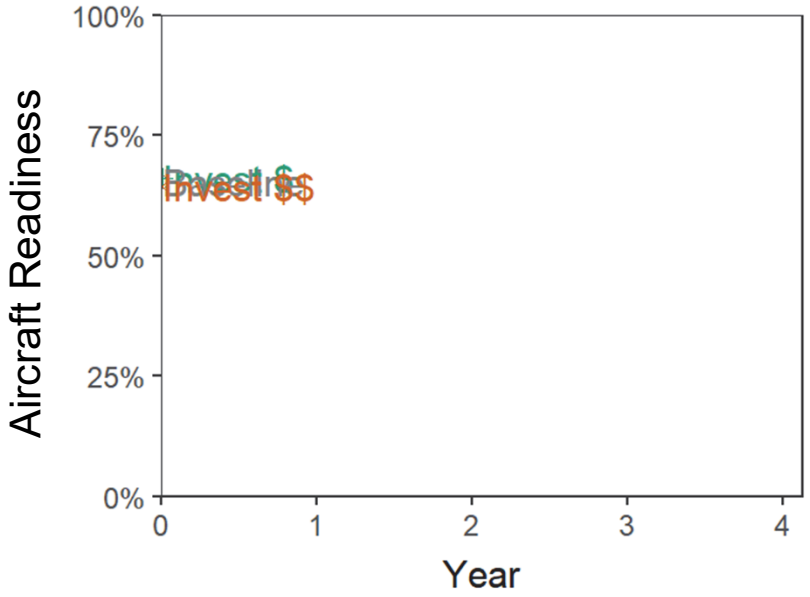
Demands, backorders, time awaiting parts, and more

Where should we invest to improve readiness, and what impact can we expect?

1 | Use simulation outputs to choose candidate components



2 | Simulate again and observe readiness impact of investment options



Option A: Invest $ to improve reliability by 10%

Option B: Invest $$ to improve reliability by 20%

Baseline: No change

Up next, Cross-Cutting Data Analyses (simulation-free)

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Project Leader: Dr. Benjamin Ashwell

14. ABSTRACT

Sustainment for weapon systems involves multiple components that influence readiness outcomes through a complex array of interactions. While military leadership can use simple analytical approaches to yield insights into current metrics (e.g., dashboard for top downtime drivers) or historical trends of a given sustainment structure (e.g., correlative studies between stock sizes and backorders), they are inadequate tools for guiding decision making due to their inability to quantify the impact on readiness. In this talk, we discuss the power of IDA's end-to-end modeling and simulation (M&S) approach that estimates time-varying readiness outcomes based on real-world data on operations, supply, and maintenance. These models are designed to faithfully emulate fleet operations at the level of individual components and operational units.

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