DISCRETE EVENT SIMULATION

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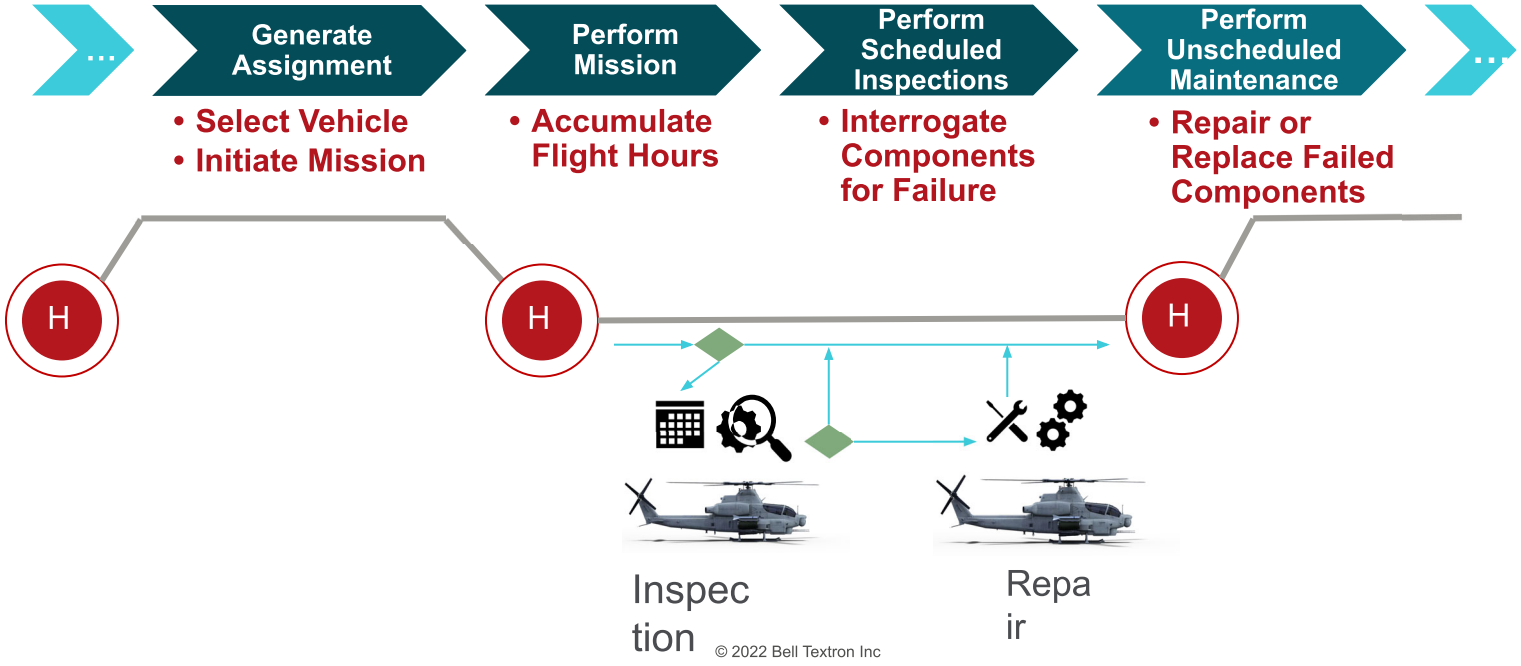
What is Discrete Event Simulation (DES)?

- DES models a system through a sequence of events that change the state of the system
- Used across industries to provide system performance feedback
- In aerospace, existing aircraft knowledge and reliability distributions can model aircraft reliability, availability, and maintainability (RAM)
- Allows problems to be anticipated (a challenge for our industry)
- Bell's DES informs how the aircraft is sustained during utilization
- Key program metrics from DES help to inform design decisions

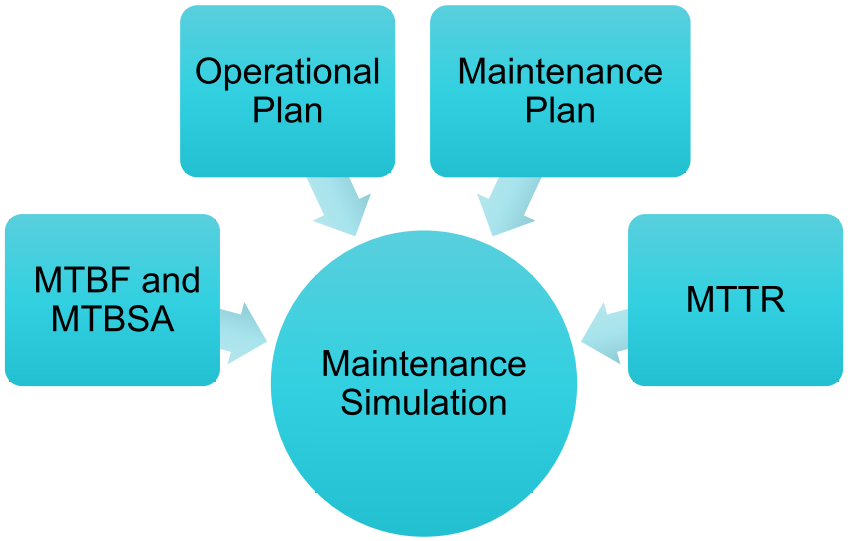
DES Events

Evaluate repeatable events, consider resources, analyze and make complex decisions



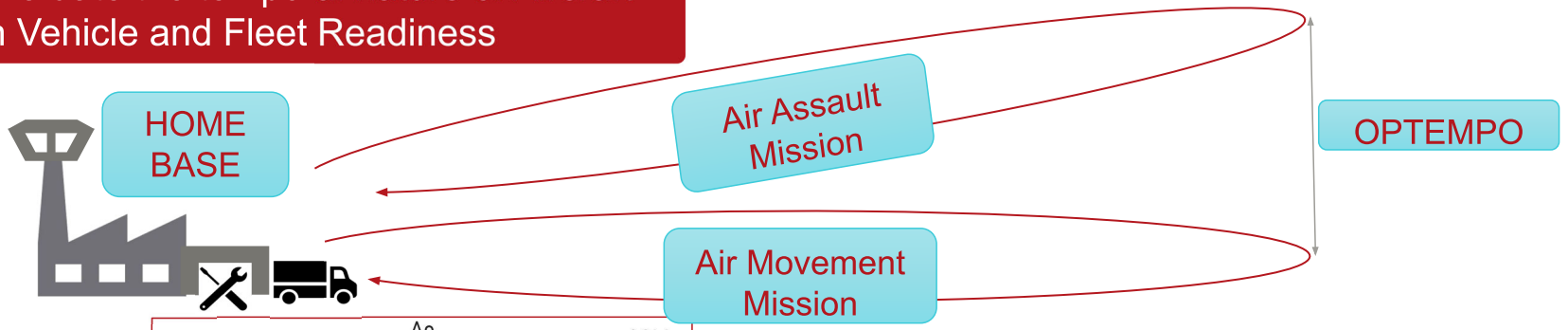
Lifetime Maintenance Simulation

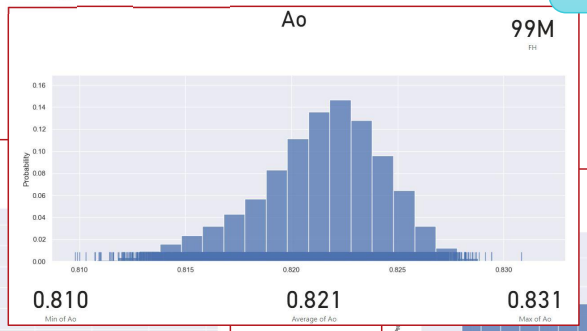
Typical model inputs

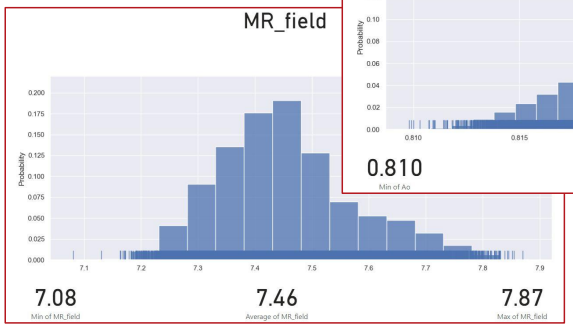


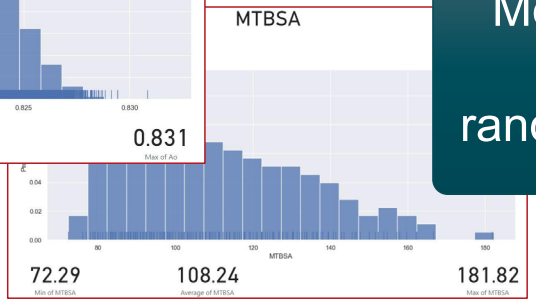
Discrete Event Simulation for Sustainment

GOAL: Evaluate the temporal nature of Aircraft usage on Vehicle and Fleet Readiness









Metrics determined by Monte Carlo analysis due to randomness of system reliability

Discrete Event Simulation for Fleet Utilization

This animation represents:

- A fleet of 96 air taxis performing missions
- Individual aircraft flying their respective flight plans
- Each aircraft accumulating flight hours and generating events
- Tracking number of aircraft flying, number on standby, number loading and unloading passengers and number undergoing recharge

How can DES Inform the R&M community?

DES real-world scenarios:

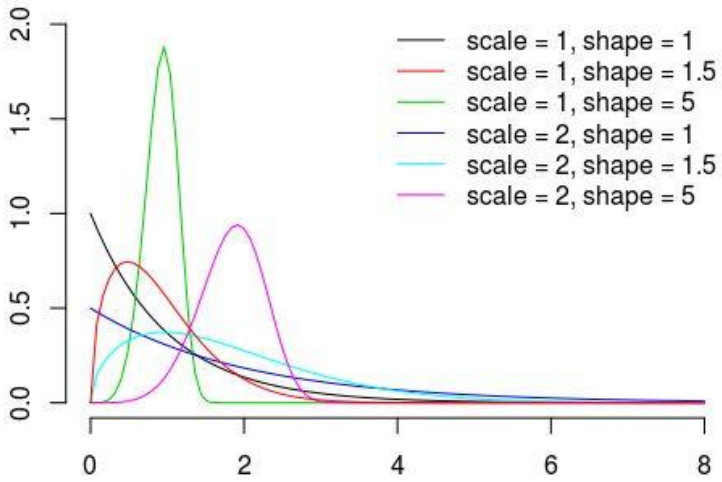
- Predict aircraft level metrics
- Derive subsystem requirements
- Inform trade studies

Weibull Predictions

FRACAS Data

- **Aircraft Serial Number**
- **Part Number**
  - System or Component
- **Serial Number**
- **Flight Hour at failure**

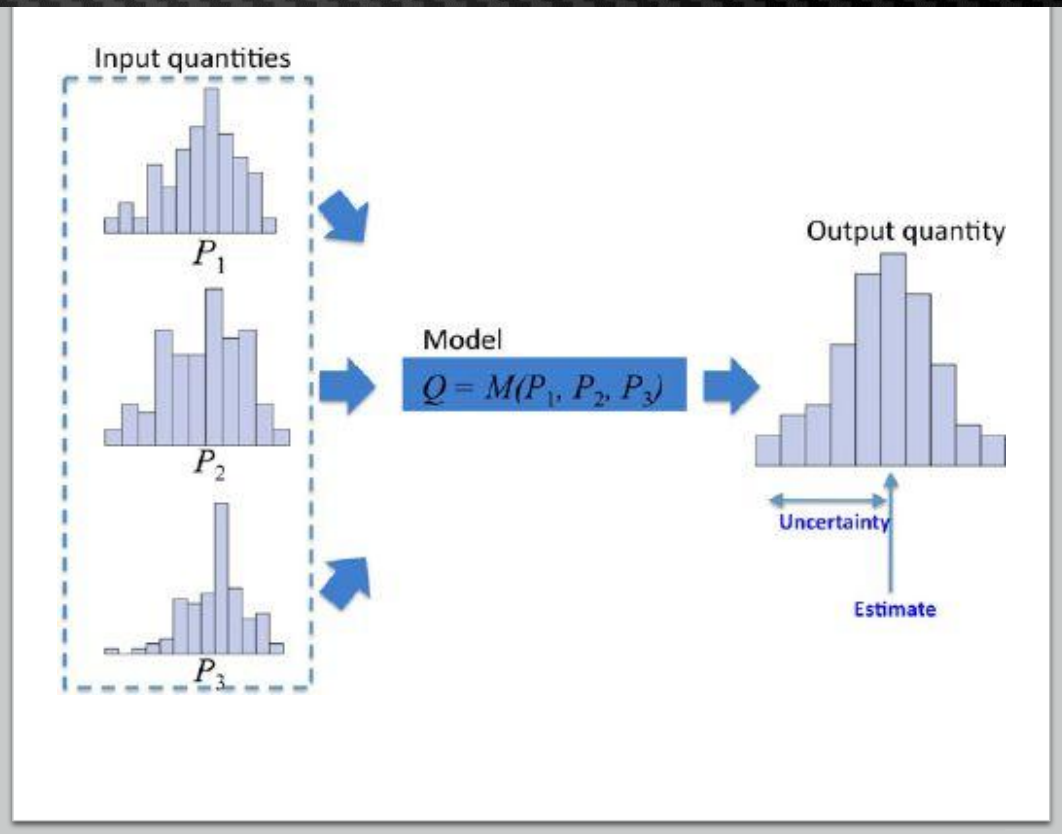
Weibull Parameters



- Shape < 1: Indicative of infantile or early-life failures.
- Shape = 1: Indicative of useful life or random failures.
- Shape > 1: Indicative of premature wear issues, lack of proper maintenance

Monte Carlo Analysis

- Uses distributions of data as inputs instead of averages
- Tens of thousands of random simulations to create output distribution
- Increases confidence in output accuracy
- Can predict many Aircraft-level metrics including availabilities, maintenance ratios, etc



Derive subsystem requirements

As you establish thresholds and run the simulation the different “knobs” will start to become apparent

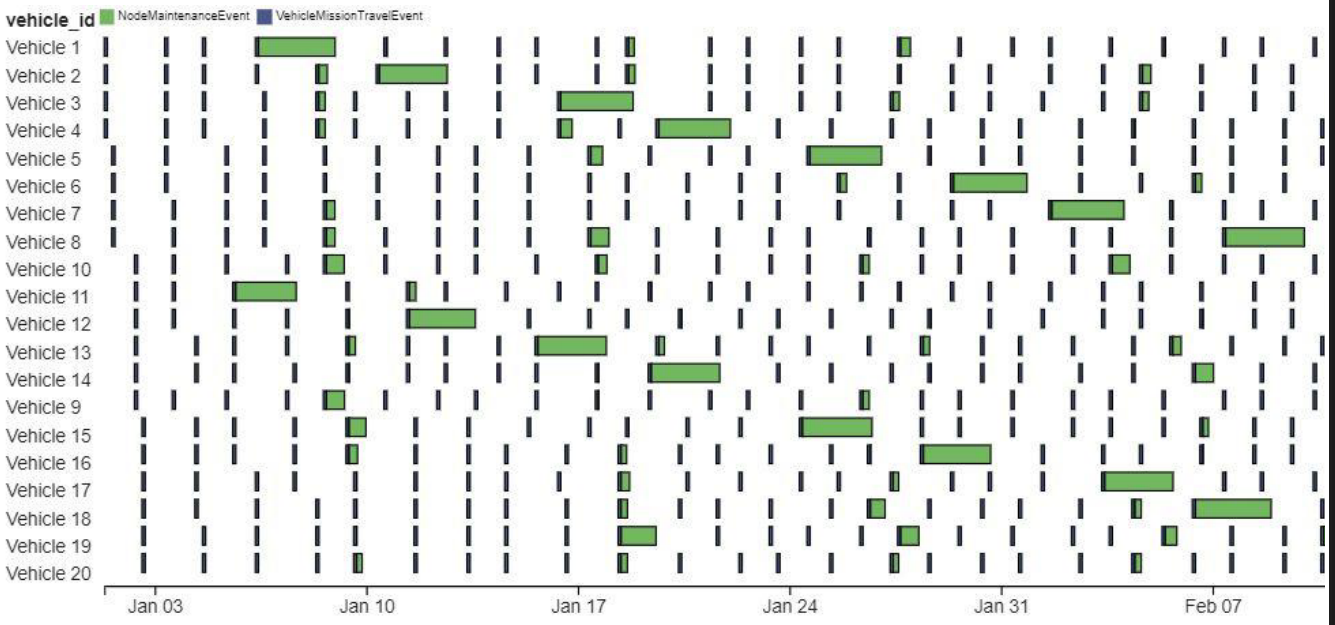
From there you can manipulate those knobs and identify where you should concentrate your efforts to improve the system

Next you can start to identify realistic subsystem goals and maintenance plans that allow you to meet any aircraft level requirements

Knobs To Turn

- Subsystem Reliability
- Subsystem Maintainability
- Squadron Maintainers
- Maintenance Scheduling
- Logistics Delay Time
- Flight Scheduling

Simulation – Squadron Mission Schedule

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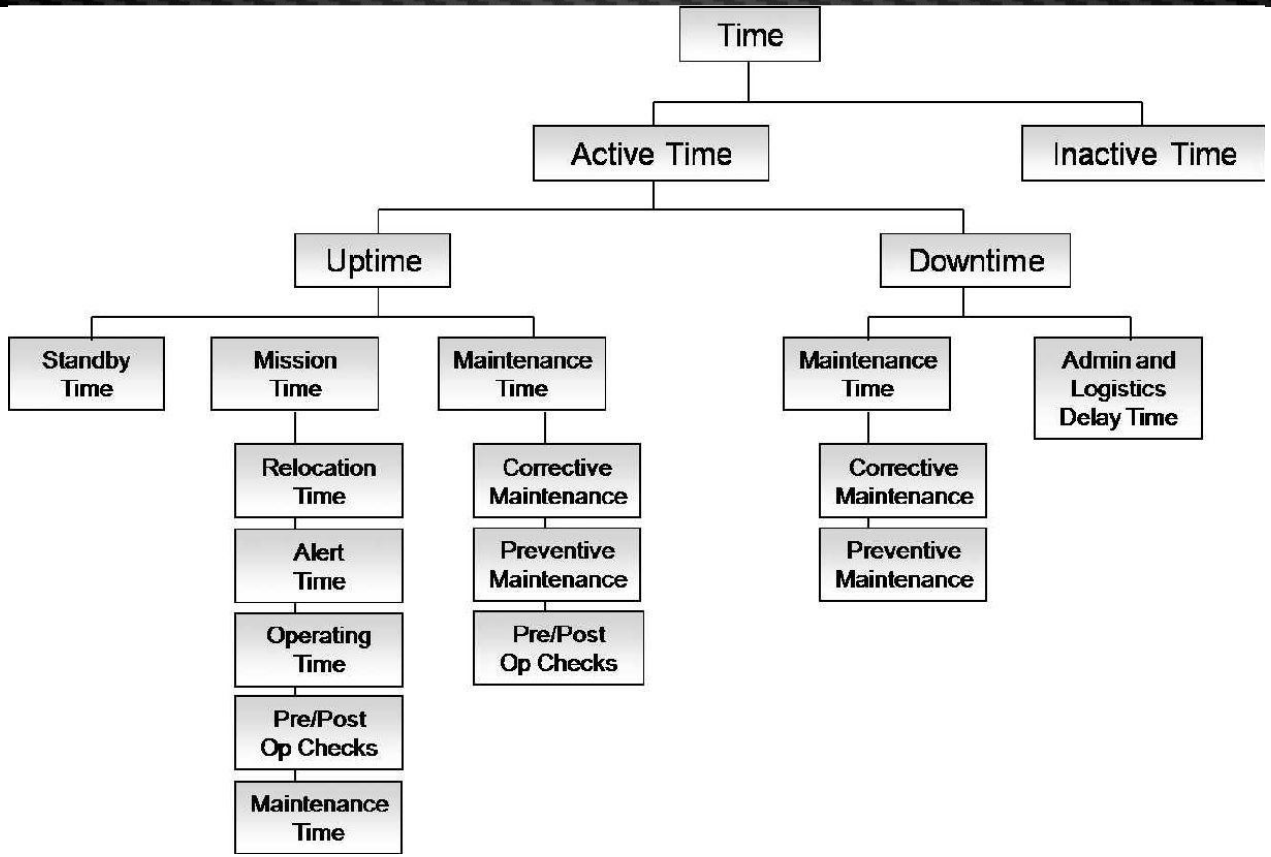
Simulation Possible Outputs



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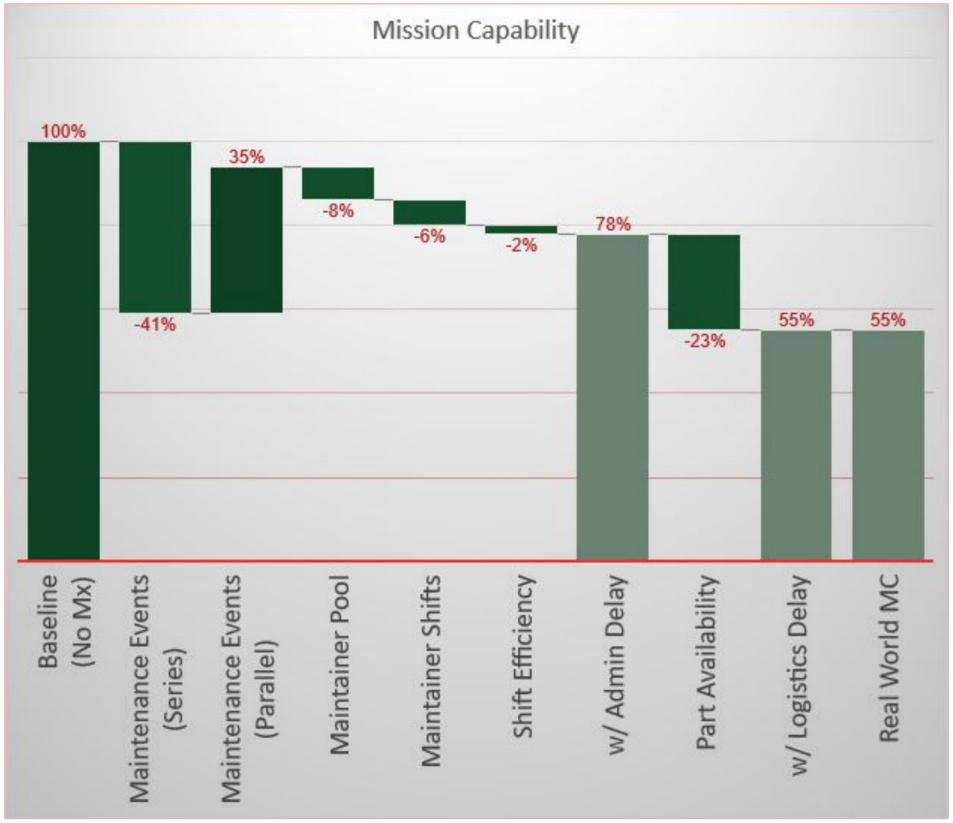

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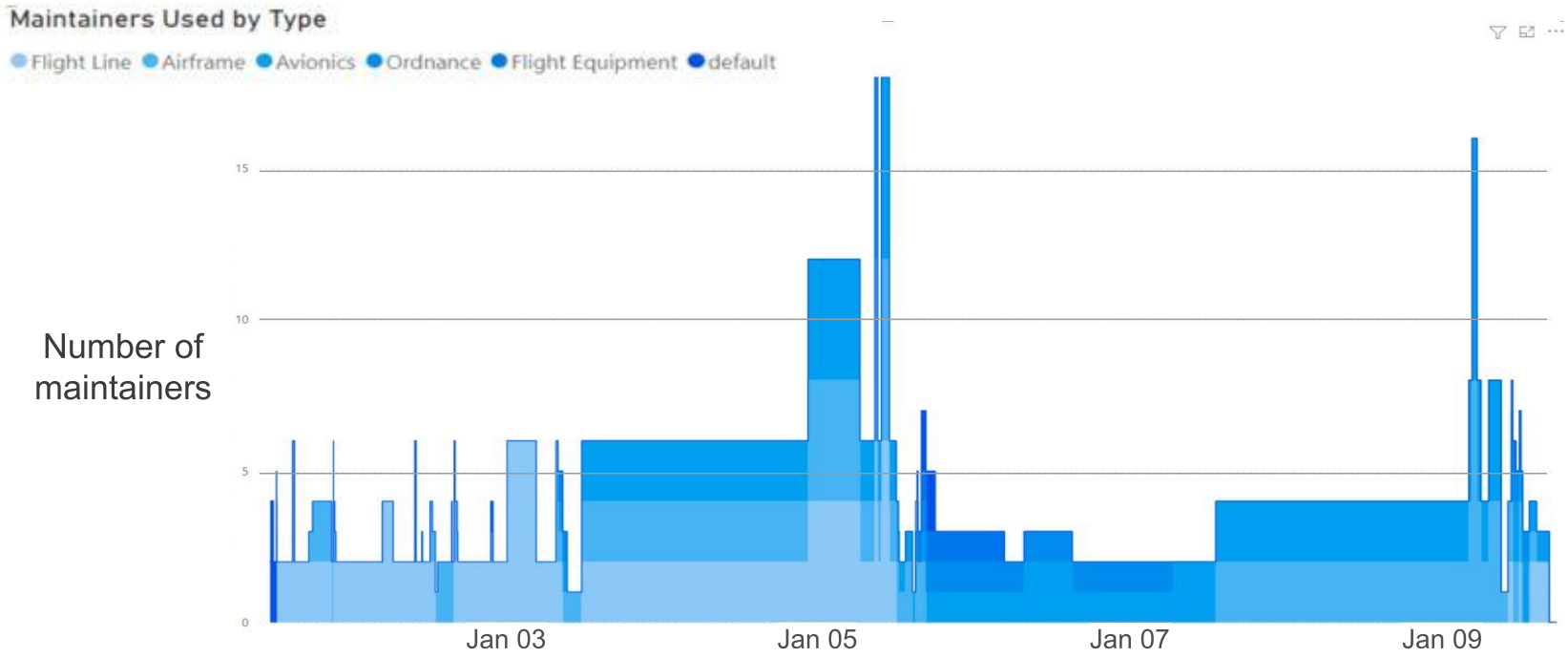

Number of maintainers

Phase Event Timeline:
Color represents maintainer type

Inform Trade Studies

Comparing design and maintenance plan changes to a baseline

- Upfront cost for reliability improvement vs cost from failures and higher MMH
- Performance gains from reduced weight vs reduced reliability or difficult maintenance

THANK YOU