# A Simulation-Based Approach to Assess Multiple Courses of Action for Diminishing Manufacturing Sources and Material Shortages (DMSMS)

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ISMOR
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Jonathan Dukat, Abhishek Paul
Northrop Grumman Aerospace Systems

# Abstract


- The constantly evolving nature of warfare and advancing technology of DoD systems has led to ever-increasing obsolescence and Diminishing Manufacturing Sources and Material Shortages (DMSMS) challenges for logisticians. “Without a proactive process to resolve DMSMS issues, mission readiness is severely degraded and operations costs skyrocket (Jethon & Barger, 2017).” Traditional mitigation approaches tend to focus primarily on lower-level solutions without sufficient analysis to inform decision makers of longer term weapon system readiness impacts. A common approach is to focus on sub-optimal solutions to satisfy cost or schedule constraints without fully exploring alternatives that could potentially ensue in reliability and maintainability enhancements that result in greater availability and cost improvements over the life cycle. Decision makers charged with ensuring continued readiness of DoD systems need an approach that holistically examines impacts on weapon system operational availability (Ao) and operating and support (O&S) costs over the life cycle. The purpose of this study is to provide an approach to assess these mitigation solutions, compare their benefits holistically across the logistics elements, and to analyze their potential impact on weapon system availability and O&S cost. This approach could be tailored for use on similar problems where impacts of weapon system modification efforts over the life cycle of a system need to be assessed.


Reference


Jethon, R. G., & Barger, J. (2017). An Approach to Resolving DMSMS: How a NAVSUP WSS Program Saved over $100M. *DSP JOURNAL* , 8-12.

# Agenda

- Tool Overview
- Scenario
- Results
- Conclusions

Note: Reliability, Maintainability, Supportability and Cost Data Used To Illustrate the Methodology is Notional Data

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# Tool Overview:
# Model for Aircraft Availability Forecasting (MAAF)

# Model For Asset Availability Forecasting (MAAF)

- An Object-oriented, Simulation Modeling Application Intended To Help Designers, Analysts And Planners Conduct Rapid Analyses Of A Variety Of Logistics Problems, Including:
  - Predicting Weapon System Availability Under Various Operational Scenarios
  - Allocating Logistics Resources Based On Mission Requirements
  - Impact Of Maintenance And Operational Policies On Aircraft Availability And Resources
  - Assessment Of Reliability and Maintainability (R&M) Improvements On Weapon System Availability And Logistics Resource Requirements
  - Sizing Units, Readiness Spares Packages (RSPs), Etc.
  - Analyzing The Impact Of Force Structure Changes
  - Impact of Primary Aircraft Inventory vs. Backup Aircraft Inventory

# Modeling and Simulation Trade Space

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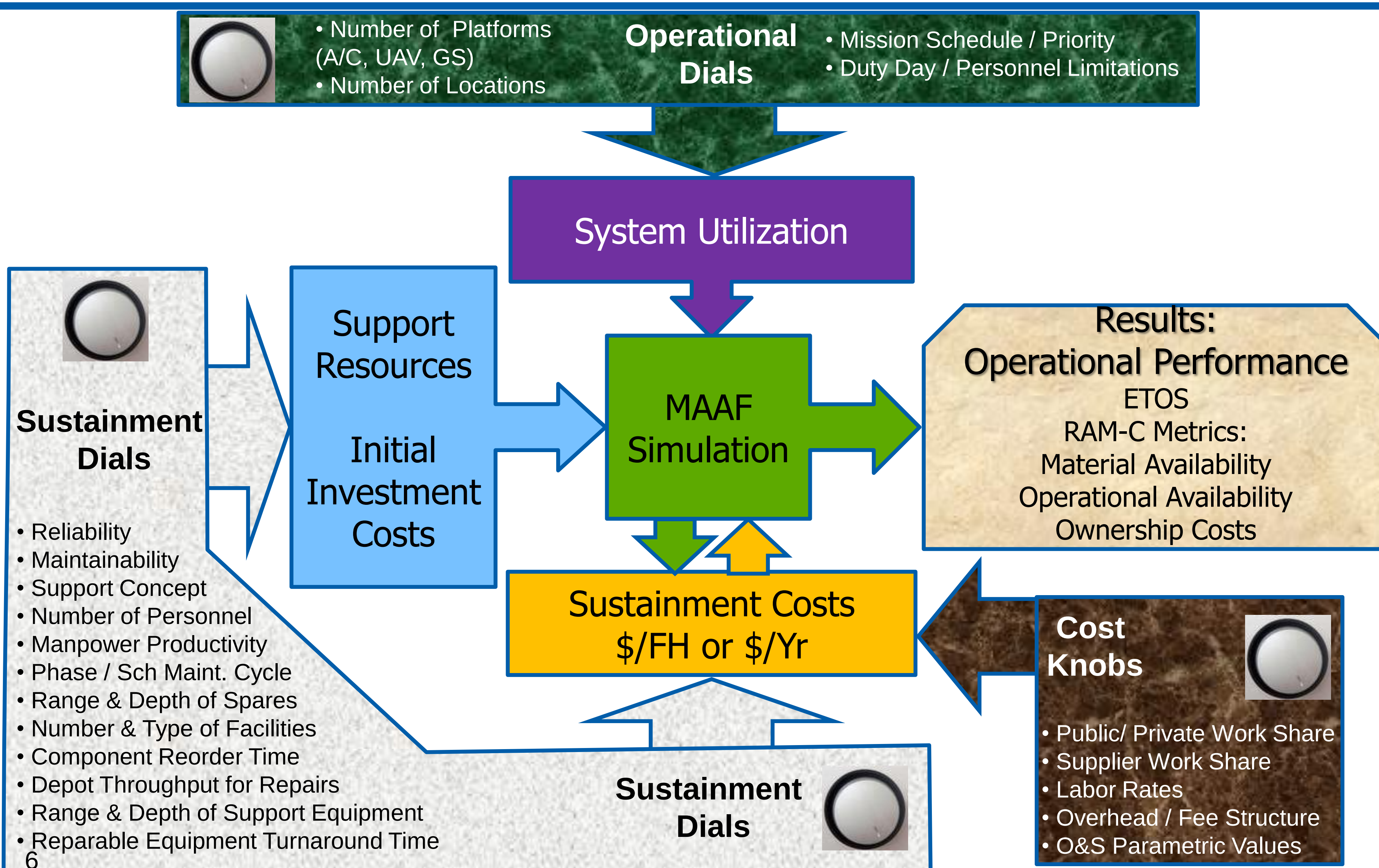

# Typical Platform MESL – Repair Actions Data

(All data is notional)

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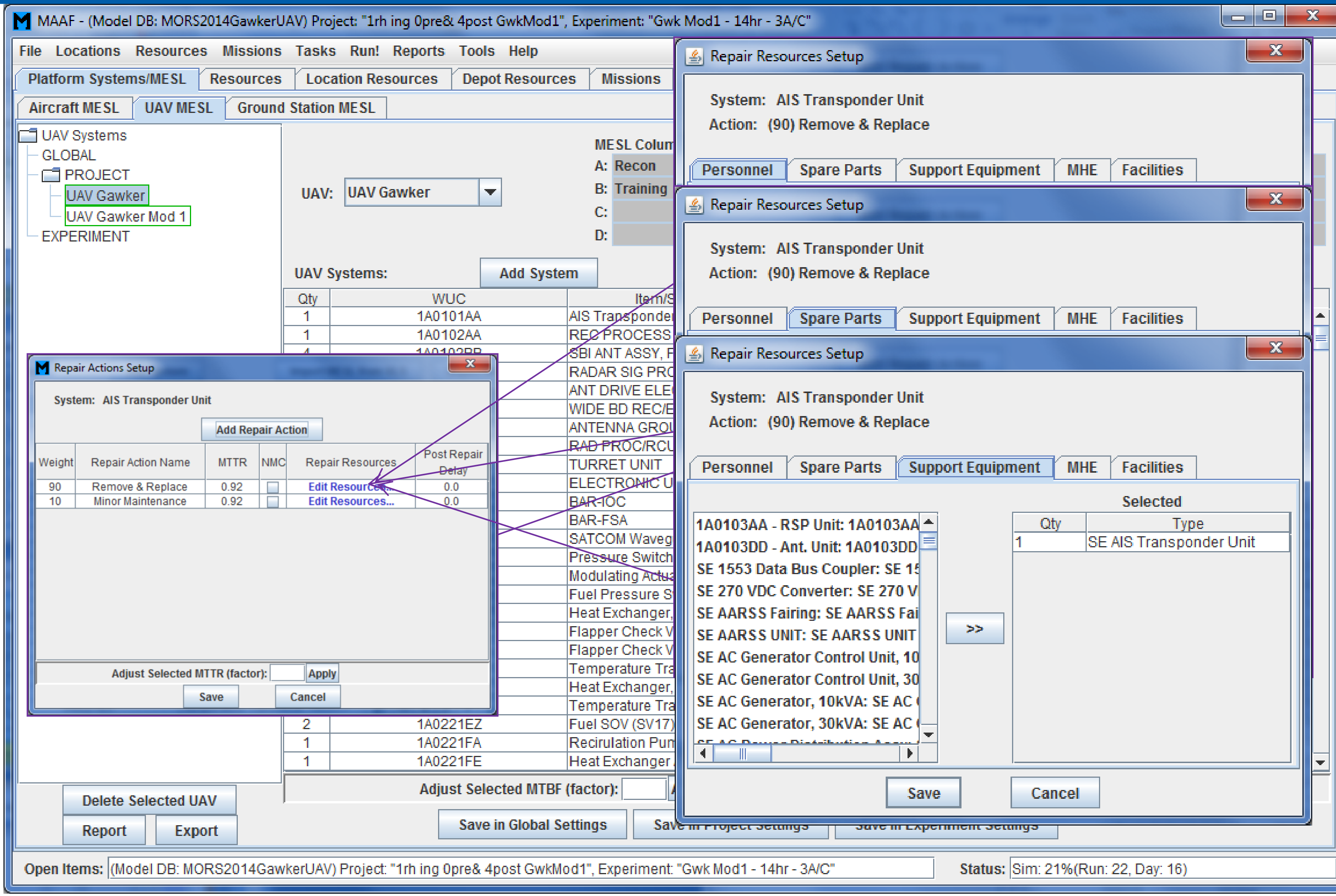
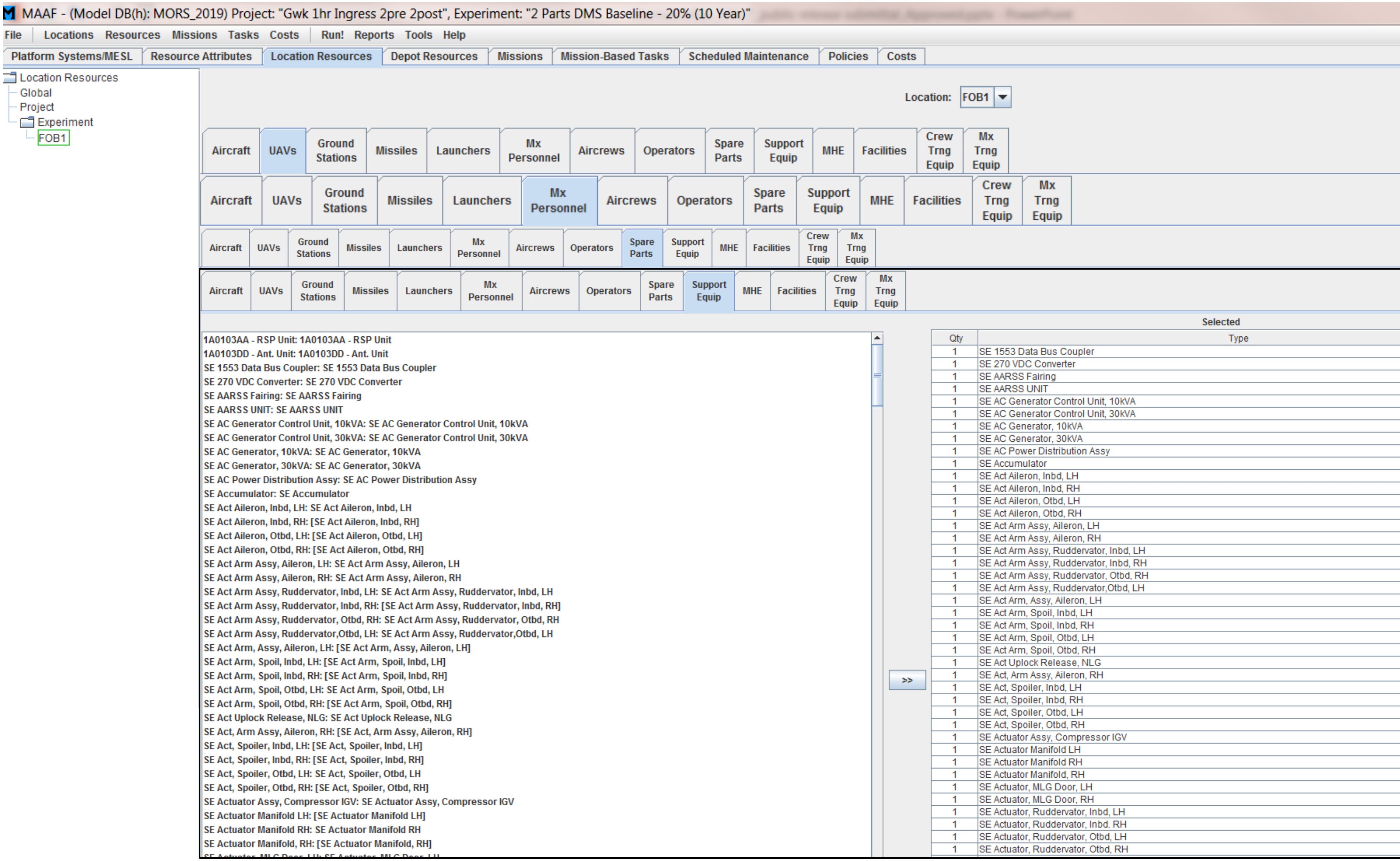


# Operational Location Resources

(All data is notional)



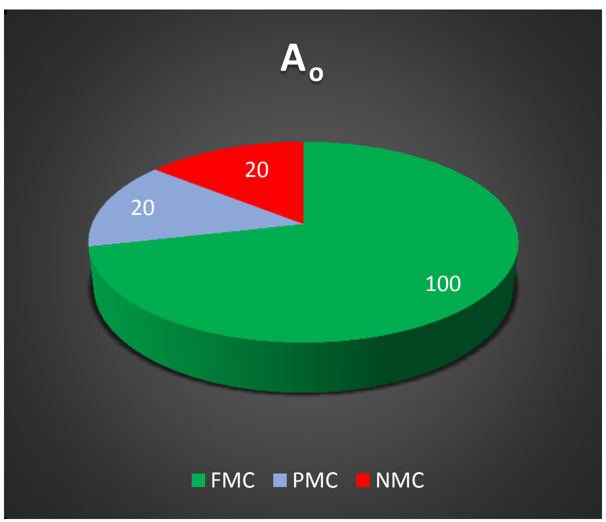
# What is *Availability*?

- Availability is a measurement of fleet readiness; how available your fleet is to perform missions
- *There are two types of Availability we measure*:

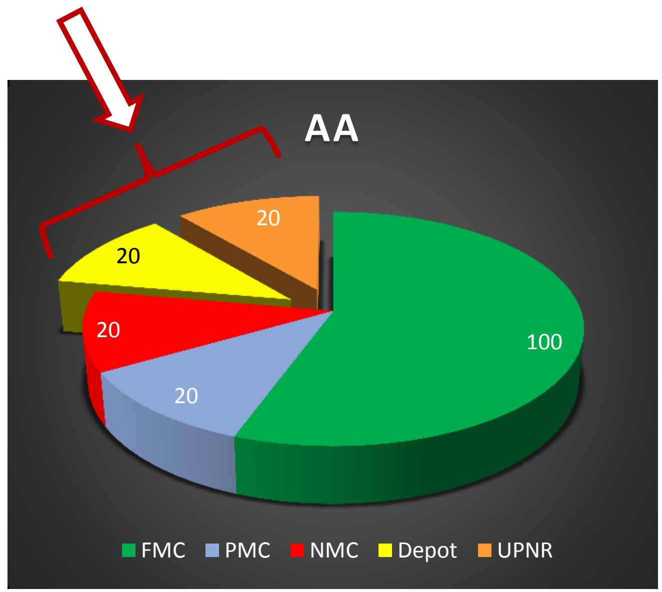
***Operational Availability*** $(A_o) = \frac{\text{FMC} + \text{PMC}}{\text{FMC} + \text{PMC} + \text{NMC}} = \frac{\text{Uptime}}{\text{Uptime} + \text{Downtime}}$ ⇨ Possessed

***Materiel Availability*** $(A_m) = \frac{\text{Uptime}}{\text{Possessed} + \text{UPNR} + \text{Depot}}$ ⇨ Non-Possessed

FMC – Full Mission Capable
PMC – Partial Mission Capable
NMC – Not mission Capable
UPNR – Unit Possessed Not Reported




$A_o = 85\%$

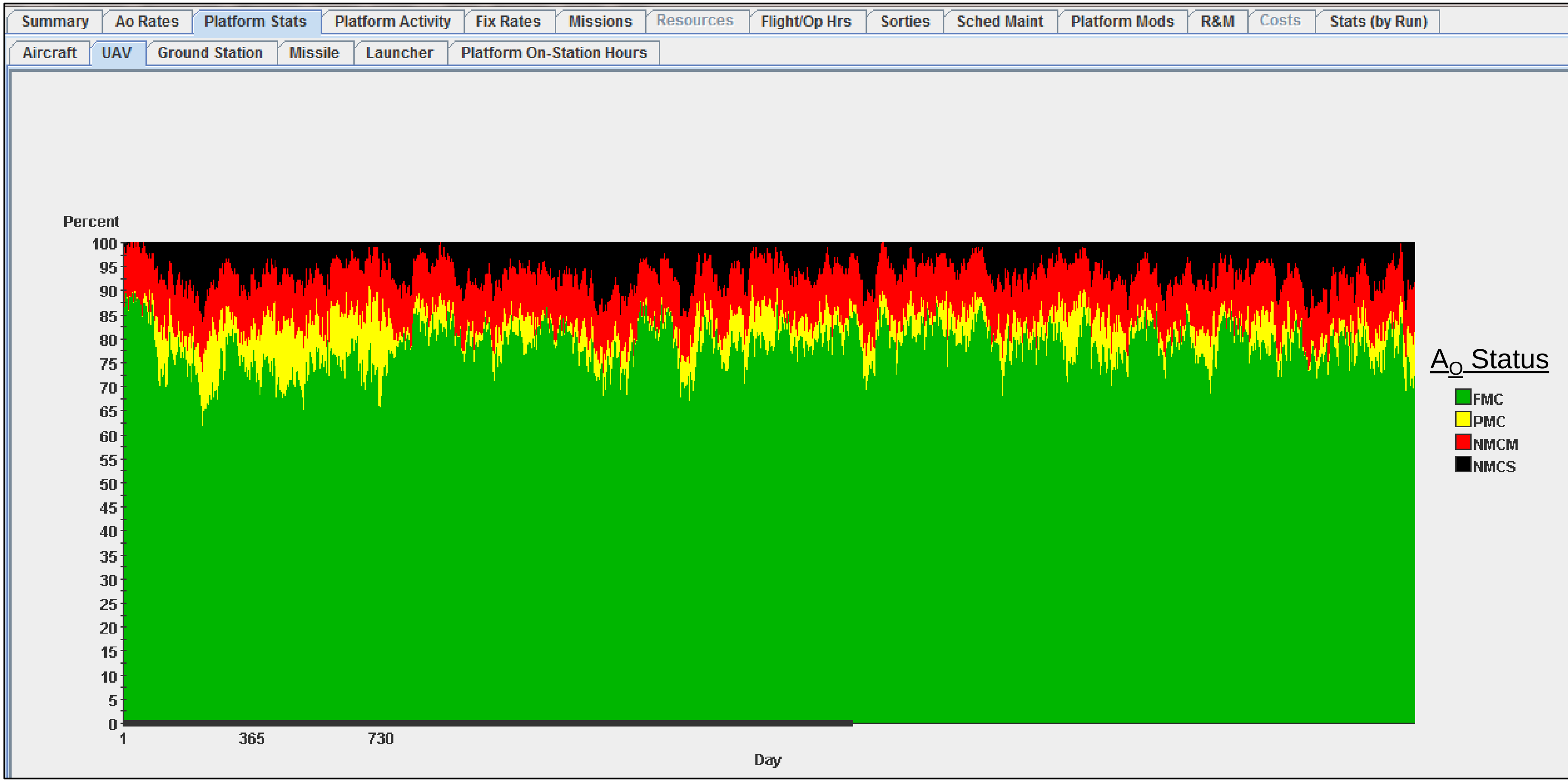



$A_m = 67\%$



Approved for public release; NG19-1037, 6/3/19

# UAV Daily $A_O$ Status




**MAAF Calculates Availability By Tail Number On A Minute by Minute / Day by Day Basis**

# Output Example: Summary Page

(All data is notional)

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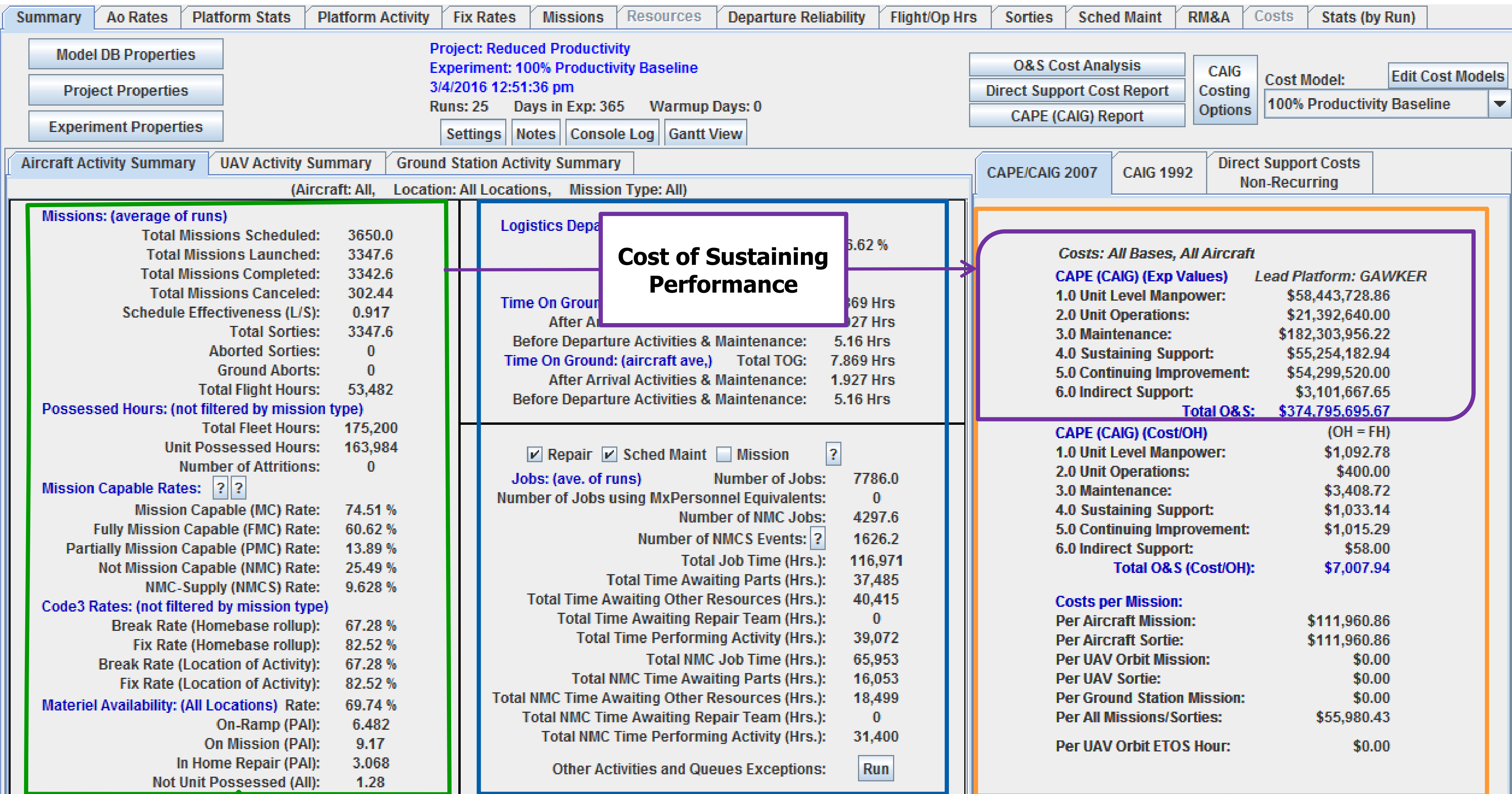



Operational & Availability Performance

Maintenance And Supply Job Summary

Operations & Support Costs

# Output Example: Summary Page (Continued)

(All data is notional)

Summary | Ao Rates | Platform Stats | Platform Activity | Fix Rates | Missions | Resources | Departure Reliability | Flight/Op Hrs | Sorties | Sched Maint | RM&A | Costs | Stats (by Run)

Model DB Properties
Project Properties
Experiment Properties

Project: Reduced Productivity
Experiment: 100% Productivity Baseline
3/4/2016 12:51:36 pm
Runs: 25 Days in Exp: 365 Warmup Days: 0

Settings | Notes | Console Log | Gantt View

O&S Cost Analysis
Direct Support Cost Report
CAPE (CAIG) Report

CAIG Costing Options

Cost Model: Edit Cost Models
100% Productivity Baseline

Aircraft Activity Summary | UAV Activity Summary | Ground Station Activity Summary

(Aircraft: All, Location: All Locations, Mission Type: All)

| Missions: (average of runs) | |
|---|---|
| Total Missions Scheduled: | 3650.0 |
| Total Missions Launched: | 3347.6 |
| Total Missions Completed: | 3342.6 |
| Total Missions Canceled: | 302.44 |
| Schedule Effectiveness (L/S): | 0.917 |
| Total Sorties: | 3347.6 |
| Aborted Sorties: | 0 |
| Ground Aborts: | 0 |
| Total Flight Hours: | 53,482 |
| **Possessed Hours: (not filtered by mission type)** | |
| Total Fleet Hours: | 175,200 |
| Unit Possessed Hours: | 163,984 |
| Number of Attritions: | 0 |
| **Mission Capable Rates: ? ?** | |
| Mission Capable (MC) Rate: | 74.51 % |
| Fully Mission Capable (FMC) Rate: | 60.62 % |
| Partially Mission Capable (PMC) Rate: | 13.89 % |
| Not Mission Capable (NMC) Rate: | 25.49 % |
| NMC-Supply (NMCS) Rate: | 9.628 % |
| **Code3 Rates: (not filtered by mission type)** | |
| Break Rate (Homebase rollup): | 67.28 % |
| Fix Rate (Homebase rollup): | 82.52 % |
| Break Rate (Location of Activity): | 67.28 % |
| Fix Rate (Location of Activity): | 82.52 % |
| **Materiel Availability: (All Locations)** Rate: | 69.74 % |
| On-Ramp (PAI): | 6.482 |
| On Mission (PAI): | 9.17 |
| In Home Repair (PAI): | 3.068 |
| Not Unit Possessed (All): | 1.28 |

| Logistics Departure Reliability: (ave. of runs) | | |
|---|---|---|
| | Home Station: | 76.62 % |
| | En-Route: | |
| | Worldwide: | |
| Time On Ground: (mission ave.) | Total TOG: | 7.869 Hrs |
| | After Arrival Activities & Maintenance: | 1.927 Hrs |
| | Before Departure Activities & Maintenance: | 5.16 Hrs |
| Time On Ground: (aircraft ave,) | Total TOG: | 7.869 Hrs |
| | After Arrival Activities & Maintenance: | 1.927 Hrs |
| | Before Departure Activities & Maintenance: | 5.16 Hrs |

☑ Repair ☑ Sched Maint ☐ Mission ?

| Jobs: (ave. of runs) | | |
|---|---|---|
| | Number of Jobs: | 7786.0 |
| | Number of Jobs using MxPersonnel Equivalents: | 0 |
| | Number of NMC Jobs: | 4297.6 |
| | Number of NMCS Events: ? | 1626.2 |
| | Total Job Time (Hrs.): | 116,971 |
| | Total Time Awaiting Parts (Hrs.): | 37,485 |
| | Total Time Awaiting Other Resources (Hrs.): | 40,415 |
| | Total Time Awaiting Repair Team (Hrs.): | 0 |
| | Total Time Performing Activity (Hrs.): | 39,072 |
| | Total NMC Job Time (Hrs.): | 65,953 |
| | Total NMC Time Awaiting Parts (Hrs.): | 16,053 |
| | Total NMC Time Awaiting Other Resources (Hrs.): | 18,499 |
| | Total NMC Time Awaiting Repair Team (Hrs.): | 0 |
| | Total NMC Time Performing Activity (Hrs.): | 31,400 |
| | Other Activities and Queues Exceptions: | Run |

CAPE/CAIG 2007 | CAIG 1992 | Direct Support Costs Non-Recurring

| *Costs: All Bases, All Aircraft* | |
|---|---|
| Aircraft: | $0.00 |
| UAV: | $0.00 |
| Ground Stations: | $0.00 |
| Aircrew Initial Trng: | $0.00 |
| Operator Initial Trng: | $0.00 |
| Mx Personnel Initial Trng: | $0.00 |
| Reparables: | $340,944,535.55 |
| Consumables: | $5,242,554.75 |
| Support Equipment: | $4,074,975.00 |
| MHE: | $0.00 |
| Aircrew Trng Equip: | $0.00 |
| Mx Trng Equip: | $0.00 |
| Facilities: | $0.00 |
| Depot Aircraft: | $0.00 |
| Depot UAVs: | $0.00 |
| Depot Mx Personnel Initial Training: | $0.00 |
| Depot Reparables: | $17,013,326.39 |
| Depot Consumables: | $1,593,531.95 |
| Depot Support Equipment: | $0.00 |
| Depot MHE: | $0.00 |
| Depot Facilities: | $0.00 |
| Depot Repair Queues: | $0.00 |
| **Total:** | $368,868,923.64 |

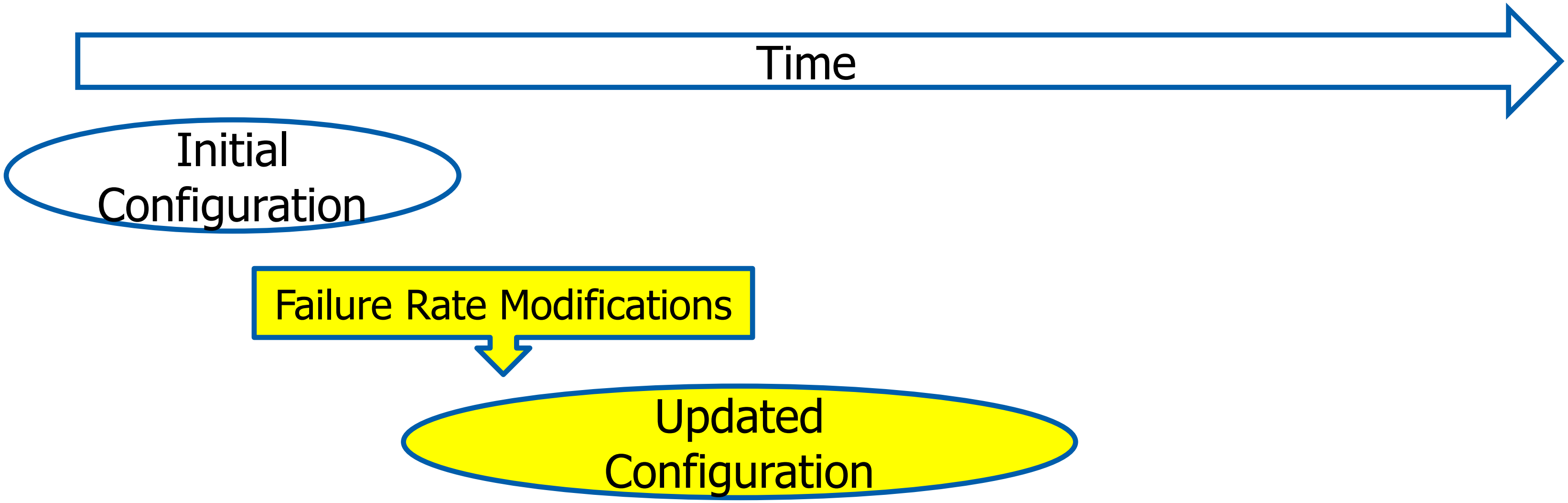
Operational & Availability Performance

Maintenance And Supply Job Summary

Non-Recurring Support Costs

# Reliability Mod Effects

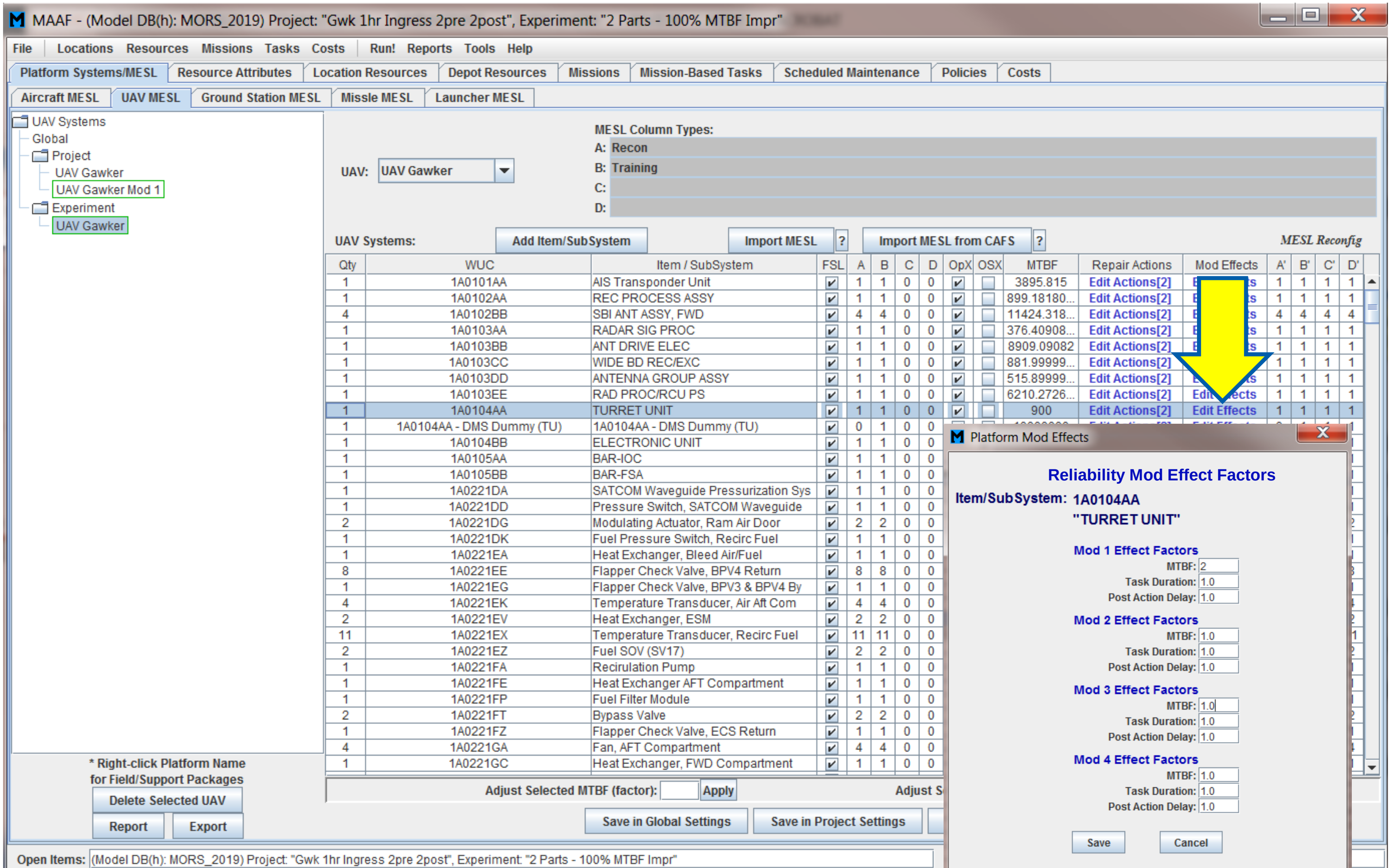
- MAAF Reliability Mod Effects can time phase expected reliability improvements at desired date to create more holistic model



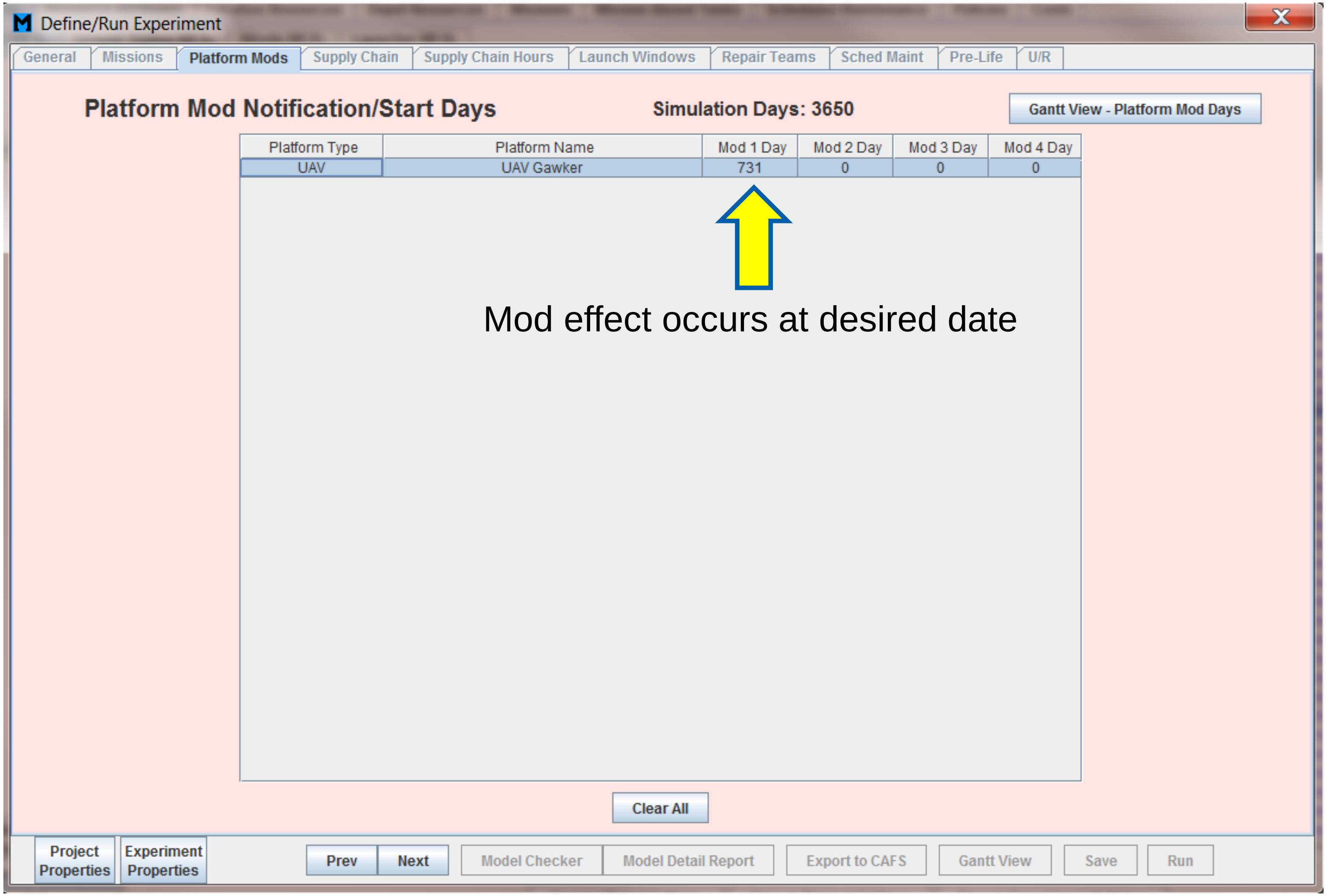

This is the specific functionality in MAAF that allows us to compare and quantify the benefits of the different DMS solutions

# Reliability Mod Effect Defined Per Part

(All data is notional)



# Time Phase Reliability Mod Effect



# Modeling using Reliability Mod Effects

- Reliability Mod Effects allows the user to implement known reliability improvements at the desired date to more accurately represent reality
  - In general, the failure rate is constant throughout the entire scenario
- Example Analysis that can be performed
  - Incorporating known future reliability improvements based on when they will be implemented
  - Assess how much the Reliability Growth of certain parts improve overall fleet Operational Availability
  - Assess different options of solving DMS based on when they are projected to start impacting the system
    - Cheaper solution with no Reliability improvement vs. solutions with Reliability improvement

# Scenario

# Problem Statement

- A UAV component will become unrepairable in two years due to DMS. What DMS solution should be pursued?
  1) Do Nothing
  2) Life Time Buy of DMS Circuit Card Assembly (CCA) Part
  3) Full Redesign of the DMS CCA Part
  4) Full Redesign of the Higher Assembly

| Example Higher Level Assy / Part Structure | | |
|---|---|---|
| **Indenture** | **Part** | **Example Part Description** |
| 1 | Higher Level Assy 1 | Computer |
| 2 | Part 1A | Circuit Board (DMS) |
| 2 | Part 1B | Hard Drive |
| 2 | Part 1C | Power Supply |

# Description of Mitigation Solutions

1) Do Nothing
   a. If there is no solution in place, fleet performance will slowly degrade as these units cause the UAV to be Not Mission Capably (NMC)

2) Last Time Buy of DMS CCA Part
   a. A sufficient quantity of the DMS part is purchased to sustain the product for the next 10 years
   b. No Failure Rate improvement as this continues to use the same part
   c. This option is not always available if the OEM has stopped all manufacturing of the part
   d. This is a “Band-Aid” fix not truly solving the DMS issue

3) Full Redesign of DMS CCA Part
   a. Estimated 50% Failure Rate Improvement
      a. This is a good opportunity to improve the failure rate of the part and improve overall performance of the system

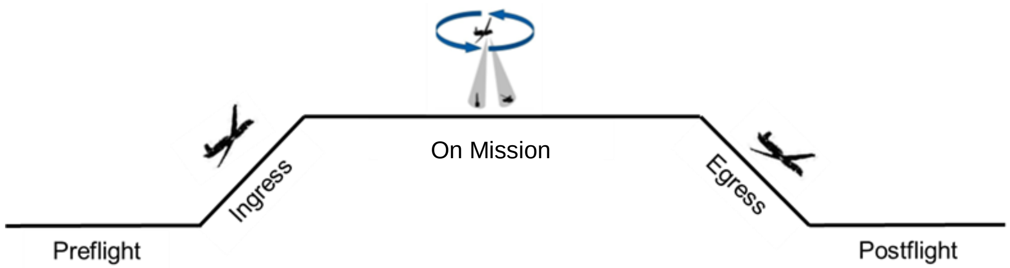
4) Full Redesign of Higher Assembly
   a. High Non Recurring Engineering (NRE) Cost
   b. 100% Failure Rate Improvement
      a. This is a good opportunity to drastically improve the failure rate of the part and improve performance of the system

# GR&A for Scenario

Note: Notional UAV Reliability, Maintainability, Supportability and Cost Data Used To Illustrate the Methodology

## Flight Ops:

- Single Forward Operating Location (FOL) with 3 UAVs in the fleet to provide continuous On Mission coverage for a 10 Year Life Cycle
  - $A_O$ Goal: 75%
  - Flight Hours Goal: 90,000
  - Mission Details
    - Preflight: 2 Hrs
    - Ingress: 1 Hr
    - On Mission: 24 Hrs
    - Egress: 1 Hr
    - Postflight: 2Hr

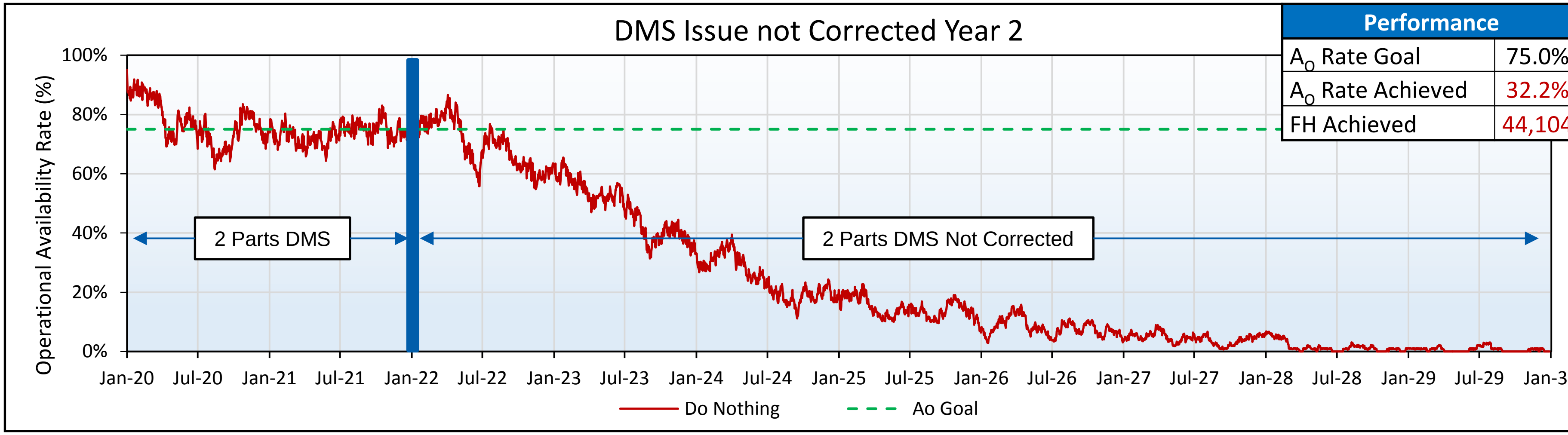



| DMS Part's Metrics | | | | | |
|---|---|---|---|---|---|
| | MTBF | New MTBF at 2 Year Mark (Full Redesign of DMS Part) | New MTBF at 2 Year Mark (Full Redesign of DMS Higher Assy) | Unit Cost | Repair Cost |
| X KA Ant Assy | 900 | 1,350 | 1,800 | $ 822,000 | $ 82,200 |
| Turret Unit | 1,000 | 1,500 | 2,000 | $ 801,791 | $ 80,179 |

# Results

# 1) Results (Notional) – Do Nothing

**No MTBF Improvement**




| Performance | |
|---|---|
| $A_O$ Rate Goal | 75.0% |
| $A_O$ Rate Achieved | 32.2% |
| FH Achieved | 44,104 |

## <u>Cost:</u> $15.4M

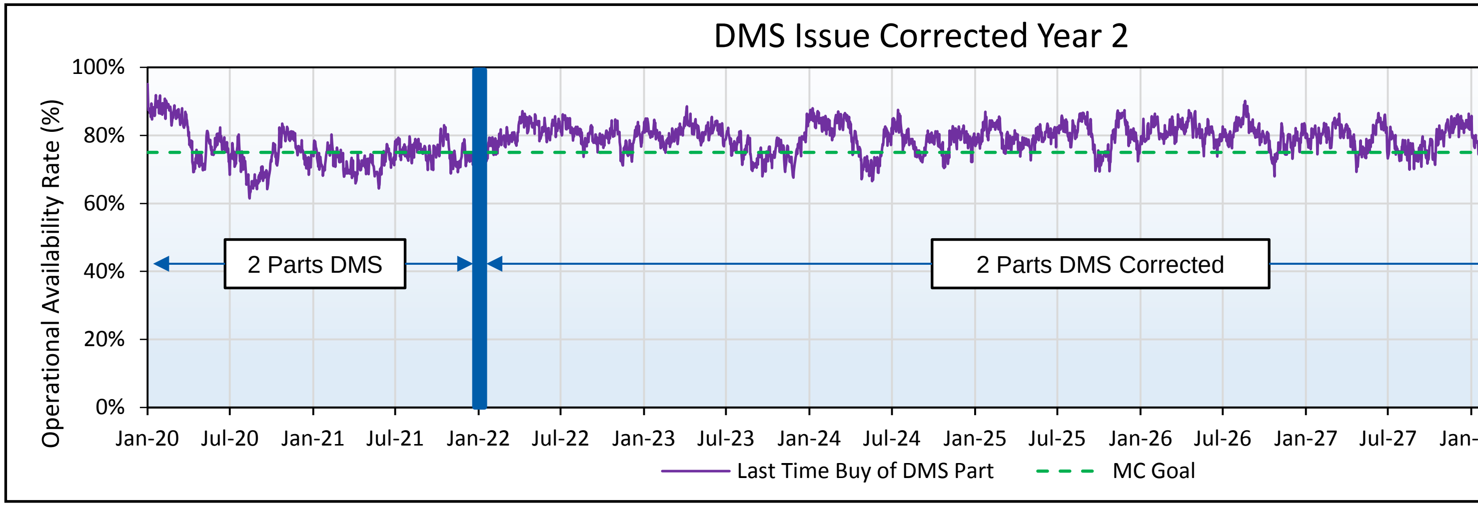
- NRE: $0
- 10 Year Sustainment Cost: $15.4M

## <u>Cost Per Flight Hour (CPFH):</u> $349/ FH

| | Repair Cost per Repair | # Repairs | Total Repair Cost | Unit Cost | # Condemned | Total Condemnation Cost | Total Repair and Condemnation Cost |
|---|---|---|---|---|---|---|---|
| X KA Ant Assy | $ 82,200 | 34.3 | $ 2,819,460 | $ 822,000 | 5.4 | $ 4,465,926 | $ 7,285,386 |
| Turret Unit | $ 80,179 | 37.9 | $ 3,041,193 | $ 801,791 | 6.3 | $ 5,078,544 | $ 8,119,737 |
| Total | | | $ 5,860,653 | | | $ 9,544,470 | $ 15,405,123 |

# 2) Results (Notional) – Last Time Buy of DMS Part

**No MTBF Improvement**




| Performance | |
|---|---|
| $A_O$ Rate Goal | 75.0% |
| $A_O$ Rate Achieved | 78.3% |
| FH Achieved | 95,251 |

<u>Cost:</u> $25.5M

- NRE: $6.6M
  - Last Time Buy of DMS part to sustain 10 years: $5M
  - 2 additional spares: $1.6M
- 10 Year Sustainment Cost: $18.9M

<u>CPFH:</u> $268/ FH

| | Repair Cost per Repair | # Repairs | Total Repair Cost | Unit Cost | # Condemned | Total Condemnation Cost | Total Repair and Condemnation Cost |
|---|---|---|---|---|---|---|---|
| X KA Ant Assy | $ 82,200 | 80.6 | $ 6,627,786 | $ 822,000 | 3.2 | $ 2,603,274 | $ 9,231,060 |
| Turret Unit | $ 80,179 | 93.6 | $ 7,507.169 | $ 801,791 | 2.7 | $ 2,164,836 | $ 9,672,005 |
| Total | | | $ 14,134,955 | | | $ 4,768,110 | $18,903,065 |

# 3) Results (Notional) – Full Redesign of DMS Part

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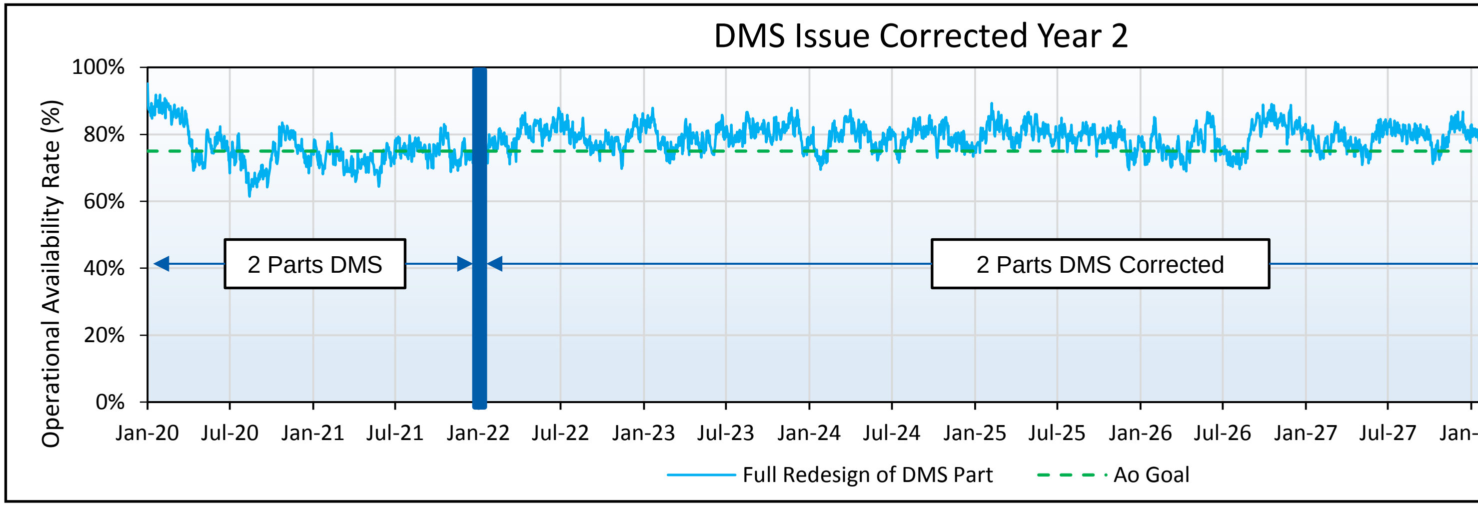
**50% MTBF Improvement**




| Performance | |
|---|---|
| $A_O$ Rate Goal | 75.0% |
| $A_O$ Rate Achieved | 78.1% |
| FH Achieved | 95,703 |

<u>Cost:</u> $23.9M

- NRE: $10M
  - $5M for Redesign
  - $5M for new initial spares and to stock UAVs
- 10 Year Sustainment Cost: $13.9M

<u>CPFH:</u> $250/ FH

| | Repair Cost per Repair | # Repairs | Total Repair Cost | Unit Cost | # Condemned | Total Condemnation Cost | Total Repair and Condemnation Cost |
|---|---|---|---|---|---|---|---|
| X KA Ant Assy | $ 82,200 | 60.0 | $ 4,934,466 | $ 822,000 | 1.9 | $ 1,534,674 | $ 6,469,140 |
| Turret Unit | $ 80,179 | 69.0 | $ 5,534,763 | $ 801,791 | 2.4 | $ 1,924,298 | $ 7,459,062 |
| Total | | | $ 10,469,229 | | | $3,458,972 | $ 13,928,202 |

# 4) Results (Notional) – Full Redesign of Higher Assembly

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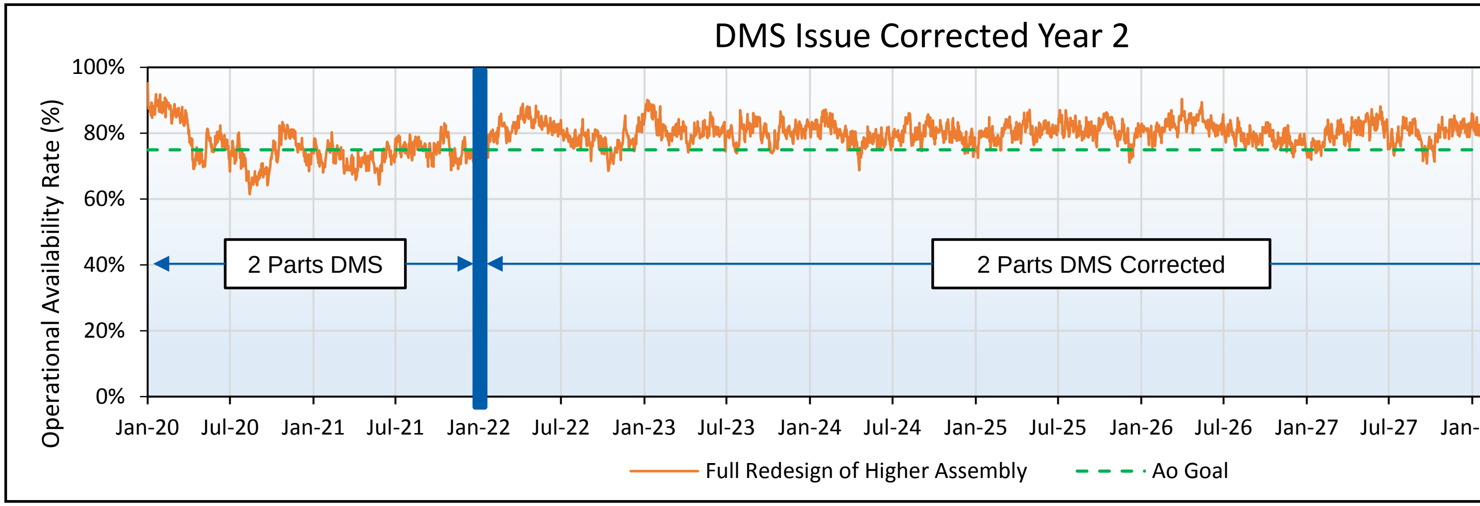
## 100% MTBF Improvement: MTBF




| Performance | |
|---|---|
| $A_O$ Rate Goal | 75.0% |
| $A_O$ Rate Achieved | 79.0% |
| FH Achieved | 97,284 |

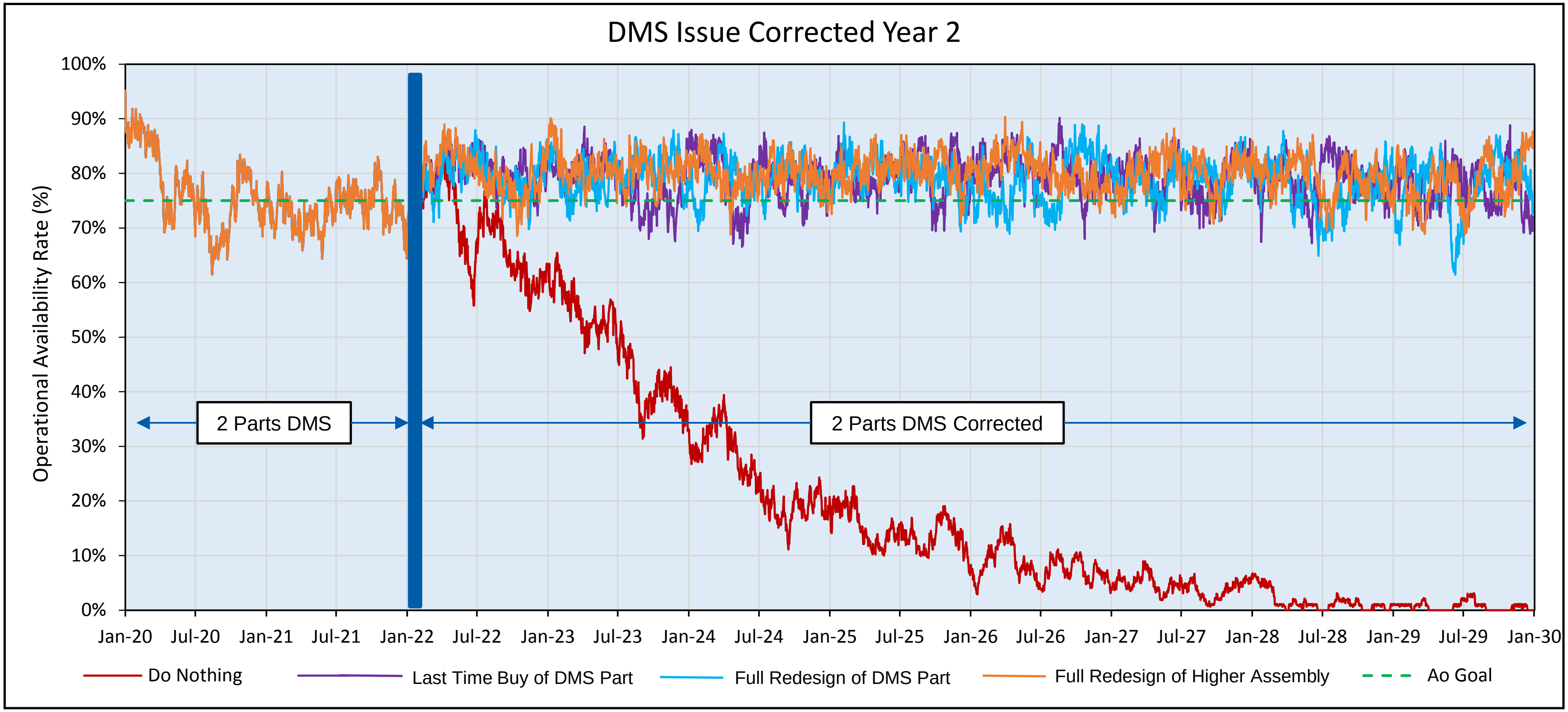
<u>Cost:</u> $41.7M

- NRE: $30M
  - $20M for Redesign
  - $10M for new initial spares and to stock UAVs
- 10 Year Sustainment Cost: $11.7M

<u>CPFH:</u> $429/ FH

| | Repair Cost per Repair | # Repairs | Total Repair Cost | Unit Cost | # Condemned | Total Condemnation Cost | Total Repair and Condemnation Cost |
|---|---|---|---|---|---|---|---|
| X KA Ant Assy | $ 82,200 | 50.8 | $ 4,178,226 | $ 822,000 | 1.6 | $ 1,315,200 | $ 5,493,426 |
| Turret Unit | $ 80,179 | 57.3 | $ 4,591,055 | $ 801,791 | 2.1 | $ 1,657,302 | $ 6,248,357 |
| Total | | | $ 8,769,281 | | | $ 2,972,502 | $ 11,741,783 |

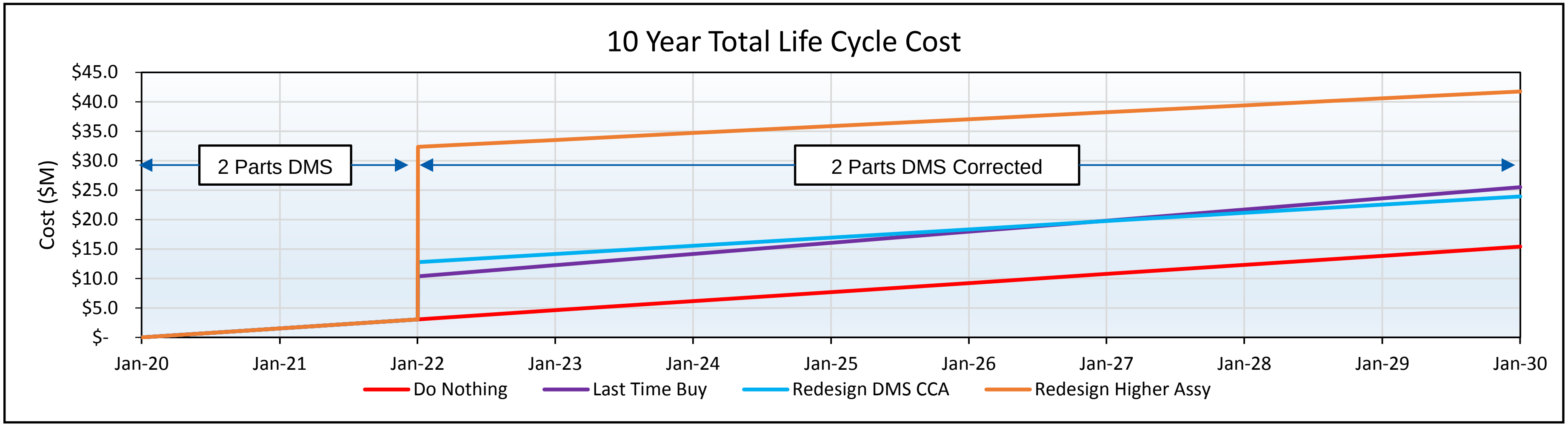
# Summary – Operational Availability Impact (Notional)




| Legend | Modeled Scenario | $A_O$ Rate (%) |
|---|---|---|
| (red line) | Do Nothing | 32.2 |
| (purple line) | Last Time Buy of DMS Part | 78.3 |
| (blue line) | Full Redesign of DMS Part | 78.1 |
| (orange line) | Full Redesign of Higher Assembly | 79.0 |
| (green dashed line) | Operational Availability Goal | 75.0 |

**All three DMS Solutions Sufficient to Achieve an Operational Availability Goal of 75%**

# Summary – 10 Year Life Cycle Cost (Notional)




| DMS Mitigation Solution | NRE Cost | 10 Year Repair Cost | 10 Year Condemnation Cost | 10 Year Life Cycle Cost | CPFH |
|---|---|---|---|---|---|
| Do Nothing | $ - | $ 5,860,653 | $ 9,544,470 | $ 15,405,123 | $349 |
| Last Time Buy of DMS CCA Part | $ 6,600,000 | $ 14,134,955 | $ 4,768,110 | $ 25,503,065 | $268 |
| Full Redesign of DMS CCA Part | $ 10,000,000 | $ 10,469,229 | $ 3,458,972 | $ 23,928,201 | $250 |
| Full Redesign of Higher Assy | $ 30,000,000 | $ 8,769,281 | $ 2,972,505 | $ 41,741,786 | $429 |

- Although this mitigation solution is initially more expensive than the Last Time Buy solution, the 10 year sustainment costs are much lower

**In This Case, Investment in the Full Redesign of the DMS Part Provides Significant Increase in $A_O$ Rate with Similar Life Cycle Cost**

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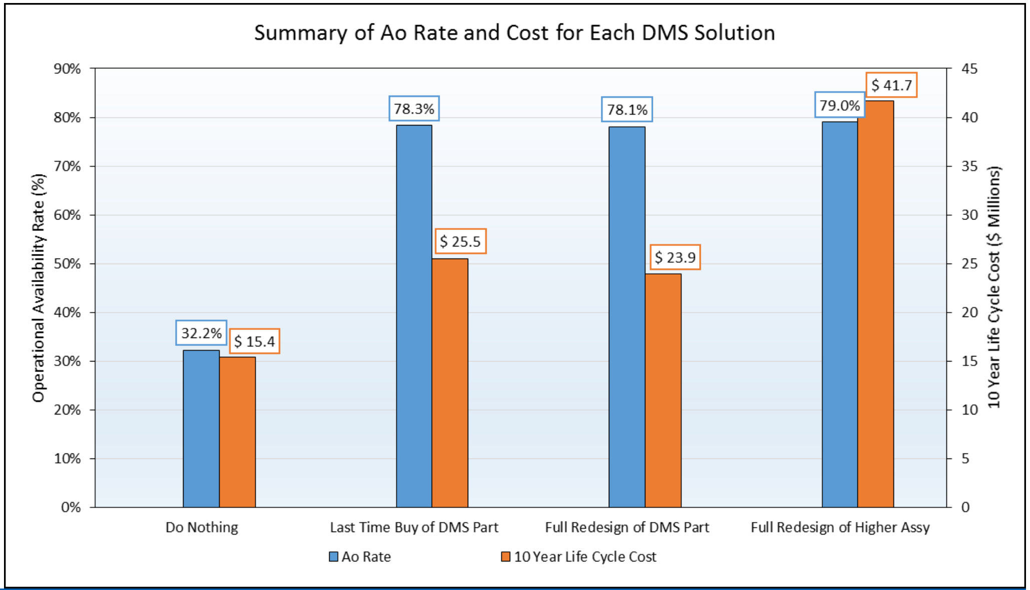
# Conclusions

# Conclusions

(Data is notional)

- The cheapest option may not be the right DMS solution
  - Critical to understand cost over the entire lifecycle of the program (this case, 10 years)
    - Bigger investment up front can result in significant cost savings of the entire life cycle
- The greatest Operational Availability improvement may not be the right DMS solution
  - Redesigning out of DMS gives the potential for Reliability Improvements to be incorporated to help the overall performance of the fleet
    - Programs can take advantage of these low hanging fruit opportunities to improve historically bad performing parts
- There is no “one right answer” to mitigate all DMS issues
  - Too many variables to make a decision purely off initial cost savings




**Gives Decision Makers More Flexibility and Options to Choose the Best Solution**

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# Questions?

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