



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

ISMOR
25 July, 2019

Jonathan Dukat, Abhishek Paul
Northrop Grumman Aerospace Systems

Distribution Statement A. This presentation/paper is unclassified, approved for public release, distribution unlimited, and is exempt from U.S. export licensing and other export approvals under the International Traffic in Arms Regulations (22 CFR 120 et seq.)

Approved for public release; NG19-1037, 6/3/19
© 2019 Northrop Grumman Systems Corporation. All Rights Reserved.

- 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.

- Tool Overview
- Scenario
- Results
- Conclusions

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



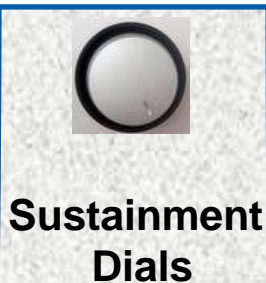
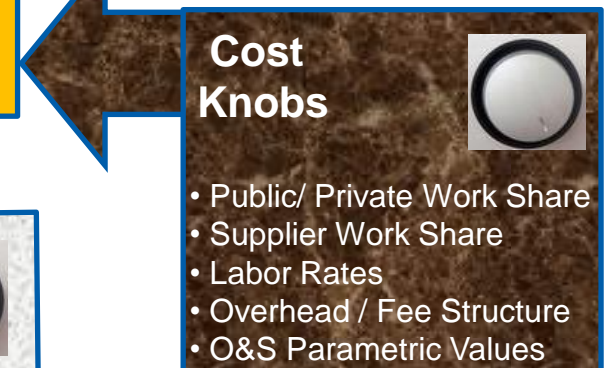
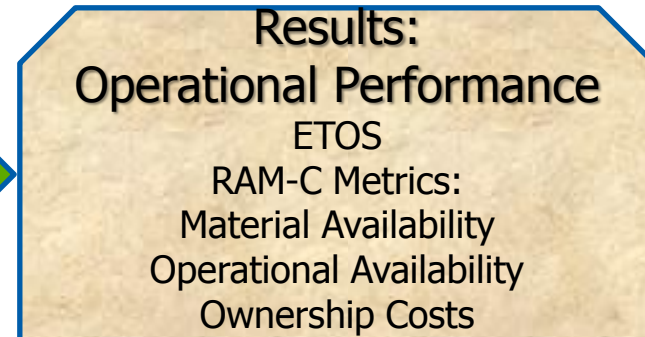
Tool Overview: Model for Aircraft Availability Forecasting (MAAF)

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



- Reliability
- Maintainability
- Support Concept
- Number of Personnel
- Manpower Productivity
- Phase / Sch Maint. Cycle
- Range & Depth of Spares
- Number & Type of Facilities
- Component Reorder Time
- Depot Throughput for Repairs
- Range & Depth of Support Equipment
- Reparable Equipment Turnaround Time



Typical Platform MESL – Repair Actions Data

(All data is notional)

MAAF - (Model DB: MORS2014GawkerUAV) Project: "1rh ing Opre& 4post GwkMod1", Experiment: "Gwk Mod1 - 14hr - 3A/C"

File Locations Resources Missions Tasks Run! Reports Tools Help

Platform Systems/MESL Resources Location Resources Depot Resources Missions

Aircraft MESL UAV MESL Ground Station MESL

UAV Systems
GLOBAL
PROJECT
UAV Gawker
UAV Gawker Mod 1
EXPERIMENT

UAV: UAV Gawker

MESL Column
A: Recon
B: Training
C:
D:

UAV Systems: Add System

Qty	WUC	Item/S
1	1A0101AA	AIS Transponder
1	1A0102AA	REC PROCESS
4	1A0103BB	SBI ANT ASSY, F
		RADAR SIG PRO
		ANT DRIVE ELE
		WIDE BD REC/E
		ANTENNA GROU
		RAD PROC/RCU
		TURRET UNIT
		ELECTRONIC U
		BAR-IOC
		BAR-FSA
		SATCOM Waveg
		Pressure Switch
		Modulating Act
		Fuel Pressure S
		Heat Exchanger
		Flapper Check V
		Flapper Check V
		Temperature Tra
		Heat Exchanger
		Temperature Tra
		Fuel SOV (SV17)
		Recirculation P
		Heat Exchanger

Repair Actions Setup

System: AIS Transponder Unit

Add Repair Action

Weight	Repair Action Name	MTTR	NMC	Repair Resources	Post Repair Delay
90	Remove & Replace	0.92	<input type="checkbox"/>	Edit Resources...	0.0
10	Minor Maintenance	0.92	<input type="checkbox"/>	Edit Resources...	0.0

Adjust Selected MTTR (factor): Apply

Save Cancel

Repair Resources Setup

System: AIS Transponder Unit

Action: (90) Remove & Replace

Personnel Spare Parts Support Equipment MHE Facilities

Repair Resources Setup

System: AIS Transponder Unit

Action: (90) Remove & Replace

Personnel Spare Parts Support Equipment MHE Facilities

Selected

Qty	Type
1	SE AIS Transponder Unit

1A0103AA - RSP Unit: 1A0103AA
1A0103DD - Ant. Unit: 1A0103DD
SE 1553 Data Bus Coupler: SE 1553
SE 270 VDC Converter: SE 270 V
SE AARSS Fairing: SE AARSS Fairing
SE AARSS UNIT: SE AARSS UNIT
SE AC Generator Control Unit, 10
SE AC Generator Control Unit, 30
SE AC Generator, 10kVA: SE AC
SE AC Generator, 30kVA: SE AC
SE AC Power Distribution Assy

Save Cancel

Delete Selected UAV Report Export

Adjust Selected MTBF (factor): Save in Global Settings Save in Project Settings Save in Experiment Settings

Open Items: (Model DB: MORS2014GawkerUAV) Project: "1rh ing Opre& 4post GwkMod1", Experiment: "Gwk Mod1 - 14hr - 3A/C" Status: Sim: 21%(Run: 22, Day: 16)

Operational Location Resources

(All data is notional)

MAAF - (Model DB(h): MORS_2019) Project: "Gwk 1hr Ingress 2pre 2post", Experiment: "2 Parts DMS Baseline - 20% (10 Year)"

File Locations Resources Missions Tasks Costs Run! Reports Tools Help

Platform Systems/MESL Resource Attributes Location Resources Depot Resources Missions Mission-Based Tasks Scheduled Maintenance Policies Costs

Location Resources
Global
Project
Experiment
FOB1

Location: FOB1

Aircraft	UAVs	Ground Stations	Missiles	Launchers	Mx Personnel	Aircrews	Operators	Spare Parts	Support Equip	MHE	Facilities	Crew Trng Equip	Mx Trng Equip
Aircraft	UAVs	Ground Stations	Missiles	Launchers	Mx Personnel	Aircrews	Operators	Spare Parts	Support Equip	MHE	Facilities	Crew Trng Equip	Mx Trng Equip
Aircraft	UAVs	Ground Stations	Missiles	Launchers	Mx Personnel	Aircrews	Operators	Spare Parts	Support Equip	MHE	Facilities	Crew Trng Equip	Mx Trng Equip
Aircraft	UAVs	Ground Stations	Missiles	Launchers	Mx Personnel	Aircrews	Operators	Spare Parts	Support Equip	MHE	Facilities	Crew Trng Equip	Mx Trng Equip

1A0103AA - RSP Unit: 1A0103AA - RSP Unit
1A0103DD - Ant. Unit: 1A0103DD - Ant. Unit
SE 1553 Data Bus Coupler: SE 1553 Data Bus Coupler
SE 270 VDC Converter: SE 270 VDC Converter
SE AARSS Fairing: SE AARSS Fairing
SE AARSS UNIT: SE AARSS UNIT
SE AC Generator Control Unit, 10kVA: SE AC Generator Control Unit, 10kVA
SE AC Generator Control Unit, 30kVA: SE AC Generator Control Unit, 30kVA
SE AC Generator, 10kVA: SE AC Generator, 10kVA
SE AC Generator, 30kVA: SE AC Generator, 30kVA
SE AC Power Distribution Assy: SE AC Power Distribution Assy
SE Accumulator: SE Accumulator
SE Act Aileron, Inbd, LH: SE Act Aileron, Inbd, LH
SE Act Aileron, Inbd, RH: [SE Act Aileron, Inbd, RH]
SE Act Aileron, Otbd, LH: [SE Act Aileron, Otbd, LH]
SE Act Aileron, Otbd, RH: [SE Act Aileron, Otbd, RH]
SE Act Arm Assy, Aileron, LH: SE Act Arm Assy, Aileron, LH
SE Act Arm Assy, Aileron, RH: SE Act Arm Assy, Aileron, RH
SE Act Arm Assy, Ruddervator, Inbd, LH: SE Act Arm Assy, Ruddervator, Inbd, LH
SE Act Arm Assy, Ruddervator, Inbd, RH: [SE Act Arm Assy, Ruddervator, Inbd, RH]
SE Act Arm Assy, Ruddervator, Otbd, RH: SE Act Arm Assy, Ruddervator, Otbd, RH
SE Act Arm Assy, Ruddervator, Otbd, LH: SE Act Arm Assy, Ruddervator, Otbd, LH
SE Act Arm, Assy, Aileron, LH: [SE Act Arm, Assy, Aileron, LH]
SE Act Arm, Spoil, Inbd, LH: [SE Act Arm, Spoil, Inbd, LH]
SE Act Arm, Spoil, Inbd, RH: [SE Act Arm, Spoil, Inbd, RH]
SE Act Arm, Spoil, Otbd, LH: SE Act Arm, Spoil, Otbd, LH
SE Act Arm, Spoil, Otbd, RH: [SE Act Arm, Spoil, Otbd, RH]
SE Act Uplock Release, NLG: SE Act Uplock Release, NLG
SE Act, Arm Assy, Aileron, RH: [SE Act, Arm Assy, Aileron, RH]
SE Act, Spoiler, Inbd, LH: [SE Act, Spoiler, Inbd, LH]
SE Act, Spoiler, Inbd, RH: [SE Act, Spoiler, Inbd, RH]
SE Act, Spoiler, Otbd, LH: SE Act, Spoiler, Otbd, LH
SE Act, Spoiler, Otbd, RH: [SE Act, Spoiler, Otbd, RH]
SE Actuator Assy, Compressor IGV: SE Actuator Assy, Compressor IGV
SE Actuator Manifold LH: [SE Actuator Manifold LH]
SE Actuator Manifold RH: SE Actuator Manifold RH
SE Actuator Manifold, RH: [SE Actuator Manifold, RH]
SE Actuator, MLG Door, LH: SE Actuator, MLG Door, LH

Selected

Qty	Type
1	SE 1553 Data Bus Coupler
1	SE 270 VDC Converter
1	SE AARSS Fairing
1	SE AARSS UNIT
1	SE AC Generator Control Unit, 10kVA
1	SE AC Generator Control Unit, 30kVA
1	SE AC Generator, 10kVA
1	SE AC Generator, 30kVA
1	SE AC Power Distribution Assy
1	SE Accumulator
1	SE Act Aileron, Inbd, LH
1	SE Act Aileron, Inbd, RH
1	SE Act Aileron, Otbd, LH
1	SE Act Aileron, Otbd, RH
1	SE Act Arm Assy, Aileron, LH
1	SE Act Arm Assy, Aileron, RH
1	SE Act Arm Assy, Ruddervator, Inbd, LH
1	SE Act Arm Assy, Ruddervator, Inbd, RH
1	SE Act Arm Assy, Ruddervator, Otbd, RH
1	SE Act Arm Assy, Ruddervator, Otbd, LH
1	SE Act Arm, Assy, Aileron, LH
1	SE Act Arm, Spoil, Inbd, LH
1	SE Act Arm, Spoil, Inbd, RH
1	SE Act Arm, Spoil, Otbd, LH
1	SE Act Arm, Spoil, Otbd, RH
1	SE Act Uplock Release, NLG
1	SE Act, Arm Assy, Aileron, RH
1	SE Act, Spoiler, Inbd, LH
1	SE Act, Spoiler, Inbd, RH
1	SE Act, Spoiler, Otbd, LH
1	SE Act, Spoiler, Otbd, RH
1	SE Actuator Assy, Compressor IGV
1	SE Actuator Manifold LH
1	SE Actuator Manifold RH
1	SE Actuator Manifold, RH
1	SE Actuator, MLG Door, LH
1	SE Actuator, MLG Door, RH
1	SE Actuator, Ruddervator, Inbd, LH
1	SE Actuator, Ruddervator, Inbd, RH
1	SE Actuator, Ruddervator, Otbd, LH
1	SE Actuator, Ruddervator, Otbd, RH

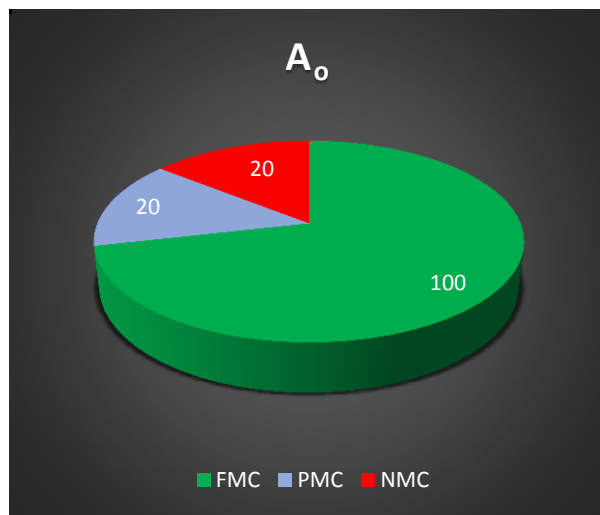
What is *Availability*?

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

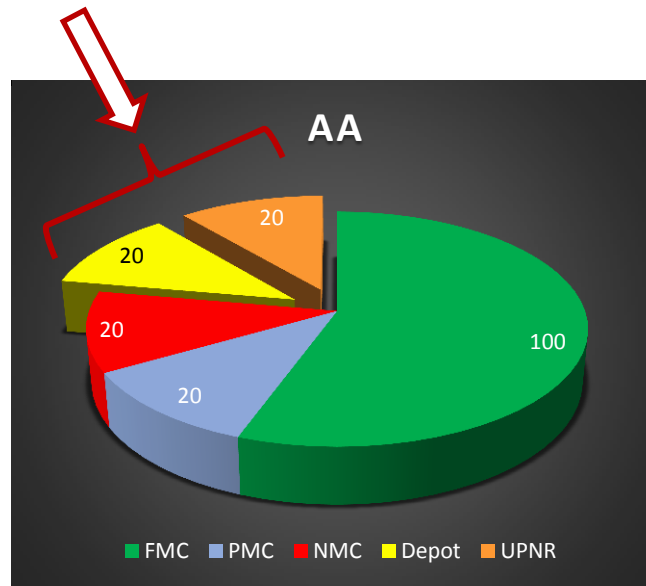
$$\text{Operational Availability (A}_o\text{)} = \frac{\text{FMC} + \text{PMC}}{\text{FMC} + \text{PMC} + \text{NMC}} = \frac{\text{Uptime}}{\text{Uptime} + \text{Downtime}} \Rightarrow \text{Possessed}$$

$$\text{Materiel Availability (A}_m\text{)} = \frac{\text{Uptime}}{\text{Possessed} + \text{UPNR} + \text{Depot}} \Rightarrow \text{Non-Possessed}$$

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

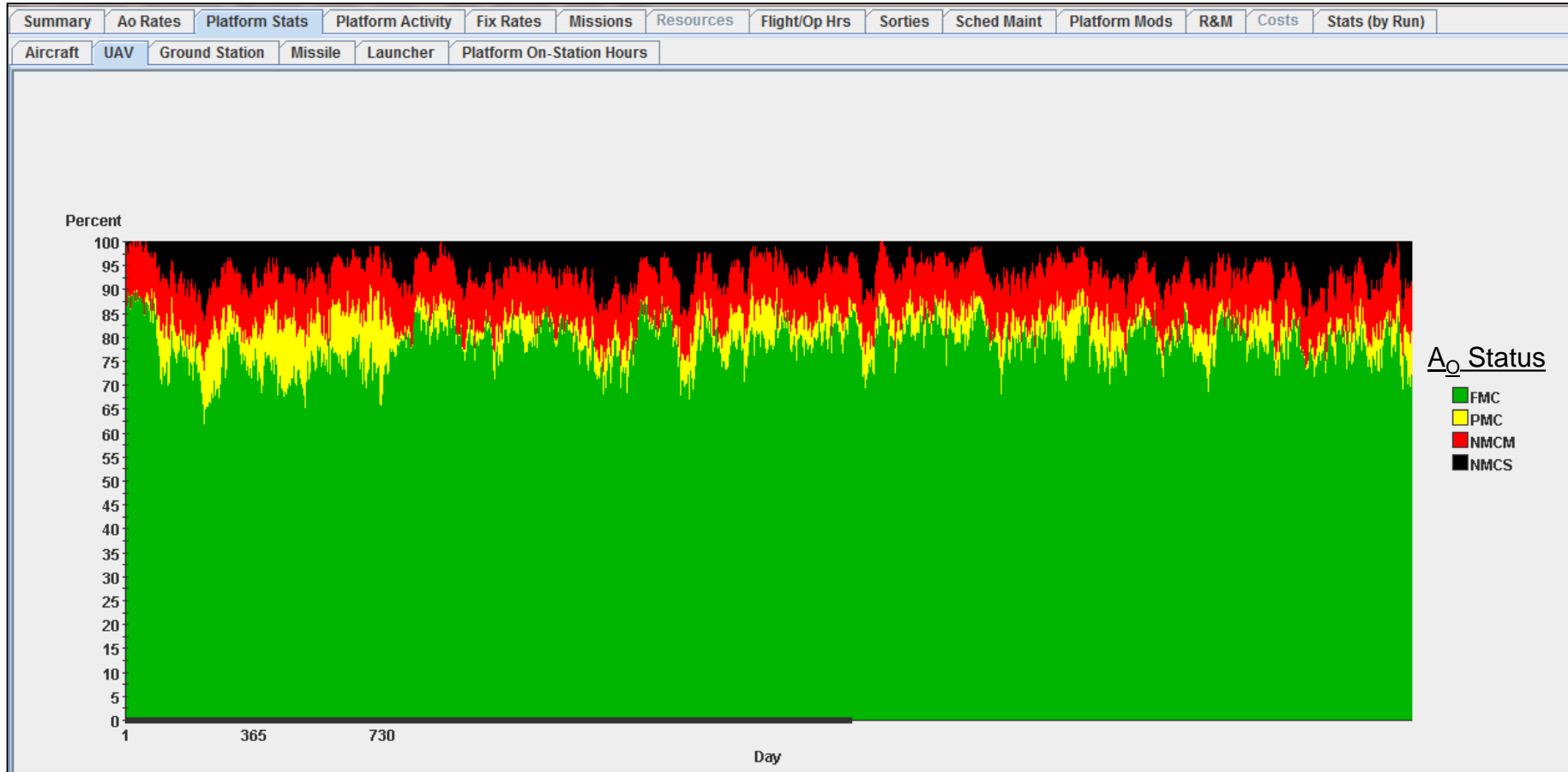


$A_o = 85\%$



$A_m = 67\%$

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)

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: 100% Productivity Baseline | Edit Cost Models

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 rollout):	67.28 %
Fix Rate (Homebase rollout):	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 Department

Time On Ground: 7.869 Hrs
After Arrival Activities & Maintenance: 1.927 Hrs
Before Departure Activities & Maintenance: 5.16 Hrs

Cost of Sustaining Performance

Time On Ground: 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

Costs: All Bases, All Aircraft

CAPE (CAIG) (Exp Values) Lead Platform: GAWKER

1.0 Unit Level Manpower:	\$58,443,728.86
2.0 Unit Operations:	\$21,392,640.00
3.0 Maintenance:	\$182,303,956.22
4.0 Sustaining Support:	\$55,254,182.94
5.0 Continuing Improvement:	\$54,299,520.00
6.0 Indirect Support:	\$3,101,667.65
Total O&S:	\$374,795,695.67

CAPE (CAIG) (Cost/OH) (OH = FH)

1.0 Unit Level Manpower:	\$1,092.78
2.0 Unit Operations:	\$400.00
3.0 Maintenance:	\$3,408.72
4.0 Sustaining Support:	\$1,033.14
5.0 Continuing Improvement:	\$1,015.29
6.0 Indirect Support:	\$58.00
Total O&S (Cost/OH):	\$7,007.94

Costs per Mission:

Per Aircraft Mission:	\$111,960.86
Per Aircraft Sortie:	\$111,960.86
Per UAV Orbit Mission:	\$0.00
Per UAV Sortie:	\$0.00
Per Ground Station Mission:	\$0.00
Per All Missions/Sorties:	\$55,980.43
Per UAV Orbit ETOS Hour:	\$0.00

Operational & Availability Performance

Maintenance And Supply Job Summary

Operations & Support Costs

Output Example: Summary Page (Continued)

(All data is notional)

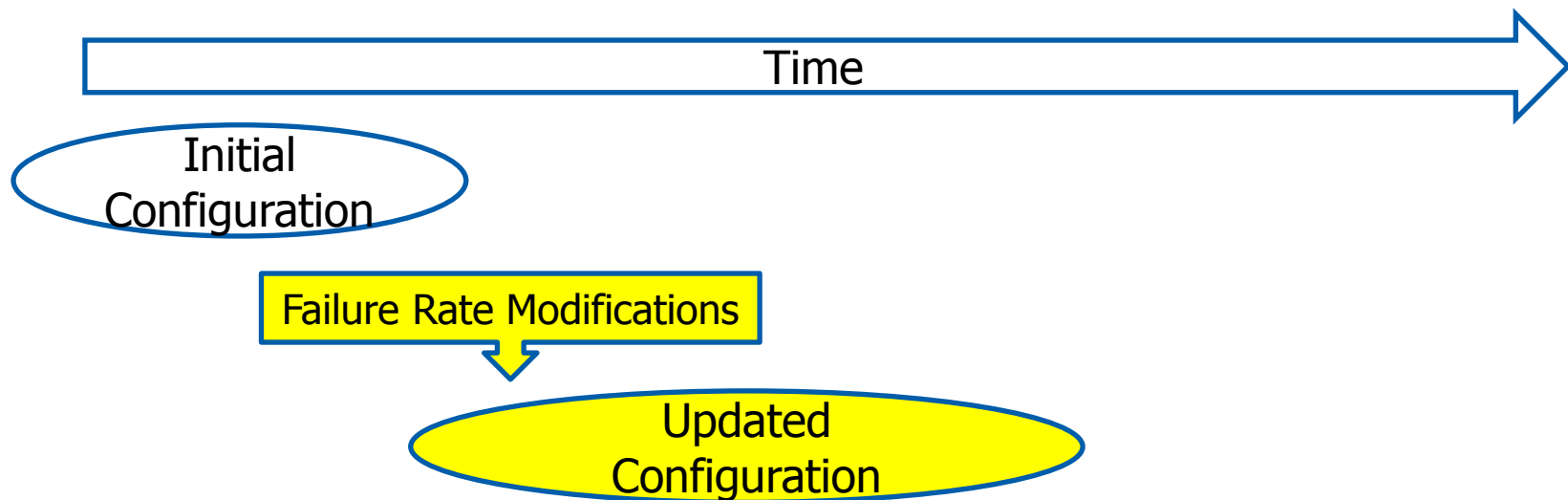
Summary	Ao Rates	Platform Stats	Platform Activity	Fix Rates	Missions	Resources	Departure Reliability	Flight/Op Hrs	Sorties	Sched Maint	RM&A	Costs	Stats (by Run)		
<div>Model DB Properties</div> <div>Project Properties</div> <div>Experiment Properties</div>				<div>Project: Reduced Productivity</div> <div>Experiment: 100% Productivity Baseline</div> <div>3/4/2016 12:51:36 pm</div> <div>Runs: 25 Days in Exp: 365 Warmup Days: 0</div> <div>Settings Notes Console Log Gantt View</div>				<div>O&S Cost Analysis</div> <div>Direct Support Cost Report</div> <div>CAPE (CAIG) Report</div>				<div>CAIG Costing Options</div> <div>Cost Model: Edit Cost Models</div> <div>100% Productivity Baseline</div>			
Aircraft Activity Summary				UAV Activity Summary				Ground Station Activity Summary				CAPE/CAIG 2007		CAIG 1992	Direct Support Costs Non-Recurring
(Aircraft: All, Location: All Locations, Mission Type: All)															
<div>Missions: (average of runs)</div> <div>Total Missions Scheduled: 3650.0</div> <div>Total Missions Launched: 3347.6</div> <div>Total Missions Completed: 3342.6</div> <div>Total Missions Canceled: 302.44</div> <div>Schedule Effectiveness (L/S): 0.917</div> <div>Total Sorties: 3347.6</div> <div>Aborted Sorties: 0</div> <div>Ground Aborts: 0</div> <div>Total Flight Hours: 53,482</div> <div>Possessed Hours: (not filtered by mission type)</div> <div>Total Fleet Hours: 175,200</div> <div>Unit Possessed Hours: 163,984</div> <div>Number of Attritions: 0</div> <div>Mission Capable Rates: ? ?</div> <div>Mission Capable (MC) Rate: 74.51 %</div> <div>Fully Mission Capable (FMC) Rate: 60.62 %</div> <div>Partially Mission Capable (PMC) Rate: 13.89 %</div> <div>Not Mission Capable (NMC) Rate: 25.49 %</div> <div>NMC-Supply (NMCS) Rate: 9.628 %</div> <div>Code3 Rates: (not filtered by mission type)</div> <div>Break Rate (Homebase rollout): 67.28 %</div> <div>Fix Rate (Homebase rollout): 82.52 %</div> <div>Break Rate (Location of Activity): 67.28 %</div> <div>Fix Rate (Location of Activity): 82.52 %</div> <div>Materiel Availability: (All Locations) Rate: 69.74 %</div> <div>On-Ramp (PAI): 6.482</div> <div>On Mission (PAI): 9.17</div> <div>In Home Repair (PAI): 3.068</div> <div>Not Unit Possessed (All): 1.28</div>					<div>Logistics Departure Reliability: (ave. of runs)</div> <div>Home Station: 76.62 %</div> <div>En-Route:</div> <div>Worldwide:</div> <div>Time On Ground: (mission ave.) Total TOG: 7.869 Hrs</div> <div>After Arrival Activities & Maintenance: 1.927 Hrs</div> <div>Before Departure Activities & Maintenance: 5.16 Hrs</div> <div>Time On Ground: (aircraft ave.) Total TOG: 7.869 Hrs</div> <div>After Arrival Activities & Maintenance: 1.927 Hrs</div> <div>Before Departure Activities & Maintenance: 5.16 Hrs</div> <div><input checked="" type="checkbox"/> Repair <input checked="" type="checkbox"/> Sched Maint <input type="checkbox"/> Mission ?</div> <div>Jobs: (ave. of runs) Number of Jobs: 7786.0</div> <div>Number of Jobs using MxPersonnel Equivalents: 0</div> <div>Number of NMC Jobs: 4297.6</div> <div>Number of NMCS Events: ? 1626.2</div> <div>Total Job Time (Hrs.): 116,971</div> <div>Total Time Awaiting Parts (Hrs.): 37,485</div> <div>Total Time Awaiting Other Resources (Hrs.): 40,415</div> <div>Total Time Awaiting Repair Team (Hrs.): 0</div> <div>Total Time Performing Activity (Hrs.): 39,072</div> <div>Total NMC Job Time (Hrs.): 65,953</div> <div>Total NMC Time Awaiting Parts (Hrs.): 16,053</div> <div>Total NMC Time Awaiting Other Resources (Hrs.): 18,499</div> <div>Total NMC Time Awaiting Repair Team (Hrs.): 0</div> <div>Total NMC Time Performing Activity (Hrs.): 31,400</div> <div>Other Activities and Queues Exceptions: Run</div>					<div>Costs: All Bases, All Aircraft</div> <div>Aircraft: \$0.00</div> <div>UAV: \$0.00</div> <div>Ground Stations: \$0.00</div> <div>Aircrew Initial Trng: \$0.00</div> <div>Operator Initial Trng: \$0.00</div> <div>Mx Personnel Initial Trng: \$0.00</div> <div>Reparables: \$340,944,535.55</div> <div>Consumables: \$5,242,554.75</div> <div>Support Equipment: \$4,074,975.00</div> <div>MHE: \$0.00</div> <div>Aircrew Trng Equip: \$0.00</div> <div>Mx Trng Equip: \$0.00</div> <div>Facilities: \$0.00</div> <div>Depot Aircraft: \$0.00</div> <div>Depot UAVs: \$0.00</div> <div>Depot Mx Personnel Initial Training: \$0.00</div> <div>Depot Reparables: \$17,013,326.39</div> <div>Depot Consumables: \$1,593,531.95</div> <div>Depot Support Equipment: \$0.00</div> <div>Depot MHE: \$0.00</div> <div>Depot Facilities: \$0.00</div> <div>Depot Repair Queues: \$0.00</div> <div>Total: \$368,868,923.64</div>					

Operational & Availability
Performance

Maintenance And Supply
Job Summary

Non-Recurring Support
Costs

- 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)

MAAF - (Model DB(h): MORS_2019) Project: "Gwk 1hr Ingress 2pre 2post", Experiment: "2 Parts - 100% MTBF Impr"

File Locations Resources Missions Tasks Costs Run! Reports Tools Help

Platform Systems/MESL Resource Attributes Location Resources Depot Resources Missions Mission-Based Tasks Scheduled Maintenance Policies Costs

Aircraft MESL UAV MESL Ground Station MESL Missile MESL Launcher MESL

UAV Systems

- Global
- Project
 - UAV Gawker
 - UAV Gawker Mod 1
- Experiment
 - UAV Gawker

UAV: UAV Gawker

MESL Column Types:

A: Recon
B: Training
C:
D:

UAV Systems: Add Item/SubSystem Import MESL Import MESL from CAFS MESL Reconfig

Qty	WUC	Item / SubSystem	FSL	A	B	C	D	OpX	OSX	MTBF	Repair Actions	Mod Effects	A'	B'	C'	D'
1	1A0101AA	AIS Transponder Unit	✓	1	1	0	0	✓	✓	3895.815	Edit Actions[2]	1	1	1	1	
1	1A0102AA	REC PROCESS ASSY	✓	1	1	0	0	✓	✓	899.18180...	Edit Actions[2]	1	1	1	1	
4	1A0102BB	SBI ANT ASSY, FWD	✓	4	4	0	0	✓	✓	11424.318...	Edit Actions[2]	4	4	4	4	
1	1A0103AA	RADAR SIG PROC	✓	1	1	0	0	✓	✓	376.40908...	Edit Actions[2]	1	1	1	1	
1	1A0103BB	ANT DRIVE ELEC	✓	1	1	0	0	✓	✓	8909.09082	Edit Actions[2]	1	1	1	1	
1	1A0103CC	WIDE BD REC/EXC	✓	1	1	0	0	✓	✓	881.99999...	Edit Actions[2]	1	1	1	1	
1	1A0103DD	ANTENNA GROUP ASSY	✓	1	1	0	0	✓	✓	515.89999...	Edit Actions[2]	1	1	1	1	
1	1A0103EE	RAD PROC/RCU PS	✓	1	1	0	0	✓	✓	6210.2726...	Edit Actions[2]	1	1	1	1	
1	1A0104AA	TURRET UNIT	✓	1	1	0	0	✓	✓	900	Edit Actions[2]	1	1	1	1	
1	1A0104AA - DMS Dummy (TU)	1A0104AA - DMS Dummy (TU)	✓	0	1	0	0	✓	✓							
1	1A0104BB	ELECTRONIC UNIT	✓	1	1	0	0	✓	✓							
1	1A0105AA	BAR-IOC	✓	1	1	0	0	✓	✓							
1	1A0105BB	BAR-FSA	✓	1	1	0	0	✓	✓							
1	1A0221DA	SATCOM Waveguide Pressurization Sys	✓	1	1	0	0	✓	✓							
1	1A0221DD	Pressure Switch, SATCOM Waveguide	✓	1	1	0	0	✓	✓							
2	1A0221DG	Modulating Actuator, Ram Air Door	✓	2	2	0	0	✓	✓							
1	1A0221DK	Fuel Pressure Switch, Recirc Fuel	✓	1	1	0	0	✓	✓							
1	1A0221EA	Heat Exchanger, Bleed Air/Fuel	✓	1	1	0	0	✓	✓							
8	1A0221EE	Flapper Check Valve, BPV4 Return	✓	8	8	0	0	✓	✓							
1	1A0221EG	Flapper Check Valve, BPV3 & BPV4 By	✓	1	1	0	0	✓	✓							
4	1A0221EK	Temperature Transducer, Air Aft Com	✓	4	4	0	0	✓	✓							
2	1A0221EV	Heat Exchanger, ESM	✓	2	2	0	0	✓	✓							
11	1A0221EX	Temperature Transducer, Recirc Fuel	✓	11	11	0	0	✓	✓							
2	1A0221EZ	Fuel SOV (SV17)	✓	2	2	0	0	✓	✓							
1	1A0221FA	Recirculation Pump	✓	1	1	0	0	✓	✓							
1	1A0221FE	Heat Exchanger AFT Compartment	✓	1	1	0	0	✓	✓							
1	1A0221FP	Fuel Filter Module	✓	1	1	0	0	✓	✓							
2	1A0221FT	Bypass Valve	✓	2	2	0	0	✓	✓							
1	1A0221FZ	Flapper Check Valve, ECS Return	✓	1	1	0	0	✓	✓							
4	1A0221GA	Fan, AFT Compartment	✓	4	4	0	0	✓	✓							
1	1A0221GC	Heat Exchanger, FWD Compartment	✓	1	1	0	0	✓	✓							

* Right-click Platform Name for Field/Support Packages

Delete Selected UAV

Report Export

Adjust Selected MTBF (factor): Apply Adjust S

Save in Global Settings Save in Project Settings

Open Items: (Model DB(h): MORS_2019) Project: "Gwk 1hr Ingress 2pre 2post", Experiment: "2 Parts - 100% MTBF Impr"

Platform Mod Effects

Reliability Mod Effect Factors

Item/SubSystem: 1A0104AA
"TURRET UNIT"

Mod 1 Effect Factors

MTBF: 2
Task Duration: 1.0
Post Action Delay: 1.0

Mod 2 Effect Factors

MTBF: 1.0
Task Duration: 1.0
Post Action Delay: 1.0

Mod 3 Effect Factors

MTBF: 1.0
Task Duration: 1.0
Post Action Delay: 1.0

Mod 4 Effect Factors

MTBF: 1.0
Task Duration: 1.0
Post Action Delay: 1.0

Save Cancel

Time Phase Reliability Mod Effect

Define/Run Experiment

General

Missions

Platform Mods

Supply Chain

Supply Chain Hours

Launch Windows

Repair Teams

Sched Maint

Pre-Life

U/R

Platform Mod Notification/Start Days

Simulation Days: 3650

Gantt View - Platform Mod Days

Platform Type	Platform Name	Mod 1 Day	Mod 2 Day	Mod 3 Day	Mod 4 Day
UAV	UAV Gawker	731	0	0	0

Mod effect occurs at desired date

Clear All

Project Properties

Experiment Properties

Prev

Next

Model Checker

Model Detail Report

Export to CAFS

Gantt View

Save

Run

- 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

- 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

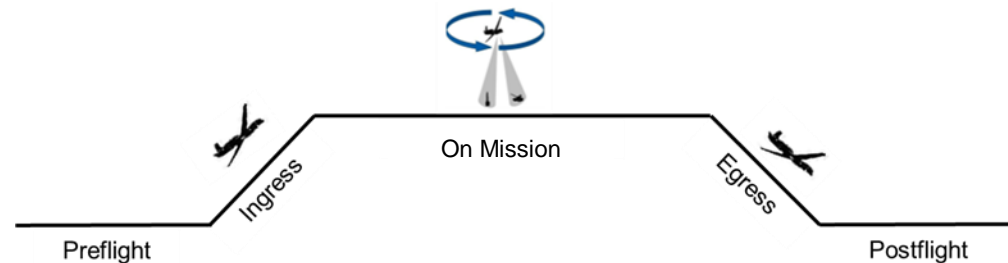
- 1) Do Nothing
 - a. If there is no solution in place, fleet performance will slowly degrade as these units cause the UAV to be Not Mission Capable (NMC)
- 2) Last Time Buy of DMS CCA Part
 - a. A sufficient quantity of the DMS part is purchased to sustain the product for the next 10 years
 - b. No 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_0 Goal: 75%
 - Flight Hours Goal: 90,000
 - Mission Details
 - Preflight: 2 Hrs
 - Ingress: 1 Hr
 - On Mission: 24 Hrs
 - Egress: 1 Hr
 - Postflight: 2Hr



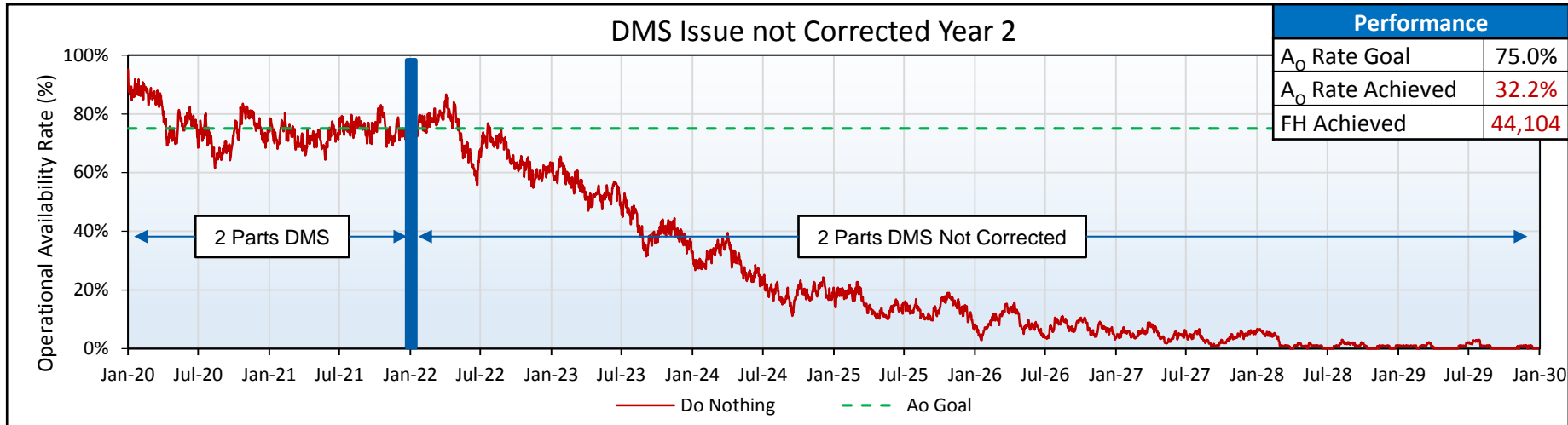
DMS Part's Metrics					
	MTBF	New MTBF at 2 Year Mark (Full Redesign of DMS Part)	New MTBF at 2 Year Mark (Full Redesign of DMS Higher Assy)	Unit Cost	Repair Cost
X KA Ant Assy	900	1,350	1,800	\$ 822,000	\$ 82,200
Turret Unit	1,000	1,500	2,000	\$ 801,791	\$ 80,179



Results

1) Results (Notional) – Do Nothing

No MTBF Improvement



Cost: \$15.4M

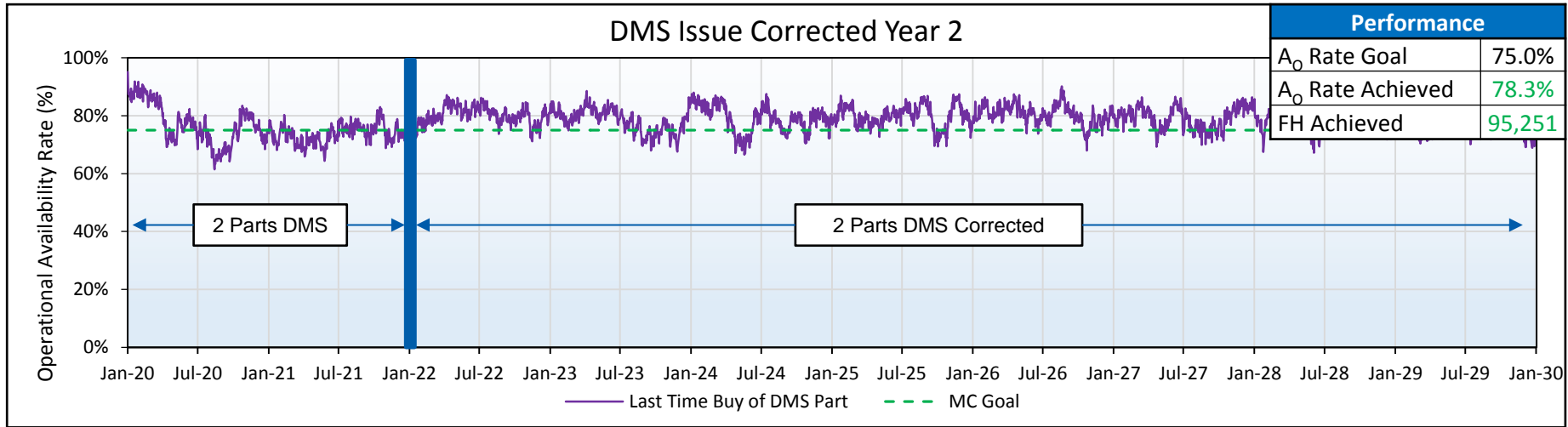
- NRE: \$0
- 10 Year Sustainment Cost: \$15.4M

Cost Per Flight Hour (CPFH): \$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 NORTHROP GRUMMAN

No MTBF Improvement



Cost: \$25.5M

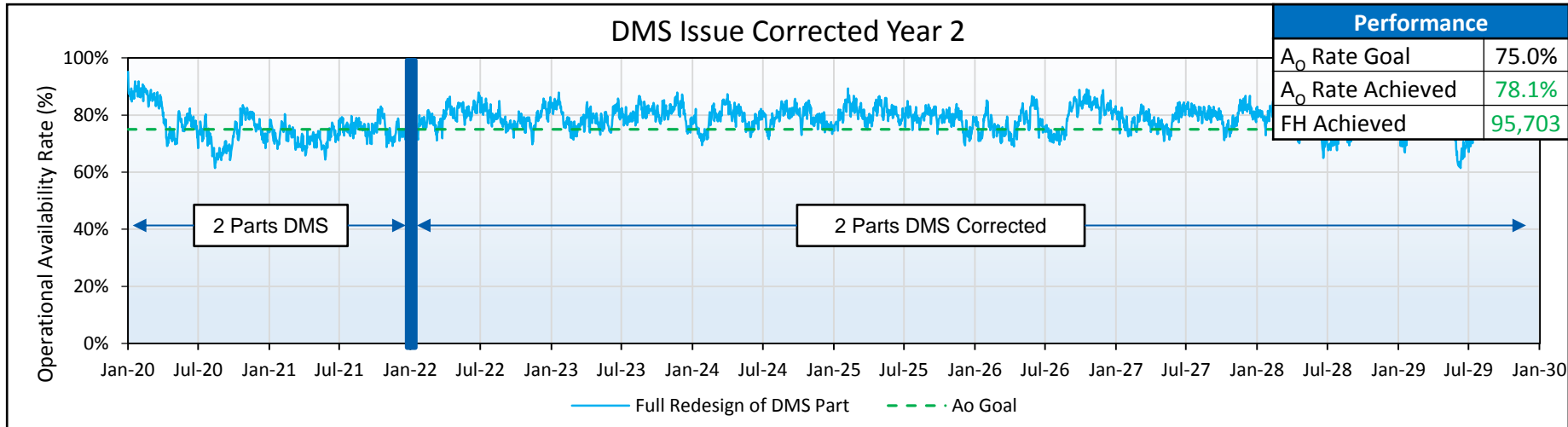
- NRE: \$6.6M
 - Last Time Buy of DMS part to sustain 10 years: \$5M
 - 2 additional spares: \$1.6M
- 10 Year Sustainment Cost: \$18.9M

CPFH: \$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

50% MTBF Improvement



Cost: \$23.9M

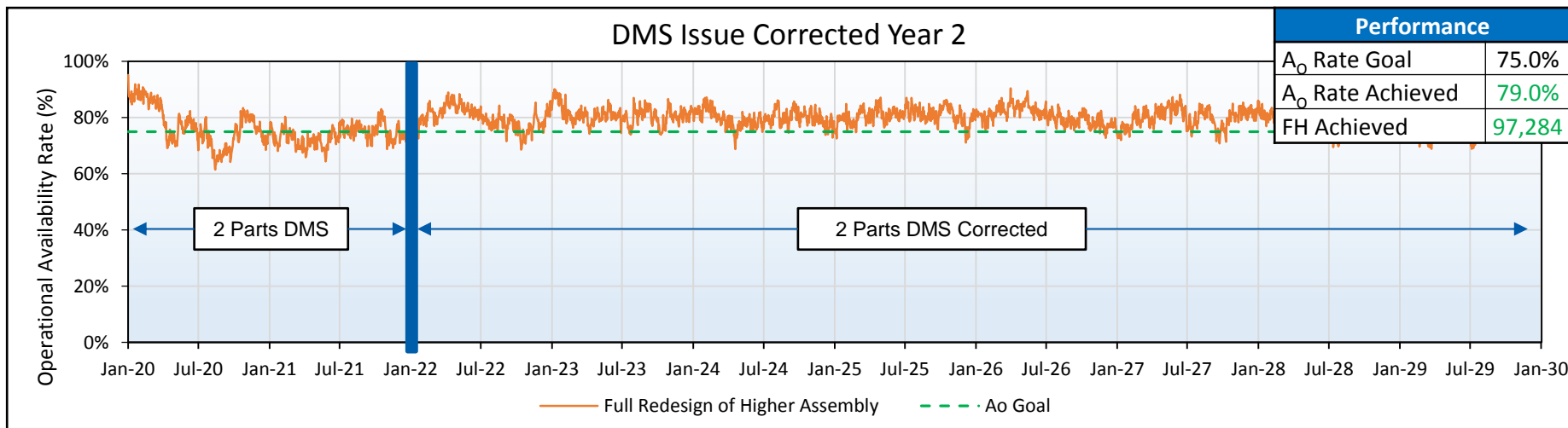
- NRE: \$10M
 - \$5M for Redesign
 - \$5M for new initial spares and to stock UAVs
- 10 Year Sustainment Cost: \$13.9M

CPFH: \$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

100% MTBF Improvement: MTBF



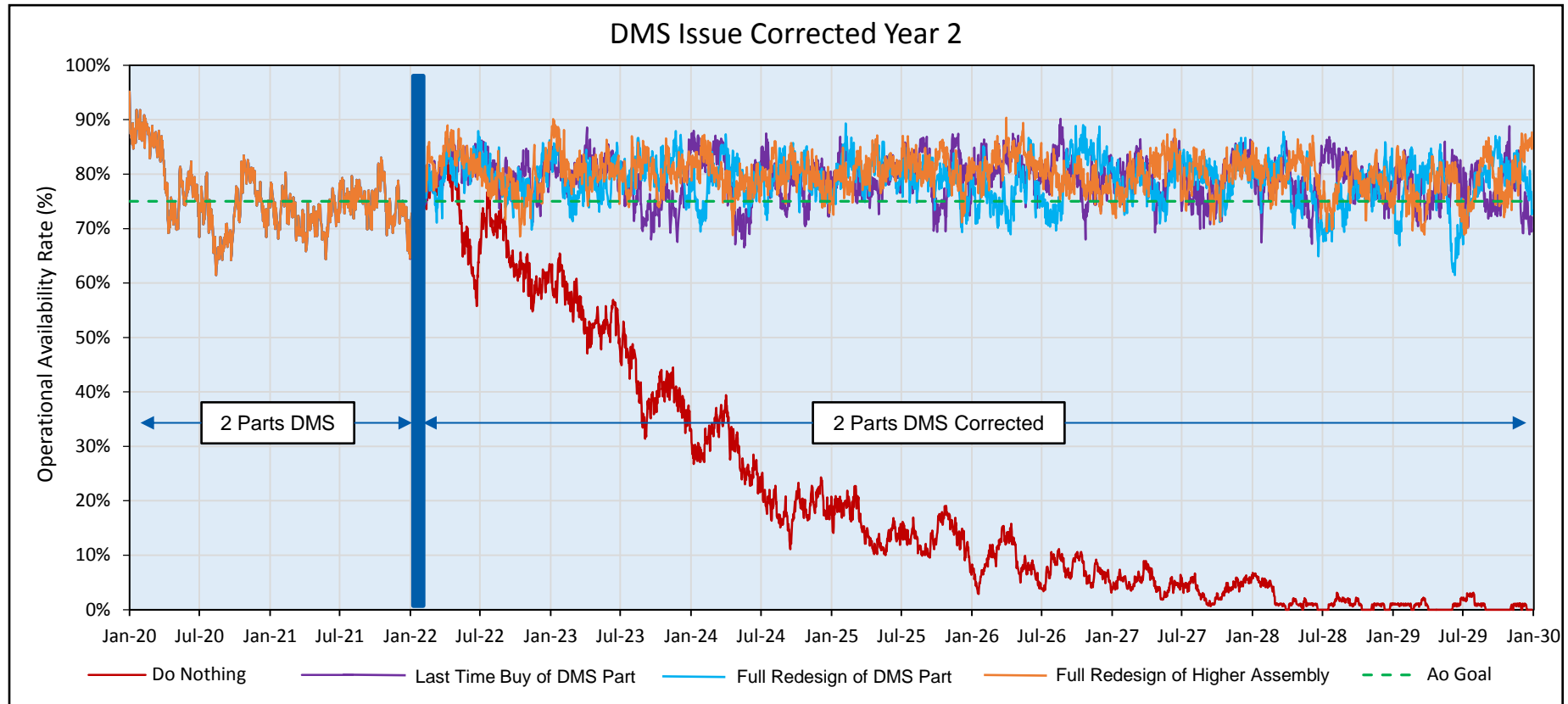
Cost: \$41.7M

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

CPFH: \$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

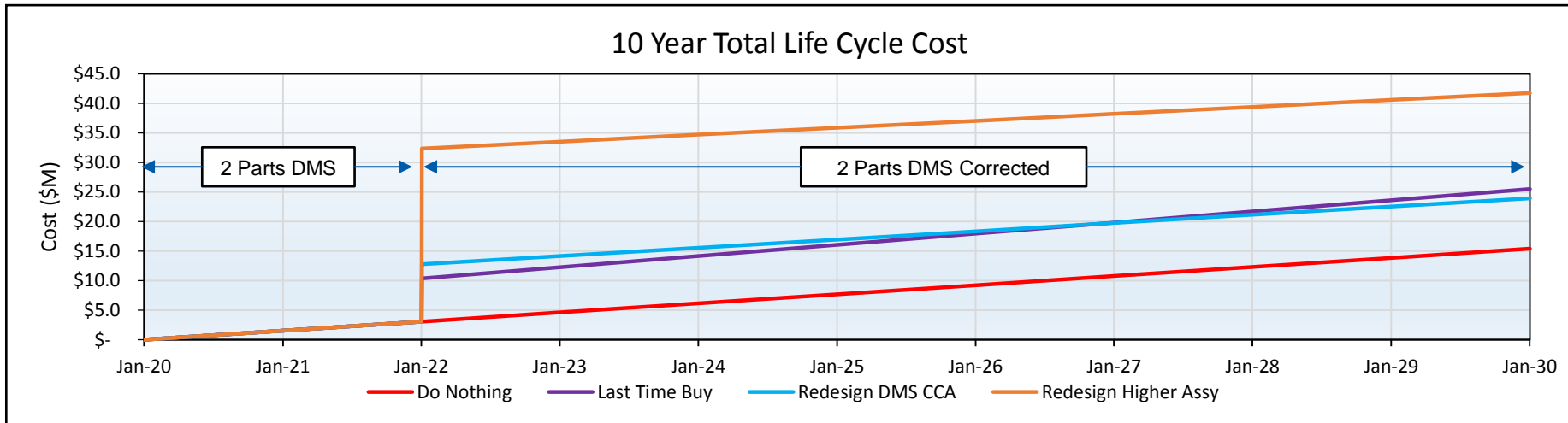
Summary – Operational Availability Impact (Notional)



Legend	Modeled Scenario	A _o Rate (%)
—	Do Nothing	32.2
—	Last Time Buy of DMS Part	78.3
—	Full Redesign of DMS Part	78.1
—	Full Redesign of Higher Assembly	79.0
- - -	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_0 Rate with Similar Life Cycle Cost

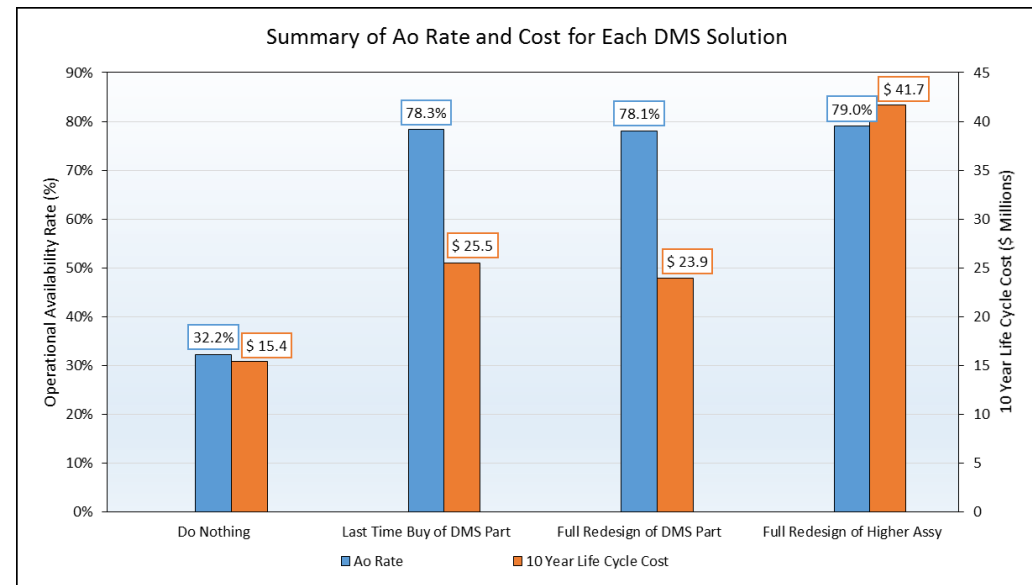


Conclusions

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



Questions?

THE VALUE OF PERFORMANCE.

NORTHROP GRUMMAN

A blue curved line graphic that starts below the company name and sweeps upwards and to the right, ending under the 'NORTHROP' portion of the name.