Cost-Wise Readiness Enabled Through Data Driven Fleet Management (DDFM)

Measuring PHM System Benefits Through Post Implementation Assessment

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Abstract—Progressively declining budgets compel the U. S. Army to utilize Data Driven Fleet Management (DDFM) technology to cut the cost of readiness and sustainment. DDFM is the application and integration of appropriate processes, technologies, and knowledge based capabilities to improve the reliability and maintenance effectiveness of Army Aircraft Systems and components. Uses a systems engineering approach to collect data, enable analysis, and support the decision-making processes system acquisition, sustainment, and operations. As part of an effort to mitigate rising costs, the Department of Defense has invested in the development of Digital Source Collectors as an onboard aircraft data recording system used to collect data. As a result, Army Aviation has installed thousands of DSCs. As part of its DDFM initiative, DSCs support actionable information and has enabled Army Aviation's airworthiness authority to remediate certain time-based maintenance practices. This enables substantial cost avoidance, eases the Warfighter's maintenance burden, and thereby promotes greater fleetwide emphasis on the performance of higher overall quality maintenance. Army Aviation does this to support mission readiness. Algorithms provide vibration based diagnostics capability, enabling rotor track and balance, or rotor smoothing, to reduce rotor vibrations. Rotor smoothing minimizes loads on life-limited dynamic components in the rotor system. It improves aircrew human factors, reduces vibration in non-rotor system components, and supports the reduction of vibration induced failures. The algorithms automate condition monitoring, reducing time-based visual inspection requirements and component replacements that can result from human error within austere environments under the extreme pressures of combat. Data analysis shows that the technology supports fleetwide mitigation of cost and maintenance burden; where sustainment constitutes up to 70% of ownership costs. Time extensions enabled through proper DSC utilization result in significant cost avoidance benefits. This increases time on and wing, thereby reducing the frequency and magnitude of costly component replacement. The Army Aviation and Missile Command Logistics Center produced the Post Implementation Assessment methodology featured in this paper as a repeatable procedure to measure, capture, and communicate how DDFM supports efficiency.

Keywords—*Data Driven Fleet Management; Digital Source Collector; Cost-Wise Readiness; Return on Investment*

I. INTRODUCTION

Today's declining defense budgets compel the U. S. Army to utilize advanced technology to cut the cost of readiness and sustainment. The remediation of certain maintenance practices enables operations and support cost avoidance. Army Aviation does this without sacrificing safety, posing no harmful effect on airworthiness, or diminishing mission readiness. As part of an effort to contain maintenance costs, the Department of Defense has invested in developing, installing, and utilizing Digital Source Collector (DSC) technology in order to enable Data Driven Fleet Management (DDFM) practices. In many cases, dedicated usage supports the mitigation of cost and maintenance burden. DSC technology enables automatic condition monitoring of certain components, allowing for the remediation of overly conservative time based part replacements, and reduces the requirement for frequent visual inspections. Application of the technology enables significant cost avoidance benefits by facilitating time between overhaul and life extensions for certain time-based component removals. This increases component time on and wing, thereby reducing frequency and magnitude of replacements fleetwide. The Army Aviation and Missile Command (AMCOM) Logistics Center (ALC) created the Post Implementation Assessment (PIA) methodology featured in this paper as a repeatable procedure to capture and communicate how technology enables efficiency. This paper demonstrates how AMCOM applies its PIA methodology to calculate the substantial results enabled through multiple efficiency improving initiatives. The War Fighter's maintenance burden has also been notably relieved, along with damage to other associated components due to less frequent removal for access and subsequent reinstallation. For more than a decade, the Department of Defense has steadily become more interested and involved in the investment, development, installation and utilization of technology. The dedicated utilization of the technology has been instrumental in mitigating the rising cost of operational readiness and has likewise eased the warfighter's maintenance burden. Army Aviation is leading the Department of Defense in its application of technology through the utilization of DSC. To capture and communicate how technology has enabled significant increases in efficiency, the Army Aviation and Missile Command (AMCOM) Logistics Center (ALC) established

its Post Implementation Assessment (PIA). It is a repeatable and mature methodology that demonstrates how the dedicated participation and practical employment of the technology by Army Aviation battalions supports ALC in its objective to achieve Cost-Wise Readiness (CWR). This paper demonstrates how AMCOM has applied the PIA methodology to calculate substantial results of multiple initiatives implemented to increase efficiency. CWR is a top ALC objective. One goal of the Supportability and Sustainment Directorate (SSD), Sustainment Optimization & Analysis (SOA) Division is to support this mission by substantiating cost avoidances enabled through CWR.

II. BACKGROUND – ISSUES BEHIND THE COST DRIVERS AND MODIFICATION OF REQUIRED MAINTENANCE INTERVALS

A. *Component Retirement Time and Time Between Overhaul Limits far too Conservative with no Suitable Monitoring*

As part of maintaining airworthiness, Army Aviation Units are required to keep baseline risk within accepted levels. To do this, maintainers follow procedures that require component condition inspections and component removals driven by costly time between overhaul (TBO) and component retirement time (CRT) specifications. Airworthiness requirements often base these maintenance intervals upon preserving very conservative safety margins. It is not uncommon that very significant quantities of remaining useful life (RUL) exist untapped within components. The original equipment manufacturer and/or the U. S. Army Aviation Engineering Directorate (AED) defined these margins long before the Army installed monitoring systems aircraft. Therefore, in order to act according to established requirements, it has long been compulsory to take maintenance actions on equipment prior to CRT and/or TBO while no evidence of need exists. Regardless of the actual remaining useful life. This is particularly the case regarding parts and components classified as critical safety item (CSI). The Army defines CSI items as a part of a system that contains a characteristic where, any failure, malfunction, or absence of which could cause a catastrophic or critical failure resulting in the loss or serious damage to the aircraft or weapons system, an unacceptable risk of personal injury or loss of life, or an uncommanded engine shutdown that jeopardizes safety. For decades, extraordinarily conservative safety margins have imposed millions of dollars in added costs to operations and support (O&S) activities throughout the Army's Aviation community, predominantly throughout its vast helicopter fleets.

III. MEASURING AND COMMUNICATING BENEFITS

A. *Multiple Performance Metrics Captured & Communicated*

ALC measures fleetwide performance metrics with regard to: Sum total costs assessed since implementation; the average cost since implementation; demand reduction

per 10,000 flying hours (FH); and ROI. All performance metrics are updated quarterly basis to continue measuring performance metrics as extensions remain valid and continue producing statistically significant benefits. Data and calculations to measure benefits according to the PIA methodology include:

1) Data Elements, Definitions, and Sources:

a) Time Periods (tp):

- i. Two year Base Line: Reference point established to measure against post implementation time period.
- ii. Post Implementation: Timeframe after implementation - normally at least 12 months.

b) Project Investment (PI): Sum invested to implement specific assessed project. Data Source: Life Cycle Cost Reduction (LCCR), AED Project Office, Reliability Improvement Program (RIP), Obsolescence, etc. offices.

c) Exchange Prices (EP): Price charged to Army Aviation Unit when exchanging an unserviceable component. Data Source: Logistics Modernization Program (LMP)

d) Flight Hours (FH): Flight hours reported – applied to normalize demand fluctuations from operational tempo variations. Data Source: Readiness Integrated Database (RIDB).

e) Demands (D): Quantity of demands issued before and after implementation in direct response to requisitions. Data Source: ILAP (Integrated Logistics Analysis Program) database.

f) Additional Time on Wing (ToW): Cumulative FHs component operates beyond prior limit, as allowed by increased limit(s). Data Sources: 1) Fleet Status Report, as developed by the AMRDEC Engineering Directorate (ED) Reliability, Availability & Maintainability (RAM) Engineering Division; Flight Line Indicating Trend (FLIT).

g) Field Repairs (FR): Quantity of repairs specifically accomplished in the field with respect to the project undergoing PIA.

h) Field Repair Cost (FRC): Sum parts cost to perform each field repair with respect to the project undergoing PIA.

2) Calculations and definitions

a) Level 1 Rate of Demands for Base Line (RD_{bl}) Quantity of Demands (D) as normalized per 10,000 FH for Base Line (bl).

b) Level 1 Expected Demands (ED): Quantity of unit Demands that would have occurred after implementation based on RD_{bl} .

c) Level 1 Expected Cost per Flight Hour Cost per FH that would have occurred after implementation based on ED.

d) Level 1 Actual Cost per Flight Hour (ACFH): Cost per FH after implementation.

e) Level 1 Demand Reduction (DR): Change in the supply demand per 10K Flight Hours (FH) for the component, before vs. after project implementation.

f) Level 1 Cost Avoidance (CA): Change in cost as driven by demand changes per 10K FH and actual historical prices.

g) Level 2 Direct Demand Reduction (DDR): Quantity of fewer components demanded since implementation.

h) Level 2 Indirect Demand Reductions (IDR): Quantity of fewer components demanded since implementation. This is a measure of the Demand Reduction that was not enabled through implementation of assessed project, but for other reasons.

i) Level 2 Adjusted Actual Cost per FH (L2AdACFH): Cost per Flight Hour adjusted to represent cost attributed through implementation of assessed project.

j) Level 2 Direct Cost Benefit (L2DCB): Value enabled through the implementation of a project undergoing assessment.

k) Level 2 Cost Benefit per Cost Assessment (CB/CA): Percentage of the overall Cost Assessment attributed directly to assessed project.

l) Level 2 Return on Investment (ROI) Performance measurement enabled directly through implementation of a specific project, when the US Army's airworthiness authority approve retirement change or time between overhaul limits.

m) Level 3 Direct Cost Benefit (L3DCB): Value enabled through the implementation of a project undergoing assessment, with Field Repair costs incorporated.

n) Level 3 Adjusted Actual Cost per FH (L3AdACFH): Cost per Flight Hour adjusted to represent cost attributed through implementation of assessed project.

o) Level 3 Cost Benefit per Cost Assessment (CB/CA): Percentage of the overall Cost Assessment attributed directly to assessed project.

p) Level 3 Return on Investment (ROI) Performance measurement enabled directly through implementation of a specific project, with Field Repair costs incorporated.

3) Data elements listed above as 1) a) through h) are sourced from U. S. Army systems external to the PIA methodology. Applying this data result in modeling benefits yielded with respect to ROI. Each data element The next section provides formulas and examples of each calculation listed above as 2) a) through p).

B. Time Period and Computations Examples

Each example demonstrated below includes fictitious time periods and figures in terms of supply demand, flight hours, prices, and cost. These fictitious quantities are included below in Figures 1, 2 and 3, with the objective is to avoid issues relative to applying actual figures, and the goal is to show how data elements are applied to advanced formulas in order to arrive at projects' ROIs.

Figure 1. Before and After Time Periods for Level 2 Add'l ToW

Figure 2. Before and After Time Periods for Level 3 Add'l ToW

L1 Data					L1 Calc														
Demonstrative Example Only <i>Not Actual Data</i>					Component Life Limit Extension / Field Repair Authorization Project														
					Cost Avoidance Based On Demand per Flight Hour (Level 1)						Cost Benefits Based on Add'l ToW (Level 2) and Field Repair Cost (Level 3)								
"tp" Time Periods	"pi" Project Investment	"EP" Exchange Price	"FH" Flight Hours	"D" Demands	1.1 "RD" Rate of Demands / 10k FH	1.2 "ED" Expected Demands / Base RD	1.3 "EOH" Expected Cost / FH	1.4 "ACH" Actual Cost / FH	1.5 "DR" Demand Reduction	1.6 "CA" Cost Avoidance	"ToW" Add'l Time on Wing	2.1 "DOR" Direct Demand Reduction	2.2 "IDR" Indirect DR	2.3 "L2-AdACH" Level 2 Adjusted ACFH Av. S/FH	"FR" Field Repairs	"FRC" Field Repair Cost"	2.4/3.1 "DCB" Direct Cost Benefit	3.2 "L3-AdACH" Level 3 Adjusted ACFH Av. S/FH	2.5/3.3 "CB" per "CA"
2 yr BASELINE (FY11 - 12)					475,000	625	13.16												
FY11		\$150,000	250,000	325	13.00			\$195.00											
FY12	\$1,750,000	\$157,500	225,000	300	13.33			\$210.00											
FY13		\$141,750	215,000	250	11.63	282.9	\$186.51	\$164.83	32.9	\$4,662,829									
FY14		\$127,515	200,000	200	10.00	263.2	\$167.78	\$127.52	63.2	\$8,053,579									
FY15		\$115,000	175,000	175	10.00	230.3	\$151.32	\$115.00	55.3	\$6,355,263									
	\$1,750,000		590,000	625	10.59	776.3	\$169.72	\$137.40	151.3	\$19,071,071									

Figure 3. Level 1 PIA Calculation Example

Component Life Limit Extension / Field Repair Authorization Project																			
Cost Avoidance Based On Demand per Flight Hour (Level 1)											Cost Benefits Based on Add'l ToW (Level 2) <small>Plus Field Repair Cost (Level 3)</small>								
"tp" Time Periods	"PI" Project Investment	"EP" Exchange Price	"FH" Flight Hours	"D" Demands	1.1 "RD" Rate of Demands / 10k FH	1.2 "ED" Expected Demands / Base RD	1.3 "EOH" Expected Cost / FH	1.4 "ACH" Actual Cost / FH	1.5 "DR" Demand Reduction	1.6 "CA" Cost Avoidance	"ToW" Add'l Time on Wing	2.1 "DOR" Direct Demand Reduction	2.2 "IDR" Indirect DR	2.3 "L2-AdACH" Level 2 Adjusted ACFH Av. S/FH	"FR" Field Repairs	"FRC" Field Repair Cost	2.4/3.1 "DCB" Direct Cost Benefit	3.2 "L3-AdACH" Level 3 Adjusted ACFH Av. S/FH	2.5/3.3 "CB" per "CA"
2 yr BASELINE (FY11 - 12)					475,000	625	13.16												
FY11		\$150,000	250,000	325	13.00			\$195.00											
FY12	\$1,750,000	\$157,500	225,000	300	13.33			\$210.00											
FY13		\$141,750	215,000	250	11.63	282.9	\$186.51	\$164.83	32.9	\$4,662,829	15,000	17.4	15.5	\$175.01			\$2,625,205		56.3%
FY14		\$127,515	200,000	200	10.00	263.2	\$167.78	\$127.52	63.2	\$8,053,579	30,000	30.0	33.2	\$148.66			\$4,459,669		55.4%
FY15		\$115,000	175,000	175	10.00	230.3	\$151.32	\$115.00	55.3	\$6,355,263	50,000	50.0	5.3	\$118.46			\$5,922,932		93.2%
	\$1,750,000		590,000	625	10.59	776.3	\$169.72	\$137.40	151.3	\$19,071,071	95,000	97.4	53.9	\$149.30			\$13,007,807		68.2%
ROI = 6.4																			

ROI = 6.4

Figure 4. Levels 1 and 2 PIA Calculation Example

		L1 Data				L1 Calc				L3 Data				L2 Calc				L3 Data				L3 Calc	
Demonstrative Example Only <i>(Not Actual Data)</i>		Component Life Limit Extension / Field Repair Authorization Project																					
		Cost Avoidance Based On Demand per Flight Hour (Level 1)										Cost Benefits Based on Add'l ToW (Level 2) Plus Field Repair Cost (Level 3)											
		"tp" Time Periods	"PI" Project Investment	"EP" Exchange Price	"FH" Flight Hours	"D" Demands	1.1 "RD" Rate of Demands / 10k FH	1.2 "ED" Expected Demands / Base RD	1.3 "ECFH" Expected Cost / FH	1.4 "ACFH" Actual Cost / FH	1.5 "DR" Demand Reduction	1.6 "CA" Cost Avoidance	"ToW" Add'l Time on Wing	2.1 "DDR" Direct Demand Reduction	2.2 "IDR" Indirect DR	2.3 "L2-AdACFH" Level 2 Adjusted ACFH Av. \$/FH	"FR" Field Repairs	"FRC" Field Repair Cost"	3.1 "DCB" Direct Cost Benefit	3.2 "L3-AdACFH" Level 3 Adjusted ACFH Av. \$/FH	3.3 "CB" per "CA"		
2 yr BASELINE (FY11 - 12)				475,000	625	13.16																	
FY11			\$150,000	250,000	325	13.00			\$195.00														
FY12		\$1,750,000	\$157,500	225,000	300	13.33			\$210.00														
FY13			\$141,750	235,000	250	11.63	282.9	\$186.51	\$164.83	32.9	\$4,662,829	35,000	17.4	15.5	\$175.01	0	\$12,750	\$2,625,205	\$175.01	56.3%			
FY14			\$127,515	200,000	200	10.00	263.2	\$167.78	\$127.52	63.2	\$8,053,579	30,000	30.0	33.2	\$148.66	63	\$12,750	\$1,656,419	\$152.67	45.4%			
FY15			\$115,000	175,000	175	10.00	230.3	\$151.32	\$115.00	55.3	\$6,355,261	50,000	50.0	5.3	\$118.46	55	\$11,500	\$5,290,432	\$122.07	83.2%			
		\$1,750,000		590,000	625	10.59	776.3	\$169.72	\$137.40	151.3	\$19,071,671	95,000	97.4	53.9	\$149.30	118	\$12,125	\$11,572,057	\$151.74	60.7%			
																						ROI = 5.6	

Figure 5. Levels 2 and 3 PIA Calculation Example

1) PIA Level 1 (L1) Bases its Calculations on L1 Data Identified below to support Cost Avoidance. PIA L2 Bases its Calculations on L2 Data identified above to support Cost Benefits and Return on Investment when the Airworthiness Authority Extends Limits enabling Additional Time on Wing:

- Retirement Change Limit Extension(s) and/or
- Time Between Overhaul Limit Extension(s)

2) PIA L3 Bases its Calculations on L2 Data identified above to support Cost Benefits and Return on Investment when the Airworthiness Authority permits Field Repair; specifically those enabling Additional Time on Wing.

3) L1 thru L3 calculations demonstrated as follows:

- Level 1 (L1) Rate of Demands for Base Line (RD_{bl})

$$RD_{bl} = \frac{\sum_{m=1}^n D_{fy}}{\sum_{m=1}^n FH_{fy} * .0001} \quad (1)$$

$$13.16_{fy11-12} = \frac{(325_{fy11} + 300_{fy12})}{(250,000_{fy11} + 250,000_{fy12}) * 0.0001}$$

$$G5 = +(F6 + F7) / ((E6 + E7) * 0.0001)$$

- L1 Expected Demands (ED)

$$ED_{tp} = \sum_{fy=1}^n RD_{bl} * (FH_{fy} * 0.0001) \quad (2)$$

$$776.3_{fy13-fy15} = 13.16_{bl} * (215,000_{fy13} + 200,000_{fy14} + 175,000_{fy15}) * 0.0001$$

$$H11 = +G\$5 * ((E8 + E9 + E10) * 0.0001)$$

- L1 Expected Cost per Flight Hour (ECFH)

$$ECFH_{ai} = \frac{\sum_{fy=1}^n ED_{fy} * EP_{fy}}{\sum_{fy=1}^n FH_{fy}} \quad (3)$$

$$\$169.72_{fy13-fy15} = \frac{(283_{fy13} * \$141,750_{fy13}) + (263.2_{fy14} * \$127,515_{fy14}) + (230_{fy15} * \$115,000_{fy15})}{215,000_{fy13} + 205,000_{fy14} + 175,000_{fy15}}$$

$$I11 = +(H8 * D8 + H9 * D9 + H10 * D10) / (E8 + E9 + E10)$$

- L1 Actual Cost per Flight Hour (ACFH)

$$ACFH_{ai} = \frac{\sum_{fy=1}^n D_{fy} * EP_{fy}}{\sum_{fy=1}^n FH_{fy}} \quad (4)$$

$$\$137.40_{fy13-fy15} = \frac{(250_{fy13} * \$141,750_{fy13}) + (200_{fy14} * \$127,515_{fy14}) + (175_{fy15} * \$115,000_{fy15})}{215,000_{fy13} + 205,000_{fy14} + 175,000_{fy15}}$$

$$J11 = +(F8 * D8 + F9 * D9 + F10 * D10) / (E8 + E9 + E10)$$

- L1 Demand Reduction (DR)

$$DR_{ai} = \sum_{fy=1}^n ED_{fy} - D_{fy} \quad (5)$$

$$151.3_{fy13-fy15} = (282.9_{fy13} - 250_{fy13}) + (263.2_{fy14} - 200_{fy14}) + (230.3_{fy15} - 175_{fy15})$$

$$K11 = +(H8 - F8) + (H9 - F9) + (H10 - F10)$$

- L1 Cost Avoidance (CA)

$$CA_{ai} = \sum_{fy=1}^n DR_{fy} * EP_{fy} \quad (6)$$

$$\$19,071,671_{fy13-fy15} = (32.9_{fy13} * \$141,750_{fy13}) + (63.2_{fy14} * \$127,515_{fy14}) + (55.3_{fy15} * \$115,000_{fy15})$$

$$L11 = +(K8 * D8) + (K9 * D9) + (K10 * D10)$$

g) Level 2 (L2) Direct Demand Reduction (DDR)

$$DDR_{ai} = \sum_{fy=1}^n (ToW_{fy} * RD_{fy}) * 0.0001 \quad (7)$$

$$97.4_{fy13-fy15} = (15,000_{fy13} * 11.63_{fy13}) + (30,000_{fy14} * 10.00_{fy14}) + (50,000_{fy15} * 10.00_{fy15}) * 0.0001$$

$$L11=+((M8 * G8) + (M9 * G9) + (M10 * G10)) * 0.0001$$

h) L2 Indirect Demand Reductions (IDR)

$$IDR_{tp} = \sum_{fy=1}^n DR_{fy} - DDR_{fy} \quad (8)$$

$$53.9_{fy13-fy15} = (32.9_{fy13} - 17.4_{fy13}) + (63.2_{fy14} - 30.0_{fy14}) + (55.3_{fy15} - 50.0_{fy15})$$

$$O11=+(K8-N8)+(K9-N9)+(K10-N10)$$

i) L2 Adjusted Actual Cost per FH (L2AdACFH)

$$L2AdACFH_{ai} = \frac{\sum_{fy=1}^n (ED_{fy} - DDR_{tp}) * EP_{fy}}{\sum_{fy=1}^n FH_{tp}} \quad (9)$$

$$\$149.30_{fy13-fy15} = \frac{(282.9_{fy13} - 17.4_{fy13}) * (\$141,750_{fy13}) + (263.2_{fy14} - 30.0_{fy14}) * (\$127,515_{fy14}) + (230.3_{fy15} - 50.0) * (\$115,000_{fy15})}{215,000_{fy13} + 200,000_{fy14} + 175,000_{fy15}}$$

$$P11=+(((H8-N8)*D8)+((H9-N9)*D9)+((H10-N10)*D10))/(E8+E9+E10)$$

j) L2 Direct Cost Benefit (L2DCB)

$$L2DCB_{tp} = \sum_{fy=1}^n (L2ACFH_{fy} * ToW_{fy}) \quad (10)$$

$$\$13,007,807_{fy13-fy15} = (\$175.01_{fy13} * 15,000_{fy13}) + (\$148.66_{fy14} * 30,000_{fy14}) + (\$118.46_{fy15} * 50,000_{fy15})$$

$$S11=+(P8 * M8) + (P9 * M9) + (P10 * M10)$$

k) L2 Cost Benefit per Cost Avoidance (L2CB/CA)

$$L2CB_{tp} / CA_{tp} = \frac{L2CB_{TP}}{CA_{TP}} \quad (11)$$

$$68.2\%_{fy13-fy15} = \frac{\$2,625,205_{fy13} + \$4,459,669_{fy14} + \$5,922,932_{fy15}}{\$4,662,829_{fy13} + \$8,053,579_{fy14} + \$6,355,263_{fy15}}$$

$$U11=+(S8+S9+S10)/(L8+L9+L10)$$

l) L2 Return on Investment (ROI)

$$L2ROI_{tp} = \frac{L2CB - PI}{PI} \quad (12)$$

$$6.4_{fy13-fy15} = \frac{(\$2,625,205_{fy13} + \$4,459,669_{fy14} + \$5,922,932_{fy15}) - \$1,750,000}{\$1,750,000}$$

$$U12=+((S8+S9+S10)-C11)/C11$$

m) Level 3 (L3) Direct Cost Benefit (DCB)

$$L3CB_{tp} = \sum_{fy=1}^n L2ACFH_{fy} * ToW_{fy} - (FR * FRC) \quad (13)$$

$$\$11,572,057_{fy13-fy15} = (\$175.01_{fy13} * 15,000_{fy13}) - (0 * \$12,750) + (\$148.66_{fy14} * 30,000_{fy14}) - (63 * \$12,750) + (\$118.46_{fy15} * 50,000_{fy15}) - (50 * \$11,500)$$

$$S11=+(P8 * M8) - (Q8 * R8) + (P9 * M9) - (Q9 * R9) + (P10 * M10) - (Q10 * R10)$$

n) L3 Adjusted Actual Cost per FH

$$L3AdACFH_{ai} = \frac{\sum_{fy=1}^n (ED_{fy} - DDR_{tp}) * EP_{fy}}{\sum_{fy=1}^n FH_{tp}} \quad (14)$$

$$\$151.74_{fy13-fy15} = \frac{(282.9_{fy13} - 17.4_{fy13}) * (\$141,750_{fy13}) + (263.2_{fy14} - 30.0_{fy14}) * (\$127,515_{fy14}) + (230.3_{fy15} - 50.0) * (\$115,000_{fy15}) + (55 * \$11,500)}{215,000_{fy13} + 200,000_{fy14} + 175,000_{fy15}}$$

$$T11=+((((H8-N8)*D8)+(Q8 * R8))+(((H9-N9)*D9)+(Q9 * R9))+(((H10-N10)*D10)+(Q10 * R10)))/((E8+E9+E10)$$

o) L3 Direct Cost Benefit per Cost Avoidance (L3DCB/CA)

$$L3DCB_{tp} / CA_{tp} = \frac{L3DCB_{TP}}{CA_{TP}} \quad (15)$$

$$60.7\%_{fy13-fy15} = \frac{\$2,625,205_{fy13} + \$3,656,419_{fy14} + \$5,290,432_{fy15}}{\$4,662,829_{fy13} + \$8,053,579_{fy14} + \$6,355,263_{fy15}}$$

$$U11=+(S8+S9+S10)/(L8+L9+L10)$$

p) L3 Return on Investment (ROI)

$$L3ROI_{tp} = \frac{L3CB - PI}{PI} \quad (16)$$

$$5.6_{fy13-fy15} = \frac{(\$2,625,205_{fy13} + \$3,656,419_{fy14} + \$5,292,432_{fy15}) - \$1,750,000}{\$1,750,000}$$

$$U12=+((S8+S9+S10)-C11)/C11$$

IV. ENABLED U. S. ARMY AVIATION COMPONENTS

Army Aviation enables maintenance improvements through its dedication to implement fleetwide DDFM projects. Substantial benefits from improvements applied to maintaining components featured in figure 4 below have resulted. It is important for the reader to note that such results require significant time and hundreds of thousands of operating hours to realize. While overcoming the cost of implementing projects of this nature without diminishing airworthiness or users' confidence regarding indications is important. It is essential for the DSC installed on the aircraft platform the Personal Computer Ground Based Station (PCGBS) utilized by the maintainer to operate with most mature and accurate algorithms and software. Highly trained users must learn to apply the technology. This support fleetwide airworthiness and confidence.

Figure 6. AH-64 Presenting Parts Remediated with Data Driven Fleet Management

V. PIA PROCESS STANDARD OPERATING PROCEDURE

Figure 5 below shows how a typical PIA flows through the current established standard operating procedure (SOP). Validating the implementation of a project is the first step. Analysts do this by identifying the documents utilized by the Army to implement fleetwide maintenance changes. These “mechanisms” include those listed in Figure 5.

Figure 5. PIA Process Flowchart

VI. CONCLUSIONS

A. Maintenance Changes through PHM Systems Avoid Costs

Complete appreciation of this level of benefits require a deep understanding of how each operating hour after implementation adds up. While implemented maintenance changes featured in this report include only those applied to the Apache airframe, Army Aviation is pursuing similar work benefits for the Black Hawk and Chinook platforms to support CWR through the reduction of materiel costs.

B. Repeatable Methodology is Applicable to Many Systems

The maintenance improvements measured by AMCOM with the PIA Methodology featured in this report include time extensions. Systems across multiple industries could readily apply it, or a modified variation of the methodology to measure the impacts affected through their own implemented projects.

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