Next-Generation Operational Health & Decision Support in the Maintenance Environment

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Discussion Topics

- Evolution to Decision Support
- Expected Benefits
- JSF PHM Roadmap
- Operational Stakeholder Capabilities & Key Attributes
- Health Management Strategic Deployment
- Observations & Moving Forward Effectively
Achieving Next Generation Decision Support

Requires Balance and Perspective

Enabling Through Technology & Innovative Business Practices

Benefit
- Survivability
- Lethality
- Affordability
- Cost Savings
- Readiness
- Availability
- Mission Reliability
- Safety

Sophistication
- Decision Support
- Prognostics
- Rapid Maturation
- Health State
- Diagnostics
- Analysis
- Processes
- Data
- Systems

DATA

CBM+

CBM

RCM
Expected Benefits

Not Inclusive of Qualitative Values

Maintainability
- MFHB CND
- MFHBME
- MFHR
- MMH/FH

PHM Benefit
- 79–82% Improvement
- 13–14% Improvement
- 3% Improvement
- 17–32% Improvement

Support Equipment
- QTY
- Weight (Lbs.)
- Volume (cu ft)

Manpower
- QTY

Logistics Footprint
- C17 Loads, Tons

Safety
- Mishap Reduction

SGR
- SGR (Initial/Sustained)

Airframe/OML Restoration
- Recurring Cost

Key Attributes
- Proactive Decision
- Support/Triggering, Health State Based; Autonomics; Planned Continuous Improvement; Near Real Time Updates; Anomaly Management; No False Alarms

Based on Concept Demo Phase Cost Benefit Analyses

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Accessing Material Condition for Decision Support

Monitor: System or Sub-System Level; Precursors to Failure Indicators, Usage Indices, Performance

Health Analysis

Abnormal Health Warning – Unexpected Slope Delta

Prognostics
Remaining Useful Life
Trigger Points
Degraded Health Warning – New Slope

Decision Support
Resource Planning
Maintenance Action
Operational Planning

Change in Health State and Prognostic Indications

Identifying Deltas From Expectations
## Prognostics and Health Management
### Notional Roadmap to Next Generation Decision Support

#### Key Transition Events

<table>
<thead>
<tr>
<th>Event Type</th>
<th>Phase</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flight Test</td>
<td>2009</td>
<td>Pax CAFB, Eglin RFT, OT USMC IOC, USAF IOC</td>
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<tr>
<td>Deployments</td>
<td>2010</td>
<td>LRIP4, LRIP5, LRIP6</td>
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<tr>
<td>PBL Sustainment</td>
<td>2011</td>
<td>LRIP7</td>
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#### Development & Delivery

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<thead>
<tr>
<th>Activity Type</th>
<th>Phase</th>
<th>Details</th>
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<tbody>
<tr>
<td>Delivery</td>
<td>2009</td>
<td>PHM 0.5a, Bk 1, Bk 2, Bk 3</td>
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<tr>
<td>- PHM SW</td>
<td>2010</td>
<td>PHM Tracking Starts with 0.5</td>
</tr>
<tr>
<td>- HM Assessment</td>
<td>2011</td>
<td>PHM Tracking Starts with 0.5</td>
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<tr>
<td>Performance</td>
<td>2012</td>
<td>Initial</td>
</tr>
<tr>
<td>AMC/Prognostics</td>
<td>2013</td>
<td>Initial</td>
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</table>

#### Sustainment Transformation

<table>
<thead>
<tr>
<th>Transformation Type</th>
<th>Phase</th>
<th>Details</th>
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</thead>
<tbody>
<tr>
<td>Mx Mgt</td>
<td>2009</td>
<td>WO Generation, AFRS, Initial AMC</td>
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<tr>
<td>Training</td>
<td>2010</td>
<td>CBM, Differed/Opportunistic, Robust Prognostics</td>
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<tr>
<td>Supply Mgt</td>
<td>2011</td>
<td>Interfaces, Mx/Pilot Trng, Lean</td>
</tr>
<tr>
<td>Business/PBL</td>
<td>2012</td>
<td>On Demand, Functional Assessment</td>
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<tr>
<td>FD/S&amp;T Tech Refresh</td>
<td>2013</td>
<td>Autonomic Improvements, Future Development Initiatives, Service Interoperability Enhancements</td>
</tr>
<tr>
<td>Warfighter/Sust</td>
<td>2014</td>
<td>Health Based Sparing, Emerging Technology; Next-Generation Development</td>
</tr>
<tr>
<td>Policy Service Procedures</td>
<td>2015</td>
<td>FLM, Health Center, FUMS, Enhanced MEFL</td>
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</table>

#### Continuous Improvement

<table>
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<tr>
<th>Improvement Type</th>
<th>Phase</th>
<th>Details</th>
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<tbody>
<tr>
<td>RAM/Integrity</td>
<td>2009</td>
<td>Data Collection Evaluation</td>
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<tr>
<td>KD/Data Mining</td>
<td>2010</td>
<td>JRMET/FRCAS</td>
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<tr>
<td>Cost Benefit Trades</td>
<td>2011</td>
<td>FLM/RCMA, Monitor/Check and Adjust</td>
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<tr>
<td>S&amp;T Insertion</td>
<td>2012</td>
<td>CBM+</td>
</tr>
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Legend

- PHM: Prognostics and Health Management
- SDD: System Development Decision
- LRIP: Low-Risk Incremental Program
- S&T: Science and Technology
- SBIR: Small Business Innovation Research
- IRAD: Innovative Research and Development
- PBL: Production, Business, Logistics
- SDD: System Development Decision
- RAM: Reliable, Available, Maintainable
- KD: Knowledge Discovery
- CBM: Condition-Based Maintenance
- EHM: Enhanced Health Management
- FLM: Functional幸运
- RCMA: Readiness Capability Management Assessment

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Next Generation PHM
Operational Stakeholders & Key Capabilities

Sustainment Operations
- Maintenance
- Sustaining Engineering
- Continuous Improvement
- Local Logistic Support

Warfighter Operations
- Operations
- Maintenance
- Resource Scheduling
- Asset Allocation/Management

Enterprise Operations
- Development/OEMs
- Services/Program Management
- Business & Policy Managers
- Extended Logistics Support

- Efficient Failure Resolution
- Eliminate RTOK/CND
- Anomaly Management
- Integrated Continuous Improvement and Case Maturation
- Health State Knowledge Discovery
- Enhanced Scheduling
- Automated WO Generation/JTD and Failure Resolution Cases
- CBM, Opportunistic & Deferred Mxt
- AMC/Prognostics
- Autonomic Decision Support Triggers

- Health State Reporting to Pilot
- Parametric & Environmental Data Collection
- Asset Prepositioning/Downlink
- Enhanced Aircraft and System Health Status
- Functional Mission Assessment
- Enhanced Mission, Operations and Resource Scheduling
- Active Fleet Management
- Enhanced Operational Decision Support
- Enhanced PM Support
- Enhanced Fleet Health Mgt
- Lean/On Demand Training
- Health Based Inventory/SCM
- Asset Prepositioning
- Force Life Management
- RAM Enhancements
- Targeted Tech Refresh/S&T
- Rapid Life Alignment & Extension
- Enable PBL Enhanced Features
- Proactive Enterprise Decision Support
Key Attributes of Next Generation Mxt

Integration and Balance

- Maintenance Efficiency
  - Expedient Failure Resolution
  - Anomaly Management
  - Targeted Removals (CBM/Opportunistic/deferred Mxt)
  - Integrated Continuous Improvement and Case Maturation
  - Integrated Case Based Maturation

- High Integration into Operations, Training, Supply & Support Systems
  - Enhanced Scheduling
  - On Demand Training
  - Downlink
  - AMC/Prognostics

End to End Improvement
- Knowledge Discovery
- Targeted Tech Refresh
- OEM Supply
- Extended Logistics
- Fleet Health Management
- Rapid Life Optimization

PHM Data/Information Architecture Tools & Processes

Autonomic Decision Support
- Warfighter Operations
- Sustainment Operations
- Enterprise Operations
- Force Life Management
- Balanced Resource Allocation

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Health Management Strategy Deployment

Identifying Core Barriers to Success

Deliver Next Generation Health Management/Decision Support Solution

**True-North Vision**

**Focus Areas**
- **Data Management**
- **System Design**
- **Operational Health Support**
- **Performance Monitoring**
- **Decision Support**
- **Continuous Improvement**
- **Common Overarching Business/PM**

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**Strategic Deployment**

### - - Near Term - -

**Setting Direction**
- HM CONOPS, Implementation Plan, Thread Demos

**Executing the Vision**
- Organization, Value/Cost Benefit, Future Dev, Roadshow
- Interim HM Sustainment; Expectation Mgt

**Assessment Approach**
- Data Mgt, Design Viability, Architecture Rvw, Capabilities/Req’t Delivery, TPMs/Performance Monitoring
- Gaps/Barrier Identification and Product Delivery

### - - Long Term - -

**Strengthen Stakeholder Advocacy**
- Education, Create Pull Factor, Roadshow, Demos

**Deliver the Capability**
- CONOPS, Design, Capabilities, Products Maturation Plan

**Enable Autonomic Logistics**
- Decision Support (Operations, Support, Business)
- Logistics Transformation, Policies, Benefit Trade Models

**Continuous Improvement**
- Performance Monitoring, Maturation, S&T, Acquisition Strategy

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**Roadmap Provides Overarching “True-North” Alignment & Tempo**

- **Key Perspectives**
  - Warfighter Operations
  - Sustainment Operations
  - Enterprise Operations

- **Roadmap Focus**
  - Development & Delivery
  - Enhanced Sustainment
  - Continuous Improvement

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**Identifying Key Barriers to Success & Getting the Right Things Done!**

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Broad Observations &
Moving Forward Effectively

• Broad Observations
  – Achieving Our Vision Involves Multiple Disciplines and a High Degree of Integration … *that have to work towards a ‘common true north’*
  – Single Program/Service Can Not Effectively Achieve Vision Alone
  – Key Experience Resides in Legacy Programs with Pockets of Excellence
  – Need Champions & Stakeholder Advocacy – “Create the Pull Factor”
  – Common/Fundamental Core Barriers Exist – *Work Core Barriers Together*

• Moving Forward Effectively
  – Adopt a DoD Enterprise Approach to Address & Resolve Core Barriers
  – Drive for an Alliance and Coalition Approach
  – Leverage Services and Program’s Resources
    *Tools, Processes, Lessons Learned, Expertise, Data, Schedule and Funding*
  – Provide Enhanced Capabilities into Established Programs
  – Key Enterprise Focus Areas
    • Transition to Reengineered Logistics Decision Support Processes
    • Requirements Definition
    • Provide Benefit Trade Tools and Models
    • Education

*Drive Towards 2020 with “20-20 Vision”*
Questions?
Expected Benefits to Acquisition Strategy

**Maintainability**
- MFB CND
- MFBMIE
- MFBIR
- MMIFH

**PHM Benefit**
- 79-82% Improvement
- 13-14% Improvement
- 3% Improvement
- 17-32% Improvement

**Support Equipment**
- QTY
- Weight (lbs.)
- Volume (cu ft)

**Manpower**
- Reduction of 6-10%

**Logistics Footprint**
- C17 Loads, Tons
- Reduction of 45-52%

**Safety**
- Mishap Reduction
- Reduction of 2-17%

**SGR**
- SGR (Initial/Sustained)
- Reduction of 14-30%

**Airframe/CML Restoration**
- Recurring Cost
- $1.06B - 1.57B Cost Avoidance

**KPP Metric Alignment**
- Lethality, Survivability, Affordability, Supportability
- Availability
- Mission Reliability
- Readiness
- Affordability (O&S/LCC)
- AVDLR
- Supportability
- Maintainability
- LFP
- SGR
- MTTR
- MFHB
- CND
- MEHBME
- MFHBR
- MMIFH
- AVDLR

**Health Management**
- The capability to make intelligent, informed, appropriate decisions about design, logistics, maintenance and operational actions based on HM information, available resources, acquisition strategy, and operational demand.

**Diagnostics**
- Enhanced
- Prognostics
- Basic
- Architecture, Interfaces, Processes, and Tools

**Assess Material Condition**
- Health State

**Data Identification and Collection**
- Legacy failure data enhanced with parametric, surrounding, maintenance, operational and environment...from multiple sources for enterprise use

**Key Attributes**
- Proactive Decision Support/Triggering, Health State Based; Autonometrics; Planned Continuous Improvement; Near Real Time Updates; Anomaly Management; No False Alarms

**Products**
- SW & Tools
- HDRW
- Processes
- Analysis, Maturation and Sustaining Tasks

**INVESTMENT STRATEGY**
- SDD
  - LRIP/FRP – Production
  - LRIP/FRP - Sustainment
  - Future Development
  - PBL
- S&T
  - Contractor Core/IRAD

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Applying RCM to Achieve Accelerated Continuous Improvement

Health Management
Continuous Improvement Feedback Processes

- Anomaly Indication Triggered by CRM
- Operational Health Trending & Knowledge Discovery
- RCM-like Decision Logic
- Appropriate Actions Taken
- Performance Monitoring

Trend on Current Health State
- Imminent Failure Threshold
- Confidence Bands
- Historical Data
- Predicted Trend
- Time

Legacy RCM Feedback Processes

- Verified Failure Reporting
- Data Collecting & Trending Analysis
- RCM Decision Logic Applied
- Appropriate Actions Taken
- R&M Metric Monitoring

Trend on Reliability (Verified Failures)

Early Degraded Near-Real Time Health State Indications

Max Aircraft Impacted

Next Generation

Health State Monitoring Reduces Fleet Impact from Degraded Systems
Assess Material Condition

Definition

- **Healthy** - Operating Near Nominal Design Levels
- **Failure** - Operation determined to be Below Performance Specification Threshold
- **Degradation** - Measure of Movement Toward the Failure Threshold During Operation
- **Life Consumed** – Delta from Initial Operating Condition and Current Nominal Operating Condition
- **Prognose Time to Failure** – Prediction of the estimated time to failure based on Physics of Failure, trending analysis and/or environmental factors
- **Life Remaining** - Total design life less cumulative life consumed (Life limited components only)

• AMC is defined as one or more of the following AS capabilities: 1) detect and monitor a LRC’s performance as related to healthy, failed, or degrading; 2) determine life consumed; 3) prognose (predict/estimate) time to failure*; and 4) determine life remaining* estimate.

• AMC is comprised of an on-board and off-board functional component.

*Off Board Capability, but may also be hosted on acft.

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