

# AF Life Cycle Management Center

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*AFLCMC... Providing the Warfighter's Edge*



## Big Rocks

**USAF Life Cycle Management Center  
Product Support Engineering Division**

**John Hedke  
AFLCMC/EZP**

15 June 2016

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# AFLCMC/EZP DNA – It’s Who We Are!

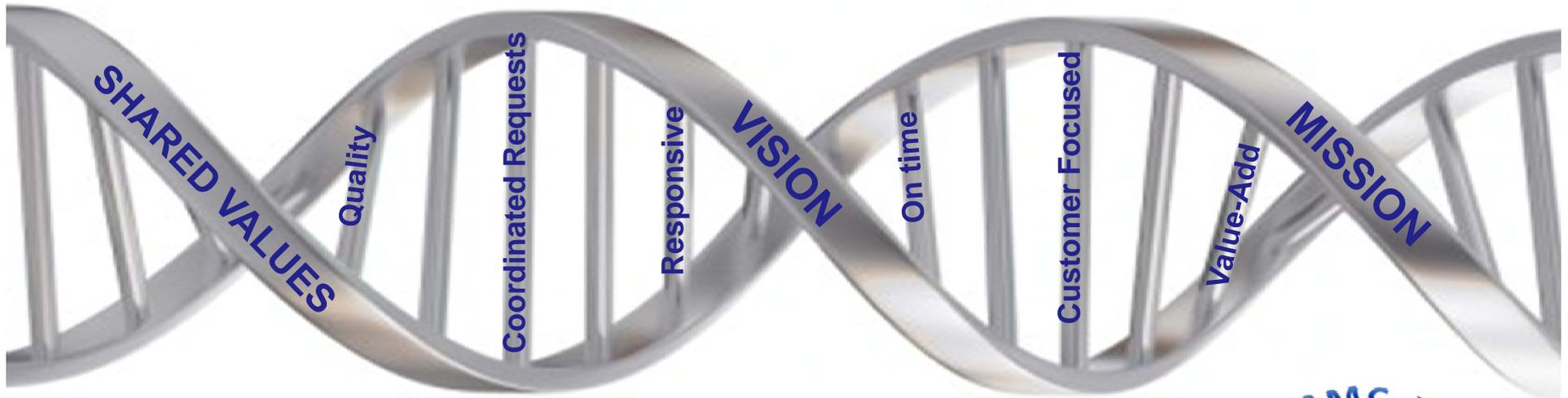


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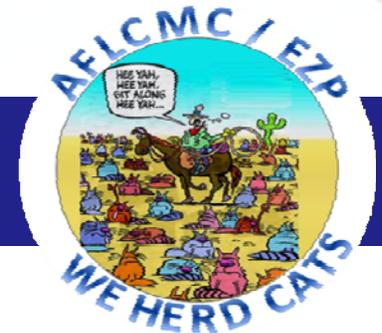
AFLCMC... Providing the Warfighter’s Edge

**Vision:** *Affordable Warfighter Readiness...Innovative Product Support Engineering Capabilities*

**Mission:** *Ensure AF Enterprise Focus by Applying Airworthiness Approach that Promotes Cost-Effective Technology and Sustainment Solutions*



**We Raise the bar!**





# AFLCMC/EZP Organization



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## Technical Disciplines

### Reliability & Maintainability (R&M) Engineering & Sustainment Branch

- Reliability Analysis, Planning, Tracking, & Reporting
- Reliability Centered Maintenance (RCM)
- Condition Based Maintenance Plus (CBM+)
- Engineering Disposition Processes
- Critical Safety Items (CSIs)
- Joint Aeronautical Commander's Group (JACG)
- Aircraft Structural Integrity Management Information System (ASIMIS)

### Sustainment Technology Transition Branch

- Airworthiness New Materials and Substitution Lead
- Weapon System Sustainment Technology Enterprise Program (WS-STEP)
- Laser De-Paint Initiative
- Chromium Risk Mitigation Initiative
- Cadmium Risk Mitigation Initiative
- Additive Manufacturing Initiative
- Sustaining Engineering Requirements Support
- AF Corrosion Working Group
- Aircraft Battle Damage Repair Engineering (ABDRE)
- Center Test Authorities (CTAs)
- Corrosion Prevention & Control Office
- Non-Destructive Inspection Office
- Advanced Composites Office
- Metals Technology Office

### Applied Engineering & Technology Branch

- Materials Handling Engineering
- Packaging Technology & Engineering
- Electronics Component Engineering



*Debbie Naguy  
Division Chief*

**Product Support  
Engineering  
Division**



*Matt Phillips  
Tech Director*



*Frank Erdman  
Branch Chief*

**Reliability  
Maintainability &  
Sustainment**



*John Hedke  
Technical Expert*



*Mark Smallwood  
Branch Chief*

**Sustainment  
Technology  
Transition**



*Mike Froning  
Technical Expert*



*Jerry Gibson  
Branch Chief*

**Applied Engineering  
& Technology**

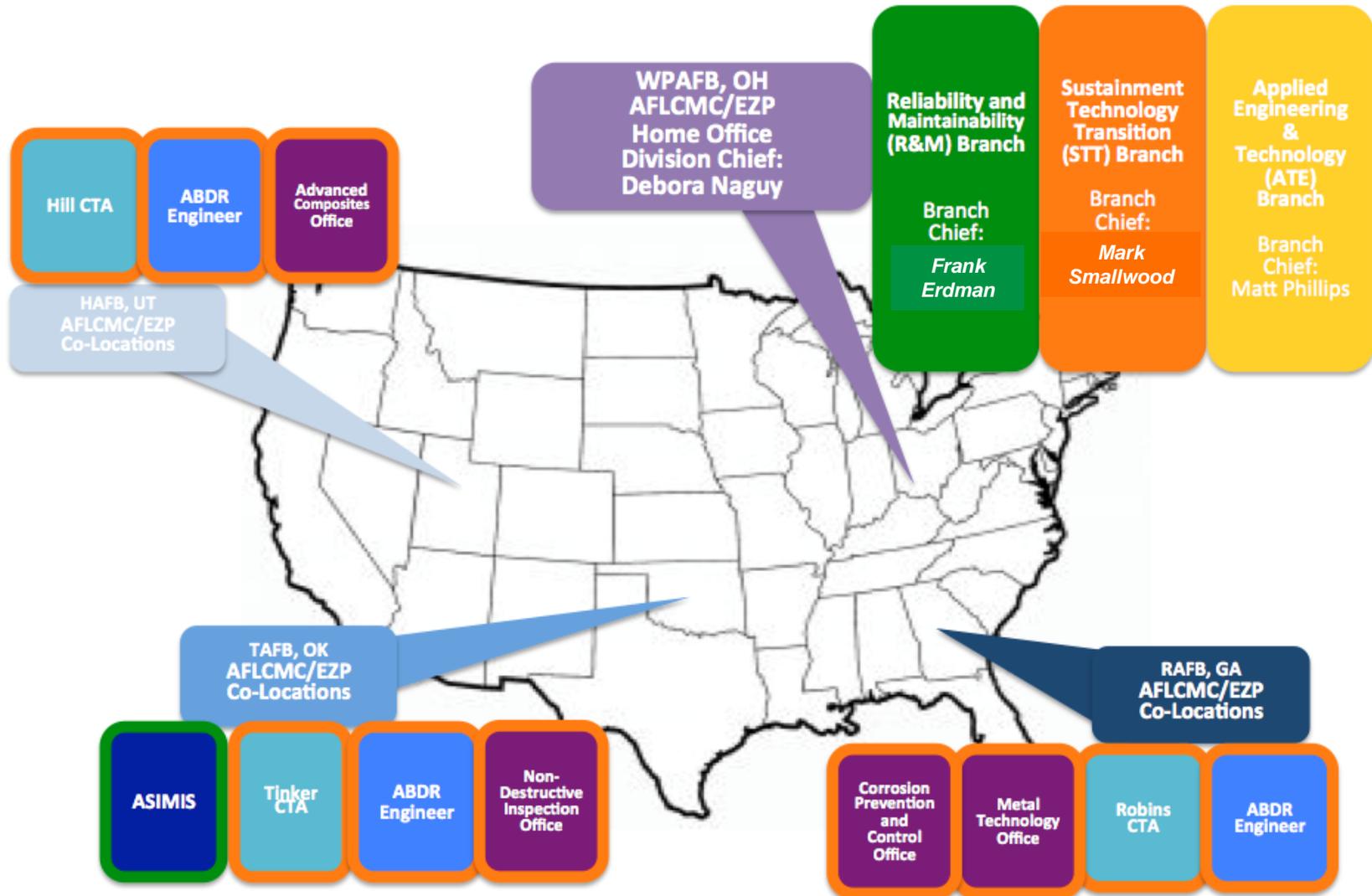


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# AFLCMC/EZP Nationwide Team



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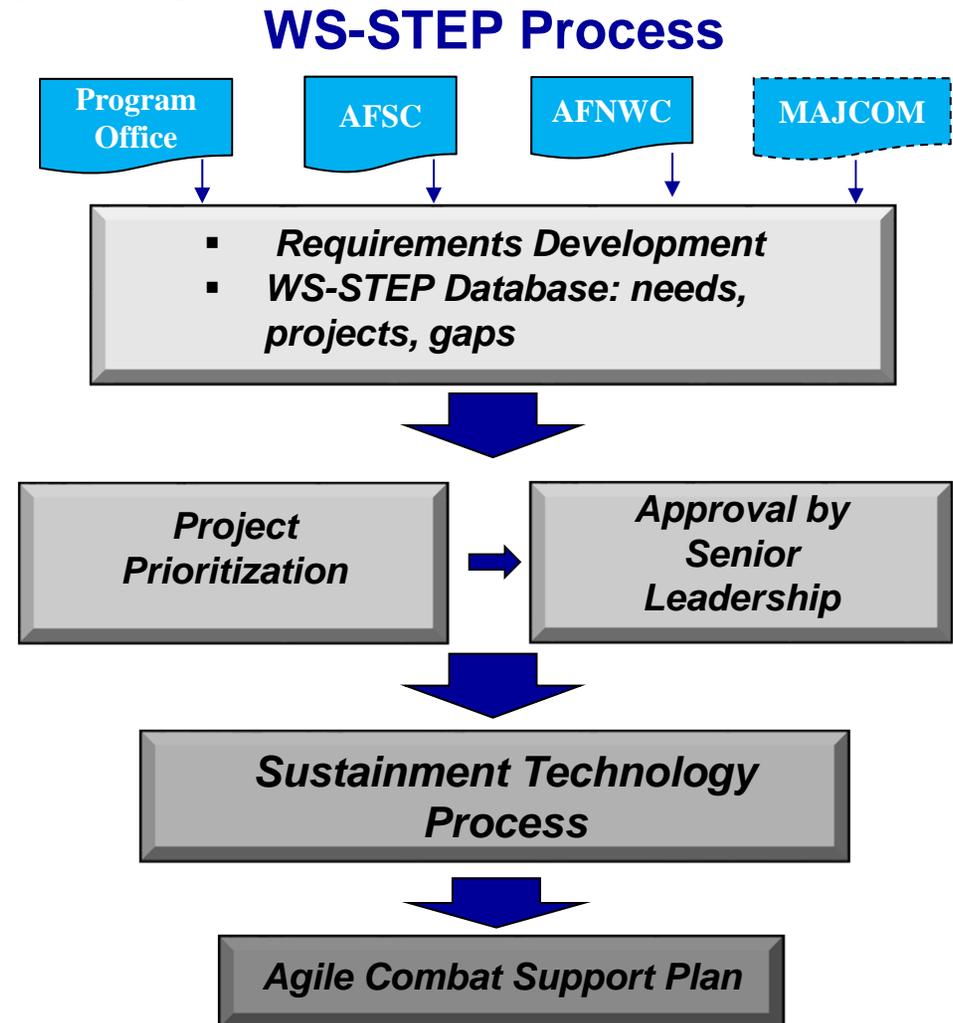
# Weapon System Sustainment Technology Enterprise Program



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- Identify and document weapon system sustainment technology needs/gaps/projects
  - Program Offices
  - AFNWC
  - AFSC
  - MAJCOM (future)
- Provide HQ AFMC STP data call with AFLCMC sustainment technology projects prioritized list approved by SLs
- Focus on Enterprise Solutions
- Follow Airworthiness Process for funded projects



**Feed STP to Ensure AF Enterprise Focus**



# USAF Airworthiness Bulletin (AWB-1015)

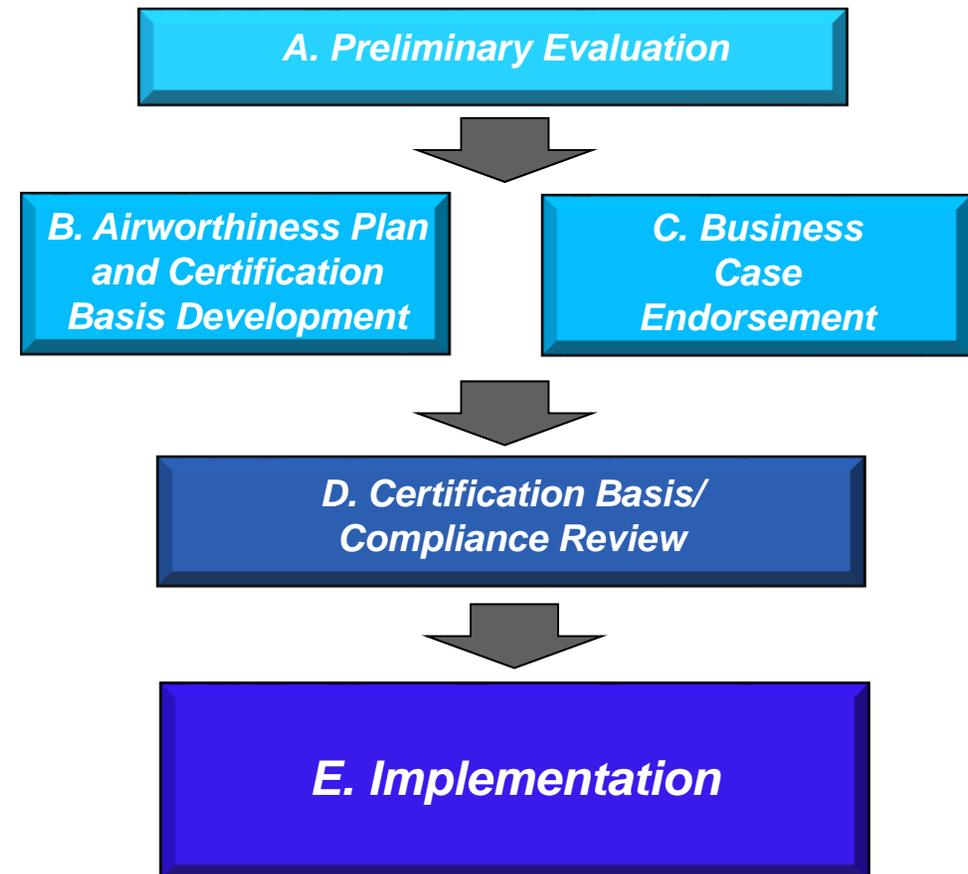


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- Applies to all New/Substitute Materials, Processes and Products on currently certified platforms
  - Reduces duplication
  - Ensures technology is mature and ready for implementation
  - Ensures Airworthiness requirements addressed
  - Faster implementation of technology across the enterprise
- Review artifacts, develop baseline requirements and initial qualification plan for safely deploying new/substitute materials, processes, or product forms

## AW Process



**Signed by AW authority by 15 July 2015**



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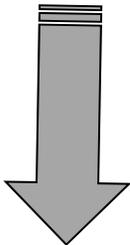
# Enterprise Implementation



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WS-STEP  
Database

- Identified Technology Requirements: needs, projects, gaps
- Current Database ( ~ 100 requirements): environmental, corrosion, cost effectiveness, sustainability, others.
- Requirements/potential enterprise solutions validated and prioritized, approved by SLs, submitted to STP
- Funding Strategy developed for Top Priorities
- Funded project entering Airworthiness Process



Airworthiness  
Process

- Start with Preliminary Evaluation
- Establish Change Evaluation Team (CET)
- Present Preliminary Evaluation Results to CET
- Develop Qualification Plan
- CET recommendations to execute Qualification plan
- Airworthiness Certification – USAF AW Bulletin (AWB-1015)

**Focus on Enterprise Solutions!**



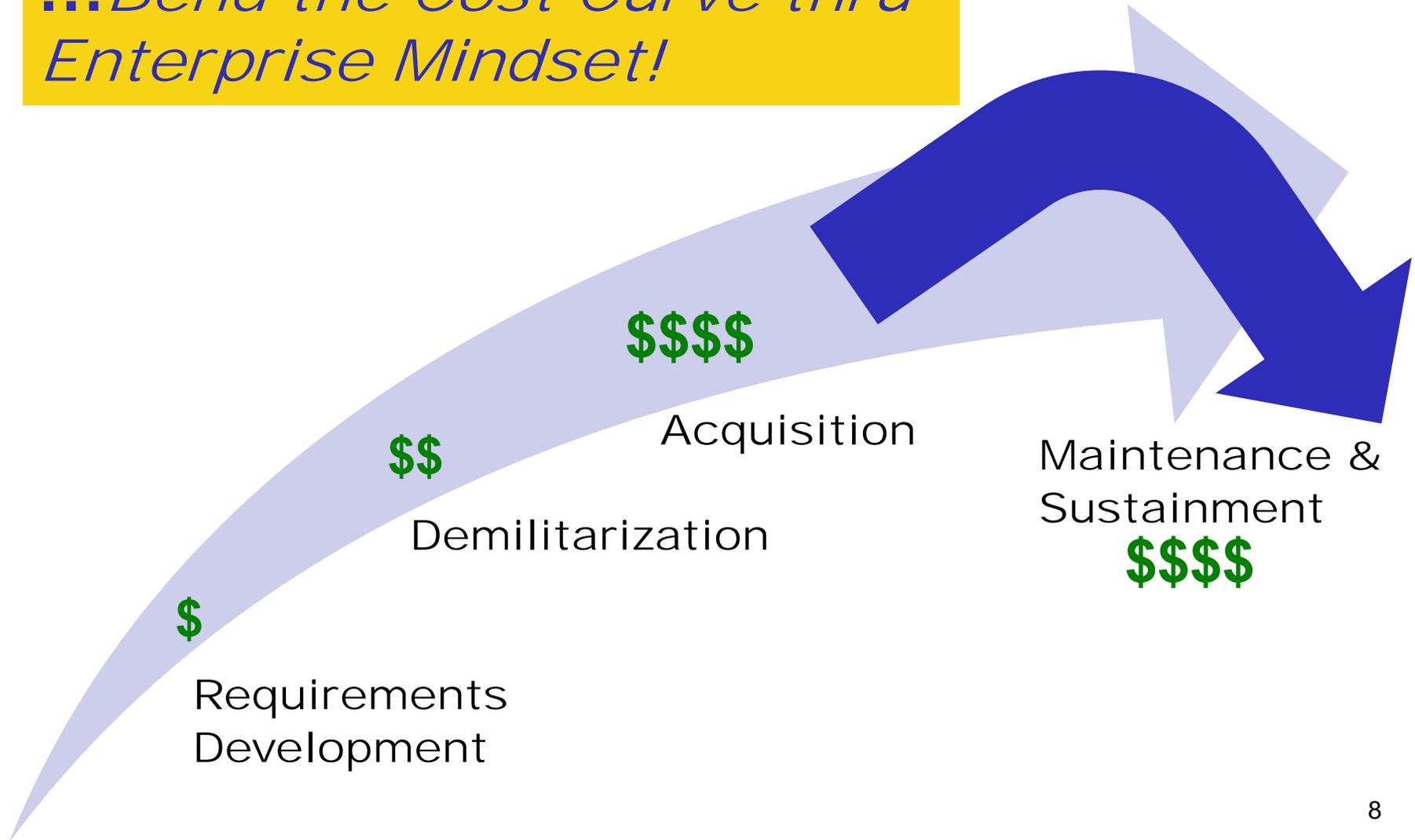
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# Tomorrow's Lifecycle Overview...



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*...Bend the Cost Curve thru Enterprise Mindset!*





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# The Innovation Journey



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- Focus on Transformational Technology Areas to **Support** and **Enhance** Technology Readiness + **Enable** Cost Effective Engineering
- Key in on Greatest Opportunities
- Stand up and Establish Long-Term Commitment to Enterprise “Big Rocks” Initiatives
  - Additive Manufacturing
  - CBM+
  - Robotics
- Apply Crawl...Walk...Run Approach





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# Opportunities for Technology Insertion Big Rock Approach to Organic A/C PDM



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Category	Total FY14 Hours
De-paint	63,280.1
Paint	57,390.4
Paint & De-paint	20,771.3
NDI	15,138.6
Corrosion Prevention	10,379.4
Corrosion Inspection & Repair	5,325.8
Hazmat Handling	6,099.9
Towing	3,931.4
Composite Honeycomb Inspection	2,671.3
Weight & Balance	1,556.9
Sealant Application	655.4
Pressurization	560.6
Component Drilling	254.6

Note: hours based on FY12 published, total organic aircraft, one induction, and includes occurrences



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# Big Rocks



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- **“Big Three Rocks”**
  - Additive Manufacturing
  - CBM+
  - Robotics Applications

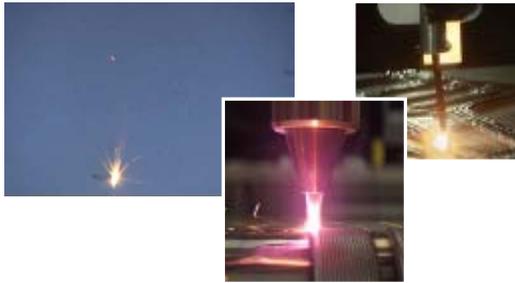


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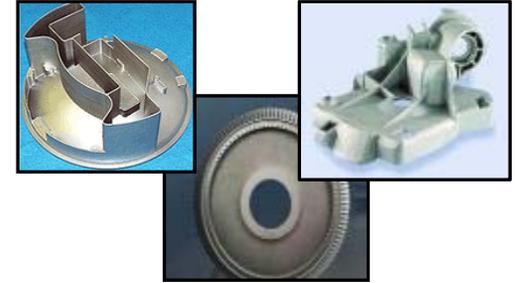
# Additive Manufacturing (3D Printing)



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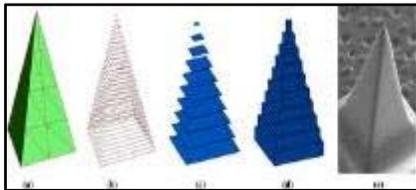
**Additive Manufacturing**  
*The next industrial evolution  
impacting design, manufacturing &  
supply chain*



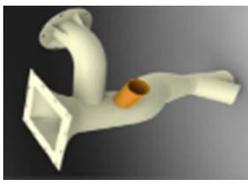
Building a part by adding material layer by layer from a CAD file versus removing or subtracting material from a larger form, e.g., machining

**Many Process Types**  
Directed Energy Deposition  
Powder Bed Fusion  
Materials Extrusion  
Materials Jetting  
Binder Jetting  
Sheet Lamination  
**Various Materials**  
Metals  
Polymers  
Composites  
Ceramics

**Benefits include...**  
◦ Geometric complexity  
◦ Reduced part cost  
◦ Weight savings  
◦ Fuel savings  
◦ Part consolidation  
◦ Logistics footprint



Today



Tomorrow

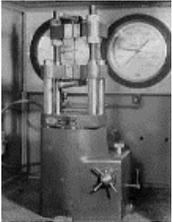


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# Additive Manufacturing Challenges



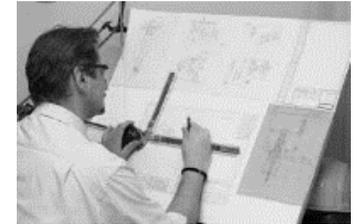
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Material standards & availability... Need to create specs & materials properties databases

Part selection... Need down-selection tools & process

Skillset development... Need Additive Manufacturing design tools, training, dedicated engineers & operators



Configuration control... Need centralized library, standard TDP's, standard process and policies



Reproducibility... Need process controls



Cyber Security... Need secure digital design storage & data transfer (e.g. convert 2D to 3D digital thread)



Part validation & qualification... Need test plans & tools (e.g. NDI)



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# Additive Manufacturing Agile Combat Support



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## Today

Decentralized Applications  
Mainly Polymer Based

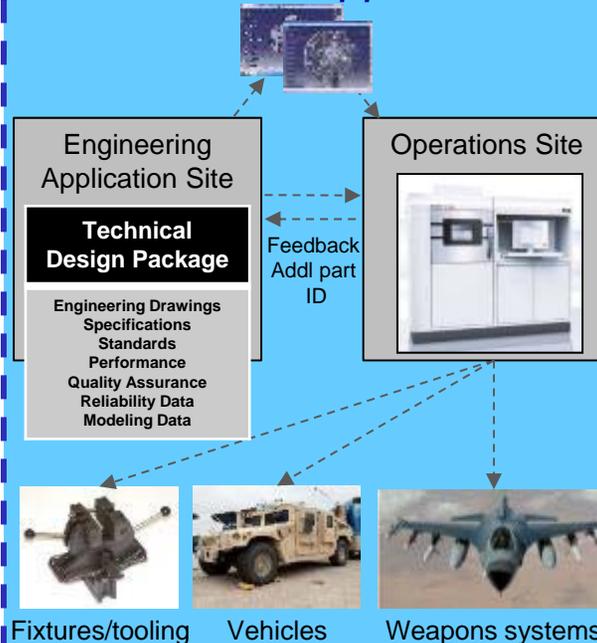


### No...

- Configuration control
- Part/material validation
- Process standardization
- Rigor or IT security
- Limited dedicated engineers/operators

## Tomorrow

Centralized Applications



- Qualify parts/components
- Address AM challenges
- Build AM capability
- Establish process discipline
- Utilize Innovation Centers

## Future

Security, Growth & Mobility



- Cyber secure parts library
- Standardized process
- Configuration controlled
- Agile, flexible forward deployment
- Future Operational CONOPS

## Ensuring the new frontier for the warfighter of the future



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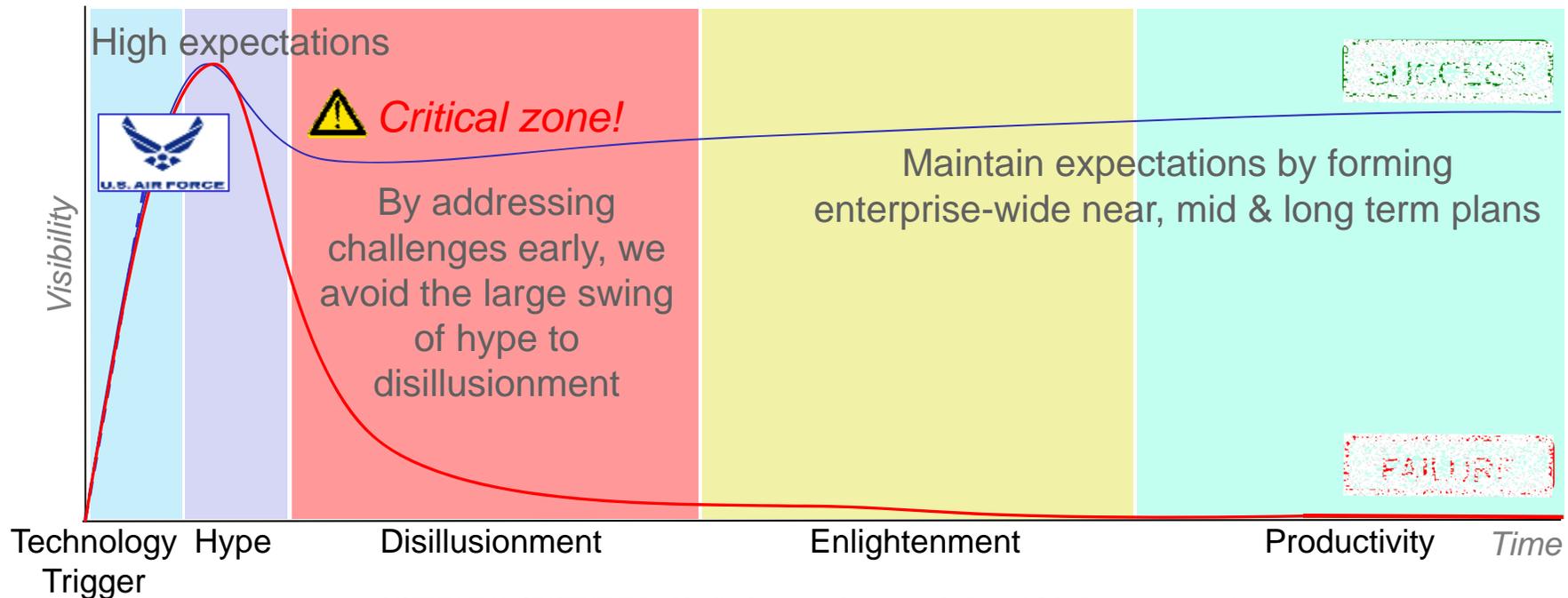
# Overcoming the Hype



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## Enterprise AM strategy to avoid disillusionment

- Technology demonstration through **smart pilot programs**
- Leverage industry partners “**pockets of excellence**”
- Develop knowledge, **define/address the challenges** & mitigate the risks
- Institute **organic, standardized** Additive Manufacturing capability
- Grow **competencies** in part design and manufacturing processes





# AM Enterprise Technology Plan

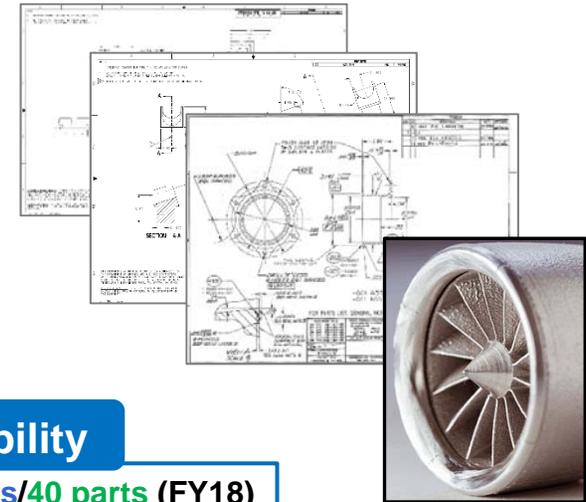


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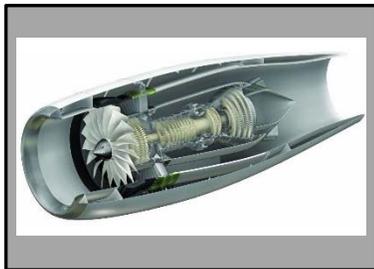
## Short Term - Accomplish Charter Objectives

- Design, build & validate **6 parts/12 parts** using Enterprise Process (TT FY16)
  - Various materials with range of complexity
    - Vehicle, packaging lab & aero hardware
- Validate Enterprise Process with a robust decision criteria strategy
- Utilize pockets of excellence; contract design & build
- Identify & strategically address challenges
- Start building organic AF capability through leveraged partnerships



## Mid Term - Continue Building Capability

- Design, build & validate **12 parts/24 parts** (FY17) & **20 parts/40 parts** (FY18)
  - Additional materials & complexity
- Continue to address challenges identified in pilot program
- Hybrid strategy with leveraged partners & organic capability
  - Continue to utilize strategic partners and pockets of excellence while growing internal design & build capabilities



## Long Term - Game-Changers

- Design, build & validate **40+ parts/80+ parts** (FY19+)
- Mostly organic capability for design, build & validation
- Agile Additive Manufacturing capability
  - Design & build parts when and where they are needed
- Deployable Additive Manufacturing capability
- Grow material data bases as well as multiple material AM

**Accelerate closing the gap, develop/procure design & part selection tools and deploy cyber-secure parts library**



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# Big Rocks



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- **“Big Three Rocks”**
  - Additive Manufacturing
  - **CBM+**
  - Robotics Applications



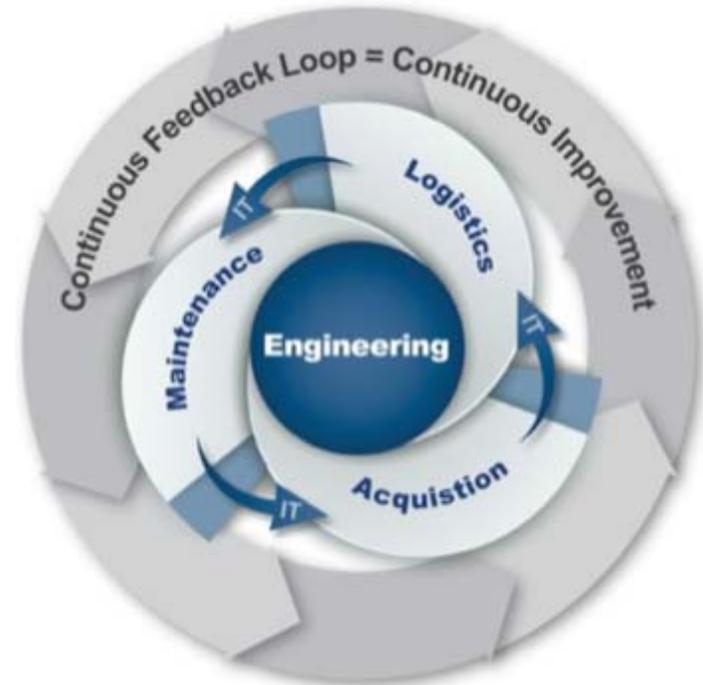
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# What is CBM+?



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- **CBM+ is an industry-proven methodology that promotes Mx upon evidence of need, not as a function of time**
- **CBM+ requires “big data” and systems interconnectivity to achieve maximum benefit**
- **Adoption of CBM+ requires the integration of emerging technologies, systems, and tools plus cross-organization coordination**





# AF CBM+ Approach Overview



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## CRAWL - Immediate Value

- Capitalize on existing pockets of excellence
- New perspective utilization of existing data and domain expertise
- Enhanced field Mx operations (MOB/AOR)
- Standardized processes to adopt predictive prognostics and monitoring
- Enhanced data integrity tools/suites & training



## WALK - Mid-Term Outlook

- Field + Depot Mx data set mash-ups and indicators
- Integration of corrosion, NDI, and other key conditional information sets (sensor feeds)
- Enhanced data integrity tools qualified for enterprise
- Cyber secure, collaborative and full-scale accessible environment



## RUN - Game-Changers

- Active CBM+ monitoring across USAF enterprise (organic + CLS)
- Real-time, state of the art data integrity systems
- Full-scale use of AIT and point of Mx tools
- Fully integrated engineering, supply & logistics operations = no unplanned Mx

**Ultimate Goal: Reduce...to Eventually No Unplanned Mx!**



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# AF CBM+ KPPs and Goals



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## Aircraft Availability

- Optimize scheduled maintenance to minimize downtime
- Reduce unscheduled maintenance
- Ensure spare parts availability
- Minimize downtime when mission aborts occur

## Mission Impacts

- Identify causes of mission aborts
- Prevent mission aborts
- Reduce mission abort rate

## Maintenance Cost Drivers

- Labor manhours and time to repair
- Component reliability and time between failures
- Spare parts and inventory costs
- Cannibalizations



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# Crawl Phase: Activities Today



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## FY15/16 Pilot Programs: B-1 & C-5



- CBM+ monitoring of select LRUs/sub-systems
- Focus Field Mx (MOB drivers)

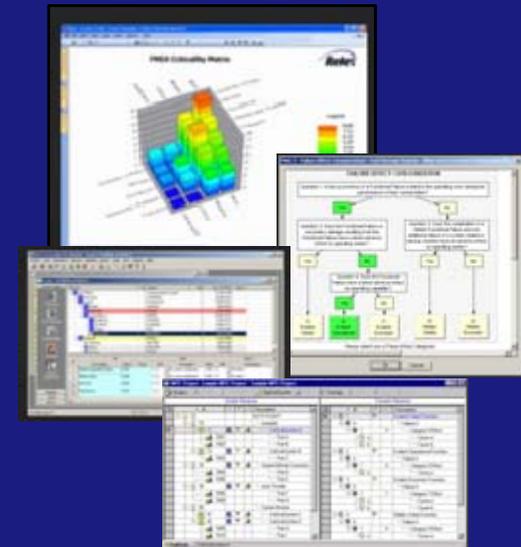
## CBM+ Enabling Technology & Processes



## COTS vs. FOSS

- Data Cleansing tools
- Data Analytics (engineering)
- Next Gen Data Collection Systems

## AF Enterprise Standardization



- Implementation or enhancement of "best practices"
- Standard tools and practices



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# FY15/16 Pilot Programs: B-1 & C-5 SPOs



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## PROJECT GOALS

- Adopt and integrate CBM+ predictive prognostics & principles
- Identify “top 5” CBM+ components
- Demonstrate CBM+ monitoring techniques and principles
  - Data- and/or model-driven techniques
- Evaluate next generation data cleansing and engineering data analytics tools
  - Enhance data integrity
  - Support by-tail condition analyses



## SUCCESSES & ACCOMPLISHMENTS

- Performed trending and computational analyses of Mx data
- Completed MOB maintainer operations assessments
- Completed C-5 MSG-3 certification deep dive
- Completed B-1 MSG-3 and RCM practices deep dive
- Completed initial review of B-1 & C-5 Mx data capture systems and data flow maps
- Initiated viability assessment of automated identification technology (AIT)
- Initiated “test drive” of data cleansing and data analytical suites (R&M engineering fundamentals)



### B-1 MOBs

Global Strike Command

Ellsworth AFB, South Dakota

Dyess AFB, Texas



### C-5 MOBs

Air Mobility Command &  
Air Force Reserves Command

Dover AFB, Delaware

Travis AFB, California



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# CBM+ Enabling Technology & Processes

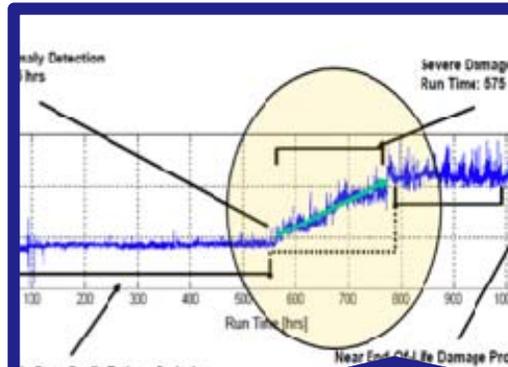


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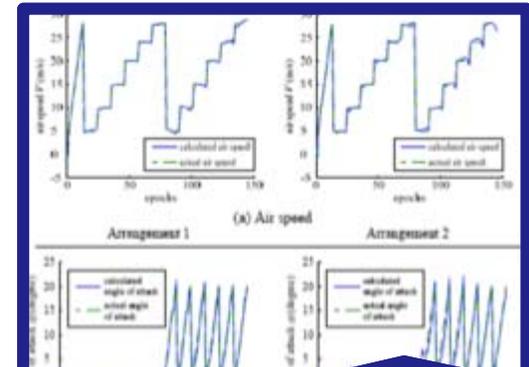
## Data Capture Tools and Systems

- Automated, real-time data entry tools & systems (i.e., AIT, IUID, interactive and mobile tools)
- Capability to highly increase data integrity



## Advanced Data Analytics and Tools

- Enhanced R&M engineering tools (i.e., fault tree analyses, block diagrams, etc.)
- Predictive prognostics and algorithms



## Data Cleansing and Neuro-Networks

- Smart-learning tools and systems
- Expedite data processing times
- Capability to host and evaluate “big data” amounts

**Intentionally Comparing COTS vs. FOSS Products!**



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# CBM+ Enabling Technology & Processes Leaning Forward



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- **Existing Pockets of Excellence – *expand viable solutions across the enterprise!***
  - Various “one hit wonders” may offer greater potential
  - Prior SBIR and SPO investments and activities
  - Direct “up-stream” solutions
    - Greatly enhances data integrity
    - Improves maintainer experience
- **Integration of Innovation – *from industry best practices, tools and systems***
  - Mobile, real-time applications
  - Direct comparisons of COTS vs. FOSS software systems and tools



**Making the Maintainer's Job Better!**

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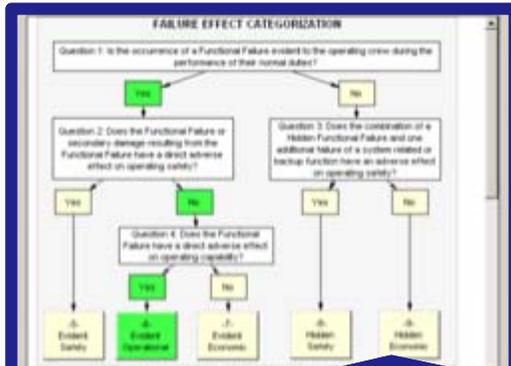


# AF Enterprise Standardization



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## R&M Best Practices and Tools

- Workforce development and trainings
- Standard contract language
- Standard tools and systems across enterprise (data and processing)

ID	Description	Other
1000	Communication Center	1000-1000
1001	...	...
1002	...	...
1003	...	...
1004	...	...
1005	...	...
1006	...	...
1007	...	...
1008	...	...
1009	...	...
1010	...	...

## R&M Documentation

- RCM/MSG-3 excellence
- “Rolling” FMECAs
- Electronic, complete asset records
- Standard system requirements

System Hierarchy	Function Hierarchy
AUTO FLIGHT	Existence
Autopilot	Existence
SubSystem A	Existence
Part A	Existence
Part B	Existence
SubSystem B	Existence
Part C	Existence
Speed/Altitude Correction	Existence
Part D	Existence
Auto Thrust	Existence
Part E	Existence
Part F	Existence
Part G	Existence
System Monitor	Existence
SubSystem C	Existence
SubSystem D	Existence
Part H	Existence

## Integration with Operations

- New product certifications and approved product lists (including cyber aspects)
- Cross-functional coordination and shared learning

# Integrating Best Practices into AF Operations!



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# AF Enterprise Standardization On the Horizon...CBM+ and Cyber



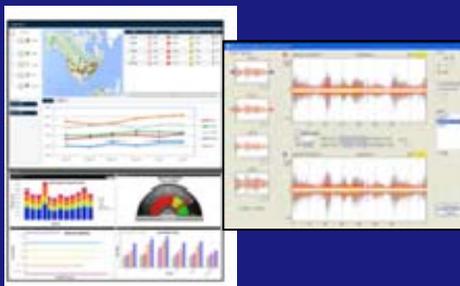
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## Today...



- Compartmentalized, separate systems & operations
- Separated data analytics & tools
- Data feeds on delay (no real-time feeds)

## Tomorrow...



- Advanced data collection systems (AIT/IUID)
- Connected data analytic tools & data systems
- "Big data" storage

## The Future... **DATA FUSION!**



- Real-time, interconnected data flows between assets and network + tools
- On-the-spot, interactive, mobile devices
- Standardized systems and tools
- Secure storage and transmission

Increasing cyber vulnerabilities →



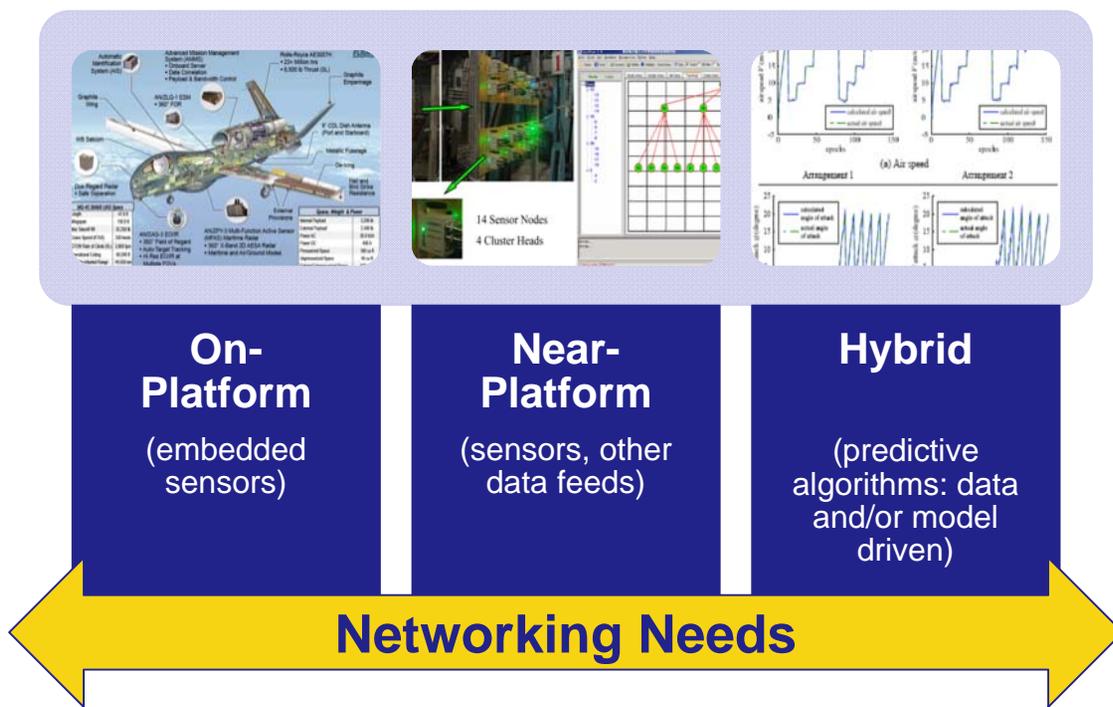
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# AF Enterprise Standardization CBM+ Cyber Vulnerabilities



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- Two primary points of vulnerability
  - Asset (actual weapon system platform)
    - On-board sensors and diagnostics
    - Flight and mission dashboards/cockpit
  - Network (“big data”)
    - Collection points
    - Transmission
    - Storage
    - Analytical tools and outputs
    - Part configuration, ordering, supply chain, and inventory points
    - Shear amount of data – *unclassified individually but collectively considered classified/sensitive = big target!*





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# Next Steps



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- **Expand SPO inclusion into active CBM+ program**
  - 2-3 SPOs planned for FY16/17
  - Initiate active CBM+ monitoring for B-1 & C-5
  - Continue CBM+ education across the AF enterprise
- **Complete CBM+ software “test drive”**
  - Assess long-term viability based on performance and cost
  - Initiate systems/tools certification requirements for viable products
- **Continue to “lean forward” with automated tools**
  - Coordinate cross-SPO demonstration of point of Mx tools
  - Evaluate AIT/UIID solutions via active demonstration
- **Initiate RCM/MSG-3 standardization efforts**
  - Start process to ensure necessary documentation across SPOs
  - Create and apply “rolling” FMECA tool/system
- **Kickoff process to create Program Protection Plans**
  - Necessary to support RUN phase interests (i.e., real-time access and interconnectivity needs)

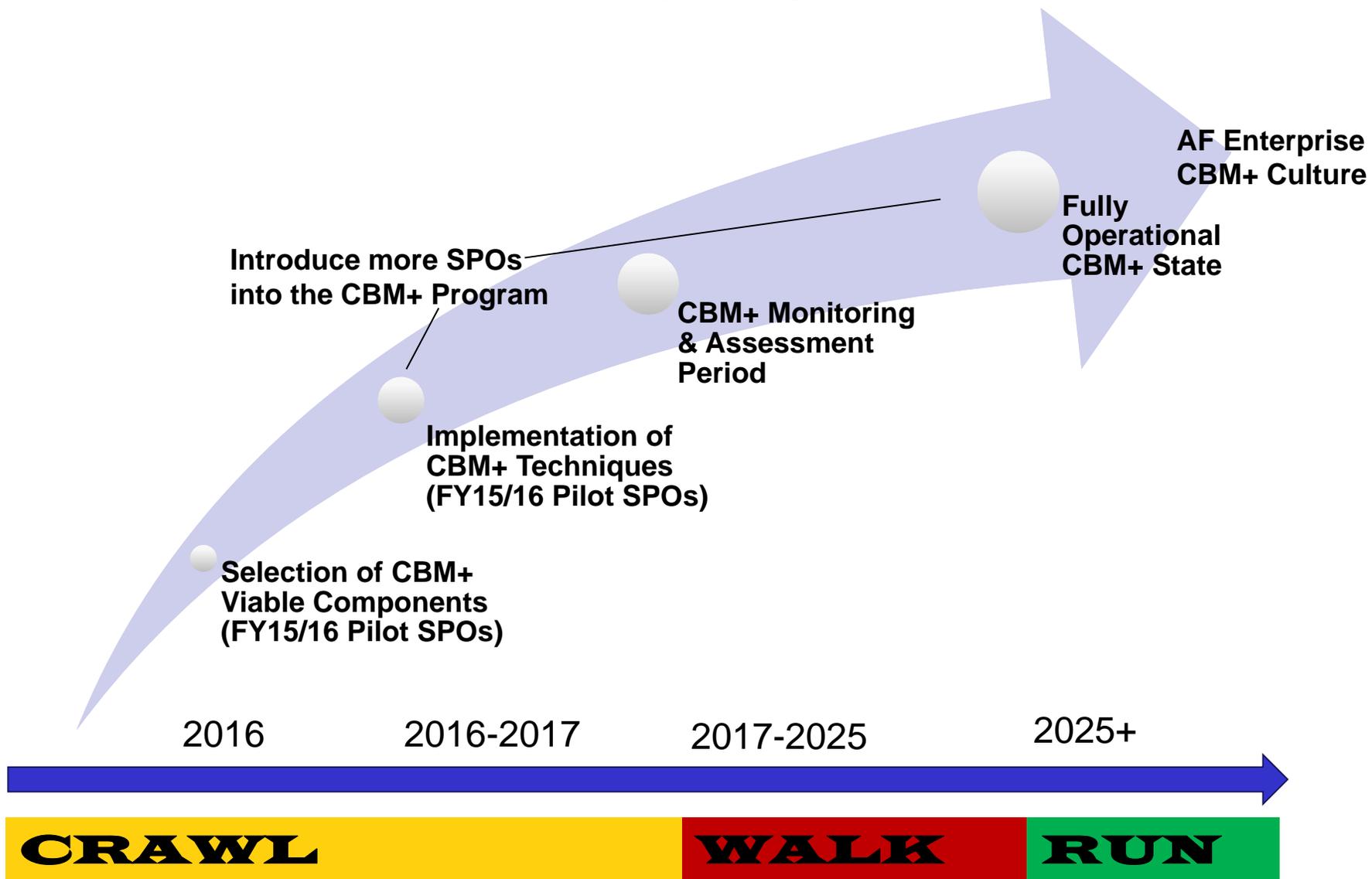


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# AF CBM+ Adoption Timeline



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# Revolutionary Changes on the Horizon



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## Mission Readiness

- Instead of flying to failure, address failures **before** they occur
- Real-time reliability assessments versus "assumed" reliability (i.e., what are the max performance limits; can we get more out of the part, when to replace)

## Asset Supportability

- Being able to predict when a part will fail improves part availability (when and where)
- Capability to enhance supply chain, spares, and inventory needs across the enterprise, globally

## Cost Effectiveness

- Don't replace parts if there is more life left
- Conduct Mx when needed and for what is needed, not time based
- Promotes "new perspective" using existing data, tools, equipment, etc.

**AF Committed to the CBM+ Journey! Onward!**

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# Big Rocks

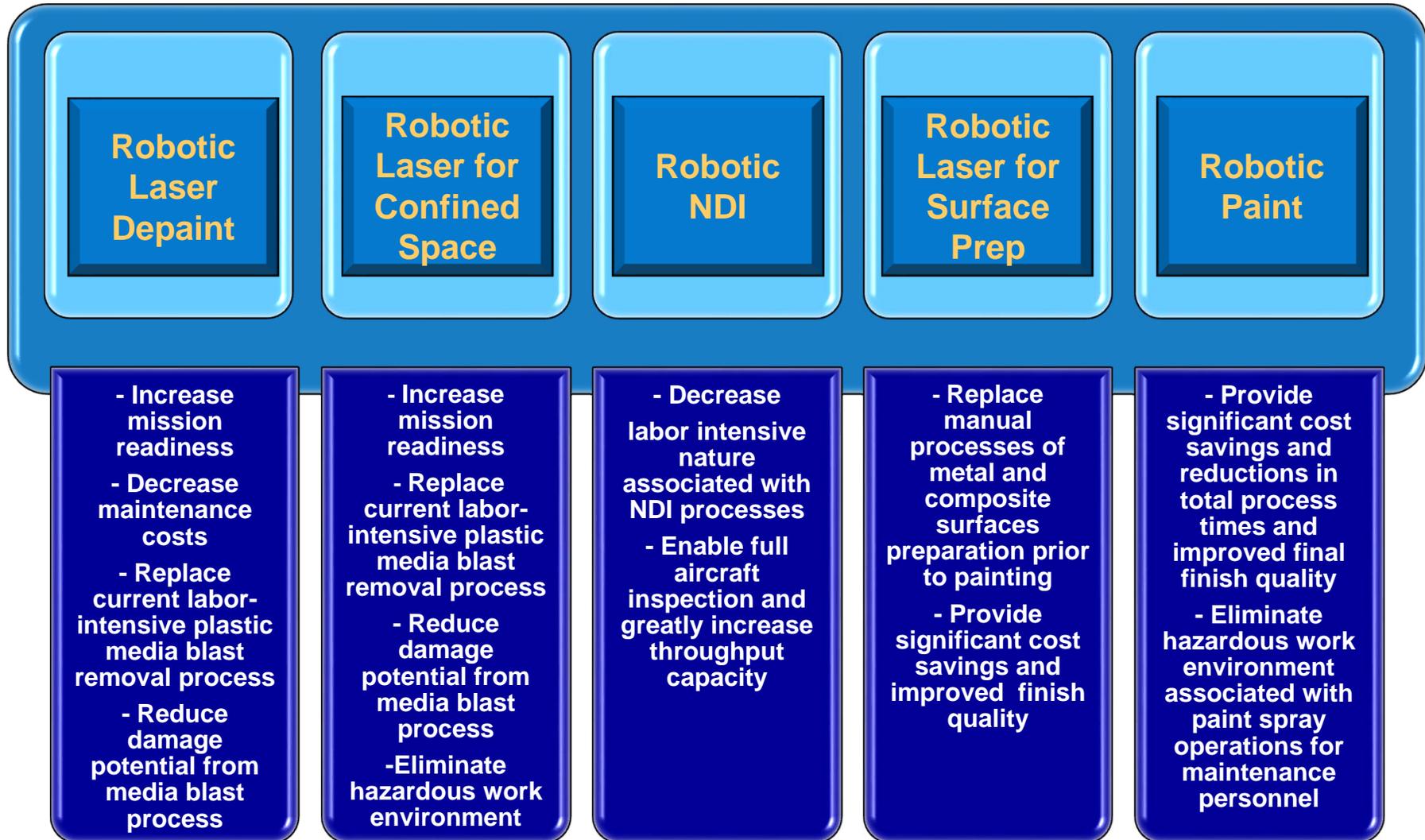


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- **“Big Three Rocks”**
  - Additive Manufacturing
  - CBM+
  - **Robotics Applications**



# Robotics Applications





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# Robotics Strategy

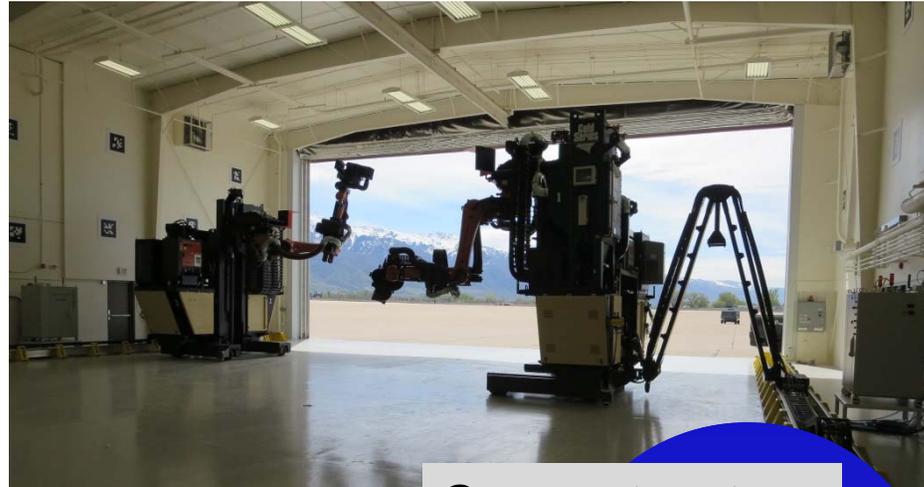


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One system to...

Robotic  
NDI

Robotic  
De-painting



One system to...

Robotic  
Cleaning

Robotic  
Painting



Preparing for Tomorrow's Journey, Today!



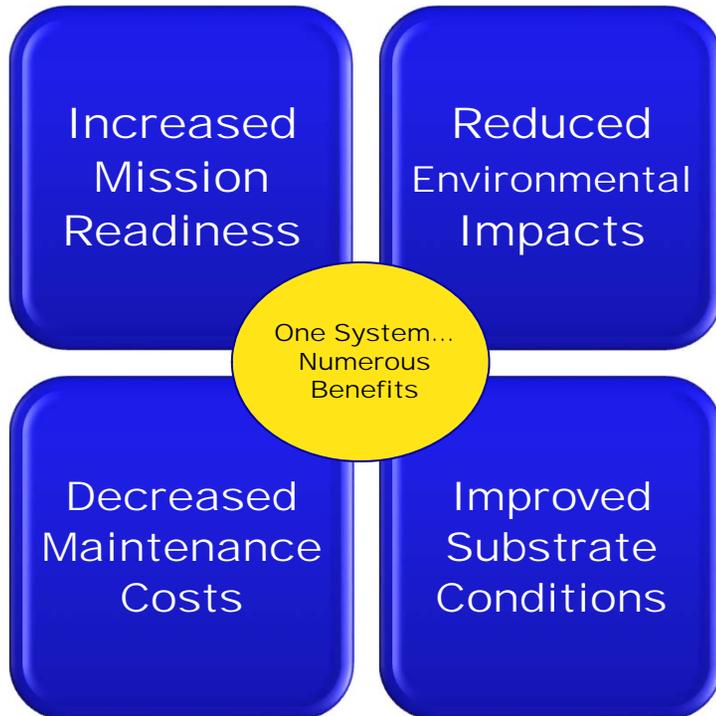
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# Robotic Laser Depaint



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Exceeding expectations! Offering numerous benefits...



Utilized a spiral approach to qualify technology



Mobile Robotic Systems for Full Aircraft



Robotic Lasers for Aircraft Components



Handheld Laser for Small Areas

Laser energy safely applied to surface for decomposition and removal of coating into collection system



# Robotic Laser for Confined Space

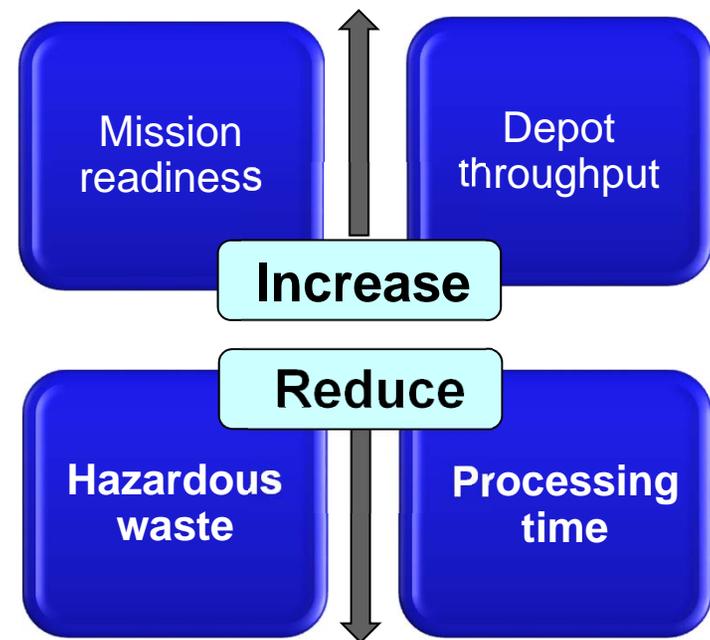


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AFLCMC... Providing the Warfighter's Edge



Automated laser coating removal system capable of selective removal of coatings from the confined location of the engine air inlet



Combine proven laser coating removal technology with advanced automation and innovative substrate sensors to create an integrated package usable at multiple aircraft maintenance facilities



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# Robotic Laser Surface Preparation

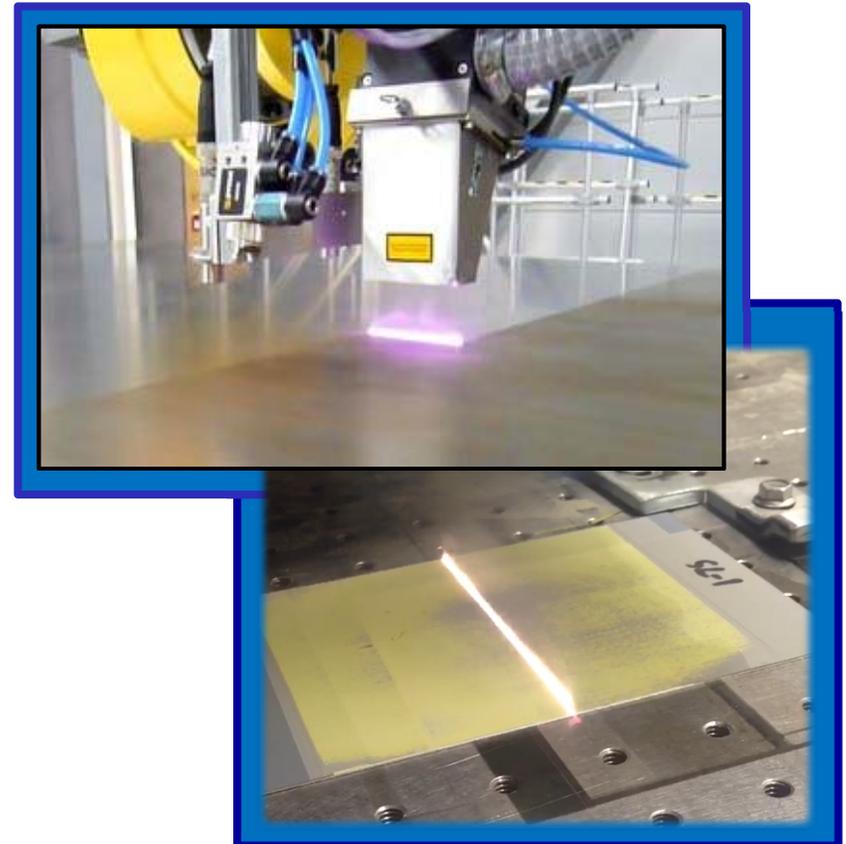


AFLCMC... Providing the Warfighter's Edge

Meet stringent aircraft coating performance requirements by cleaning and reactivating aircraft primer prior to reapplying aircraft top coat paint

## Benefits:

- Increased process efficiency due to savings in time and cost
- Improved surface cleanliness
- Enhanced paint surface adhesion
- Reduced corrosion due to better surface adhesion
- Eliminates use of hazardous chemicals





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# Robotic Paint



AFLCMC... Providing the Warfighter's Edge

**Provide quality, precision, and consistent coating application while reducing costs and process time**



## Benefits:

- Increased depot throughput (thereby increasing mission readiness)
- Reduced environmental hazards
- Decreased maintenance costs (reduce rework)
- Improved coating adherence



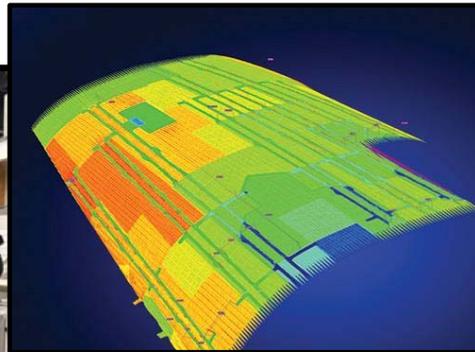
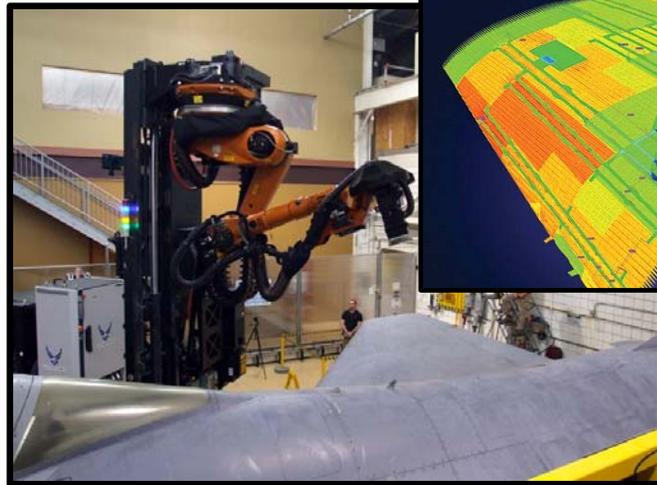
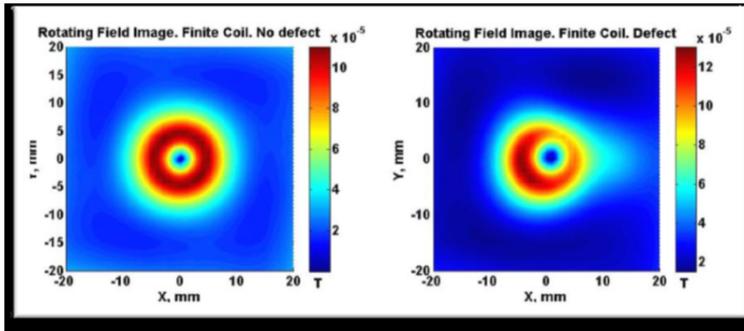


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# Robotic NDI



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## NDI Methods:

- Eddy current
- Radiography
- X-ray computed tomography
- Thermography
- Acoustic emission
- Others...

## Benefits:

- Operational cost reduction
- Aircraft downtime reduction for schedule maintenance inspection
- Improved aircraft readiness and safety concerns

**Improved situational awareness and assistance  
for the aircraft maintenance personnel**



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# Summary



AFLCMC... Providing the Warfighter's Edge

- ***AFLCMC's Strategy - Big Rocks Initiatives***
- ***Revolutionary Changes***
  - *Mission Readiness*
  - *Cost Effectiveness*
  - *Asset Supportability*
- ***Promotion of Enterprise Impact***

**Ensuring Faster Implementation of Technology  
Across the Enterprise**



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*AFLCMC... Providing the Warfighter's Edge*

