



# AIR FORCE

# LIFE CYCLE MANAGEMENT CENTER



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

*PROPULSION DIRECTORATE*



## Ensuring Propulsion Readiness Through Innovation

25 February 2019

**Mr. Rafael Garcia, SES**  
**Director of Propulsion**  
**Air Force Life Cycle Management Center**

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*Integrity - Service - Excellence*



# Overview



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- **Propulsion Directorate Mission/Focus Areas**
- **Propulsion Portfolio**
- **Challenges**
- **CBM+ Vision and Architecture**
- **Current Capabilities and Benefits**
- **2019 Analytic Application Initiatives**
- **Summary**



# Propulsion Focus Areas



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## Mission

Develops, acquires, tests, fields, sustains, and modernizes leading-edge propulsion systems through life cycle management for the U.S. warfighter and international partners

## Vision

Be the Propulsion Center of Excellence for the U.S. Air Force and International Partners



**Acquire and Support War-Winning Capabilities**

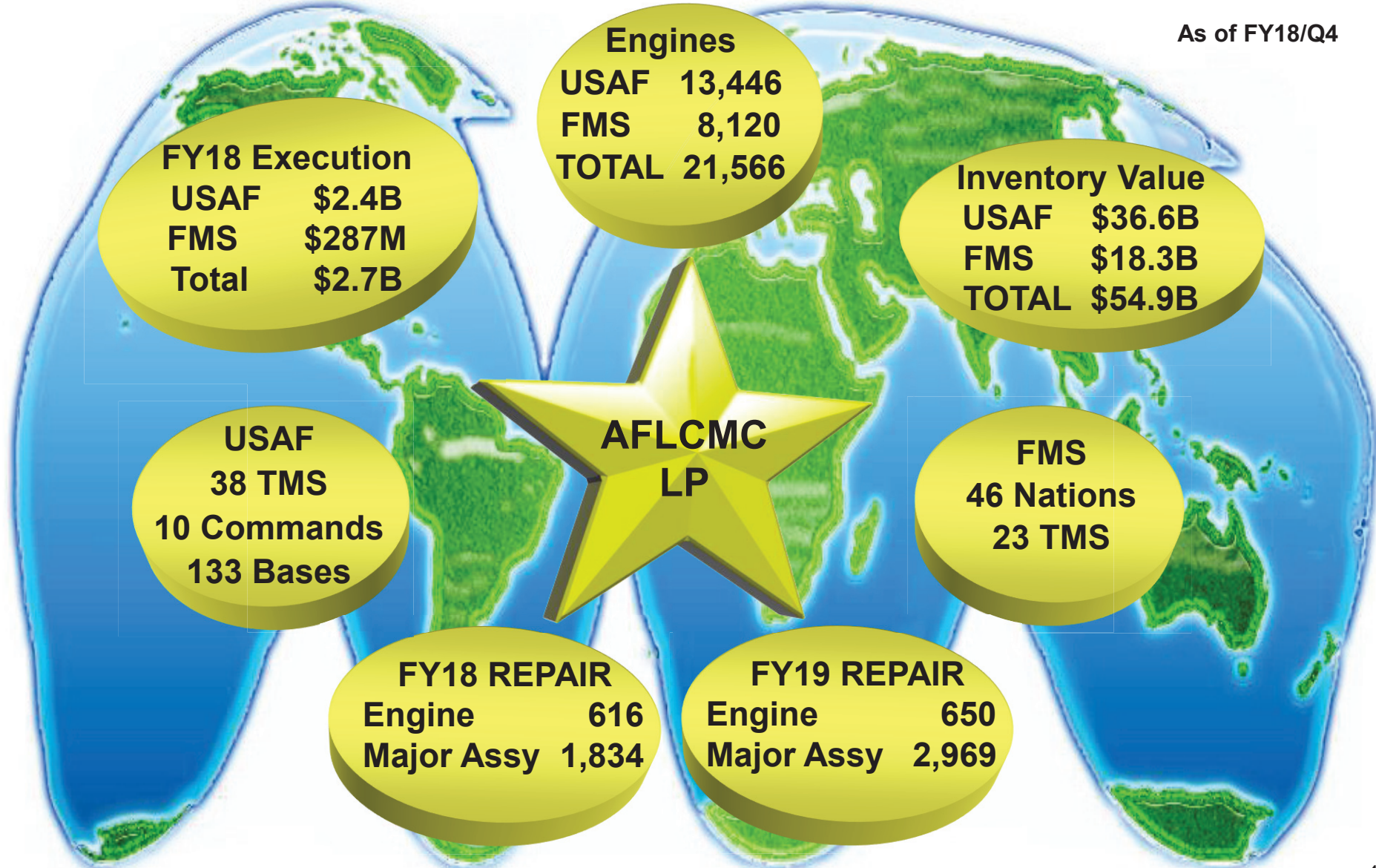


# Propulsion Portfolio



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As of FY18/Q4

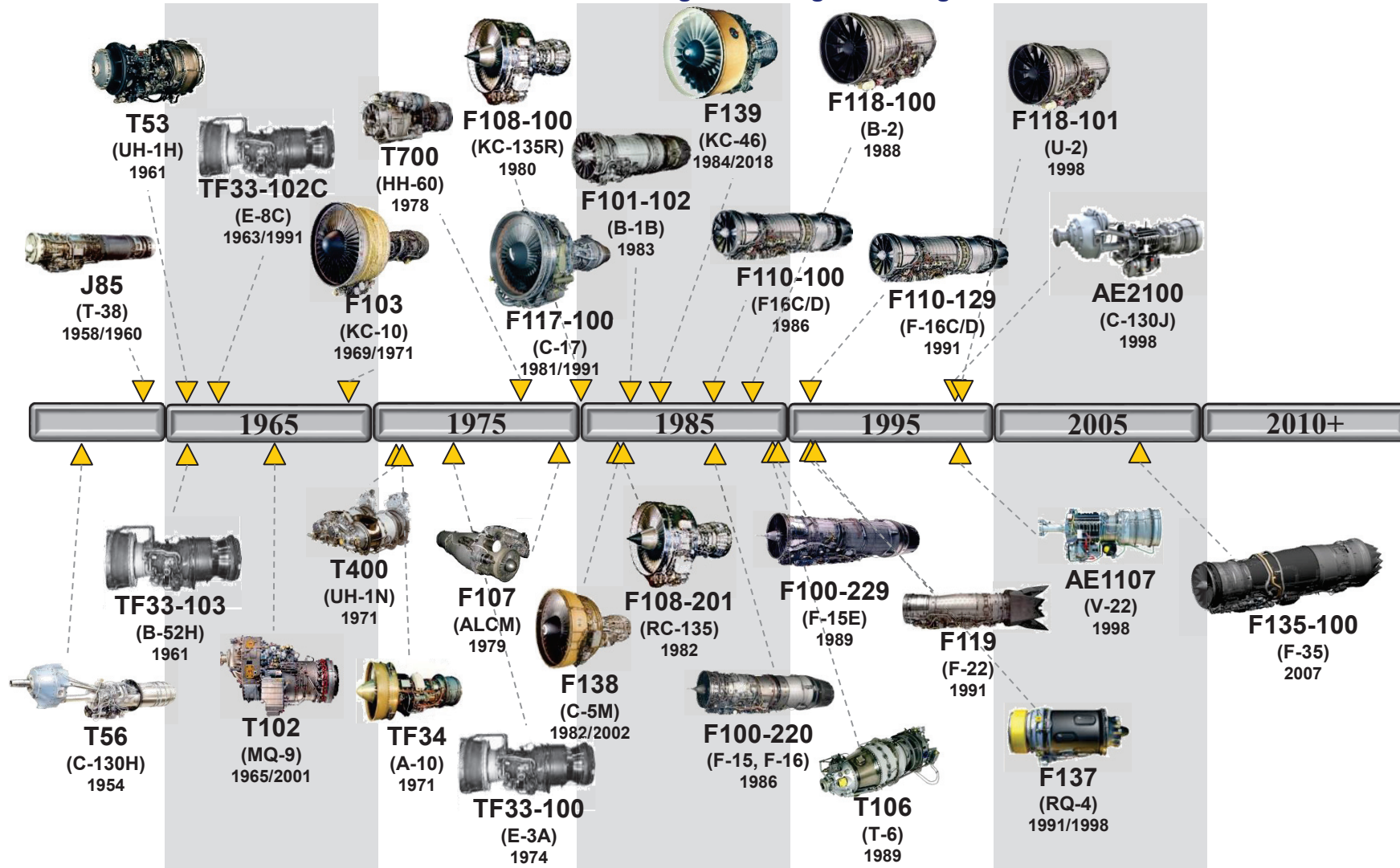




# Air Force Propulsion Portfolio



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From Early Technology To Cutting Edge Propulsion Systems



# Challenges

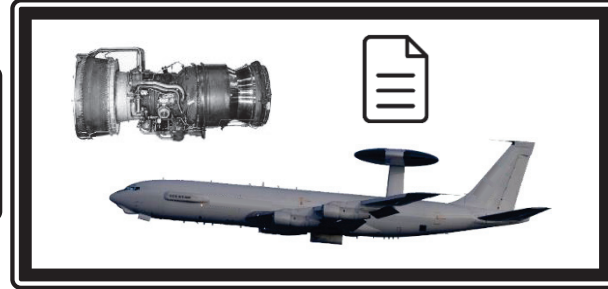
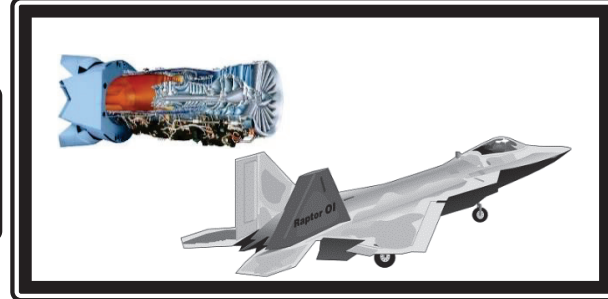
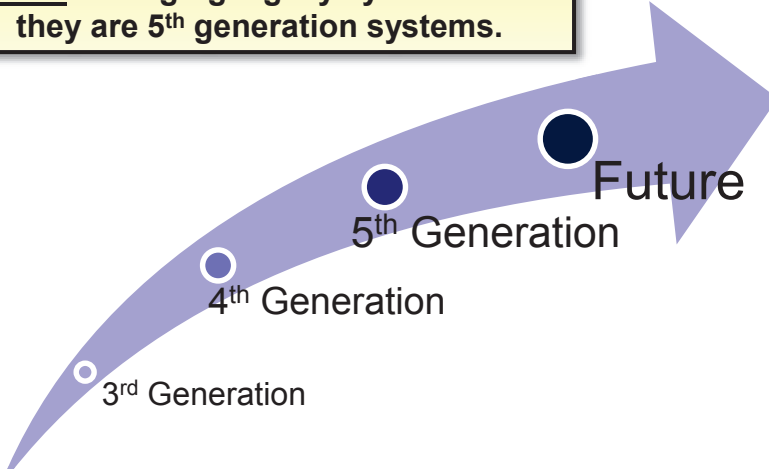
## Choice in Management Concepts



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**STOP** Stop managing 5<sup>th</sup> generation systems like they are legacy systems.

**GO** Start managing legacy systems like they are 5<sup>th</sup> generation systems.



- 3rd Gen CBM+ Tech**
- Intermediate Test Cell
  - Depot Test Cell
  - Performance Trending
  - Fleet Trending
  - Oil Analysis
  - Time Alignment

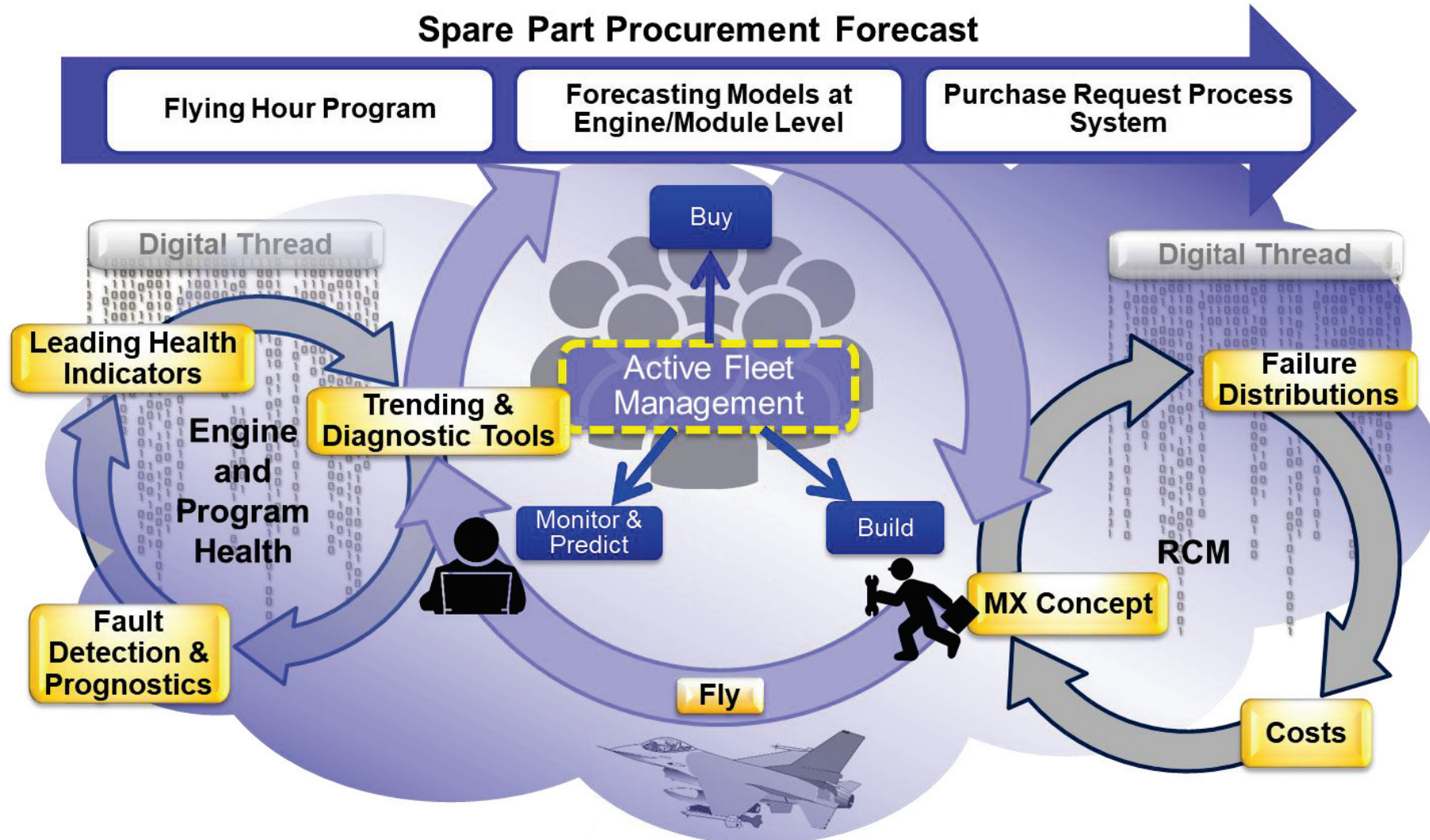
- 4th Gen CBM+ Tech**
- Intelligent Trending
  - Operating Regime Recognition
  - Module Matching

- 5th Gen CBM+ Tech**
- Usage Based Lifting
  - On-wing oil analysis

- Future CBM+ Enablers**
- Enterprise Architecture
  - Agile IT Environment
  - Automated MX Collection
  - Artificial Intelligence
  - Wireless Download

**Gather Up Stovepiped Engine Data And Use Latest Analytical Techniques To Improve Fleet Management**

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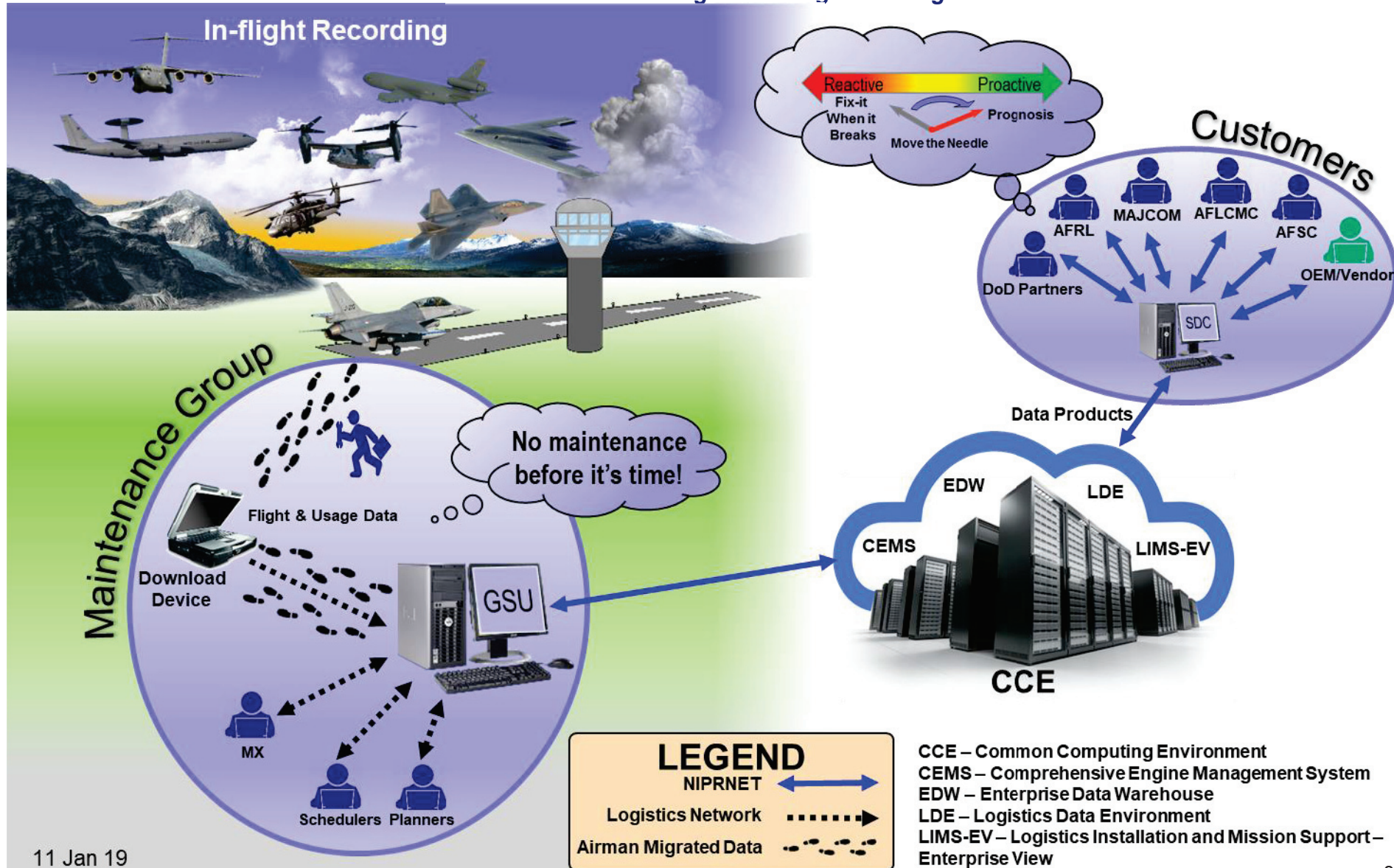
**Digitally Connect The Lifecycle, Increase Readiness**



# CBM+ Architecture



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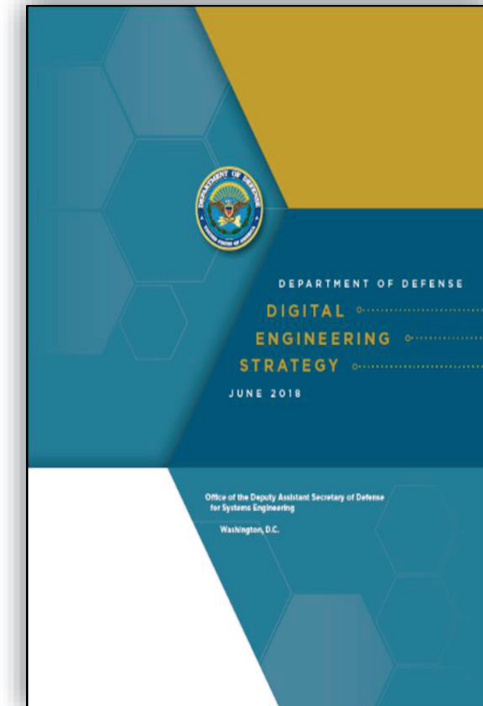


# Digital Engineering - Key Enabler



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- **Formalize Development, Integration & Use of Models**
- **Provide Enduring, Authoritative Source of Truth**
- **Incorporate Technological Innovation to Improve Engineering Practice**
- **Establish Supporting Infrastructure and Environments**



June 2018 DoD DE Strategy

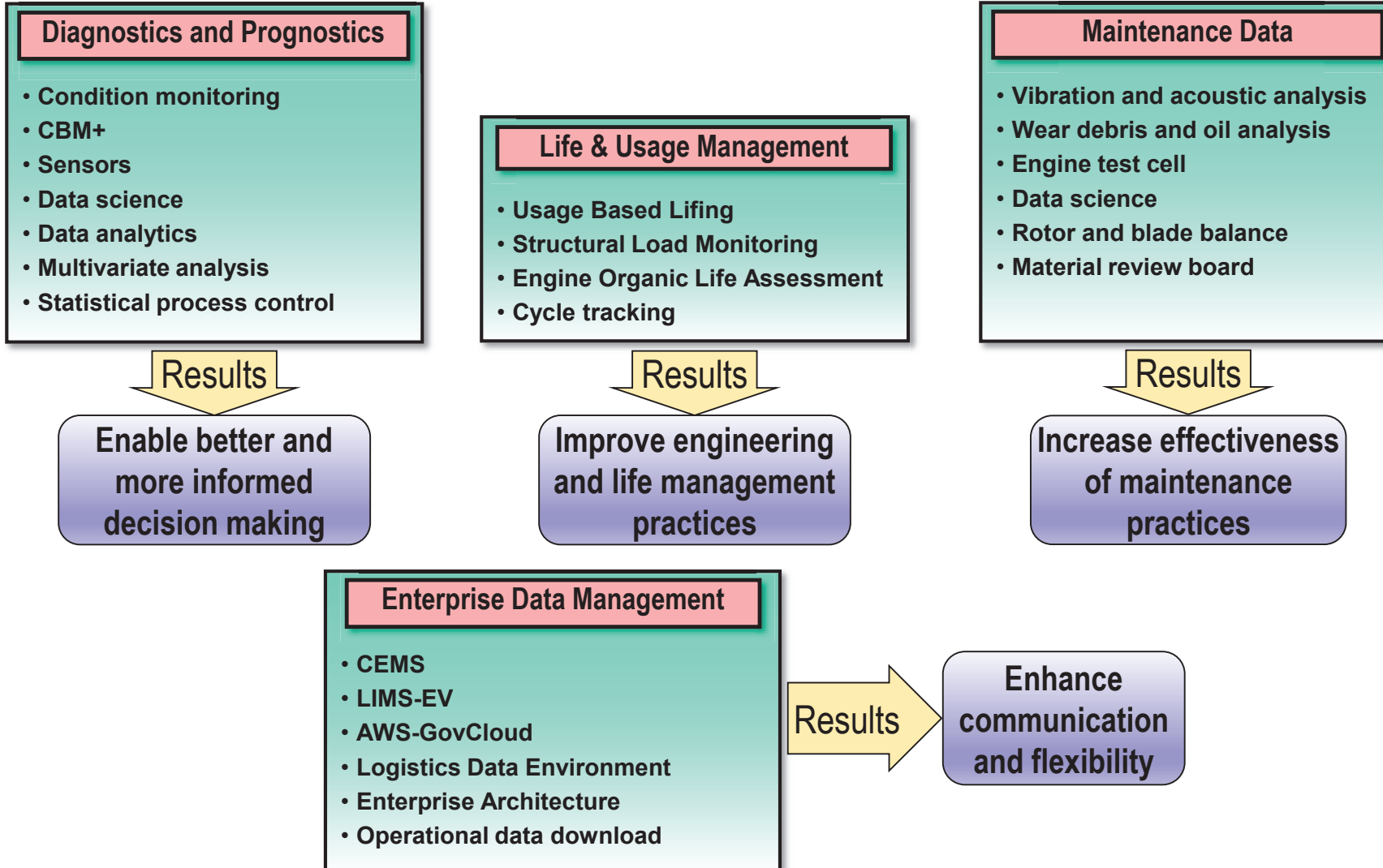
**Leveraging DoD Strategy To Accomplish Propulsion Vision**



# Current Capabilities & Benefits



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**Categorize/Prioritize To Digitally Multiply Our Force**



# Current Capabilities Update



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- Improving current diagnostics tools/techniques

  - Oil Analysis Program

FY18

Samples Tested 202,401	Hits 38	Removals 21
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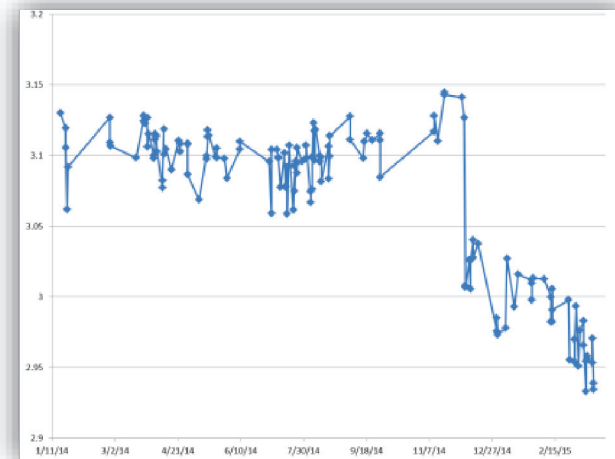




  - USAF developed diagnostics based on existing engine sensor data

    - Develop parameter relationships to detect imminent engine issues

Sorties 319,403	On-Board MX Faults 32,470	Off-Board Trend Faults 3,150
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Transform Current Diagnostics Into Predictive Actions!



# 2019 Digital Initiatives



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- **Predictive Engine Trending & Diagnostics (ET&D) based on AI tools**
- **RCM with Machine Learned (ML) failure distributions**
- **Predictive Water Wash Algorithm**
- **Digital Greenhouse**
- **Logistic apps for Actuarial Simulation & Engine Dashboard**
- **Leading Health Indicators (LHI)**

**“The best way to predict your future is to create it.”**

**~Abraham Lincoln**

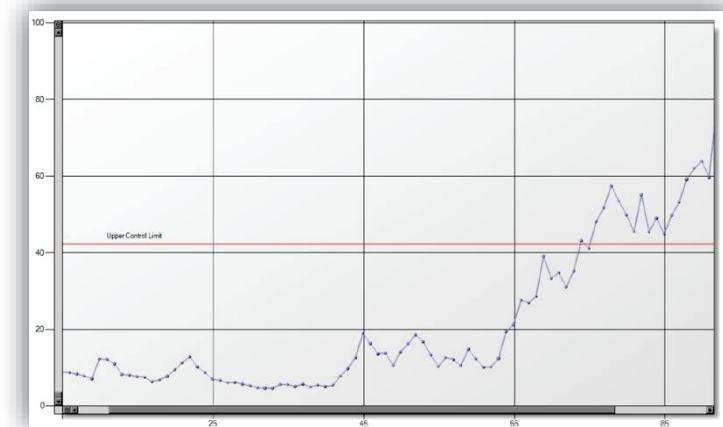
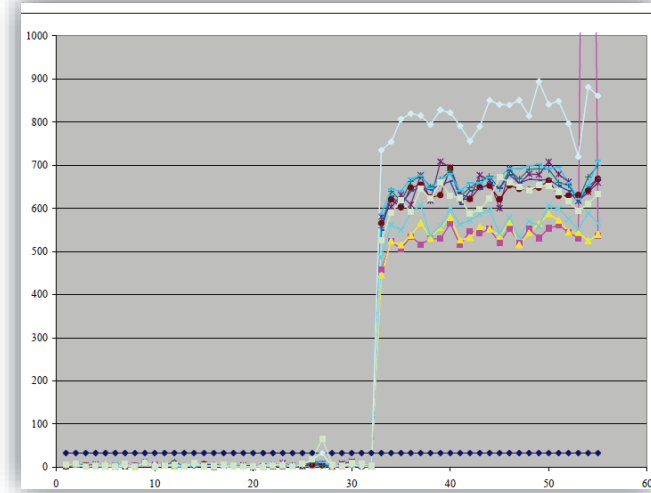


# Predictive ET&D Based on AI Tools



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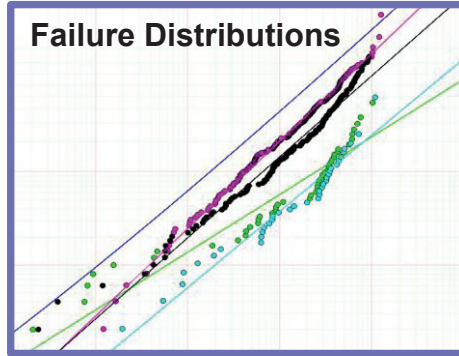
- **AI Analysis of sensor data**
  - Machine/Deep Learning
    - Demonstrated detection of engine anomalies
- **Cloud-based Predictive ET&D Apps**
  - Based on open source software
  - With companion troubleshooting trees & maintenance actions



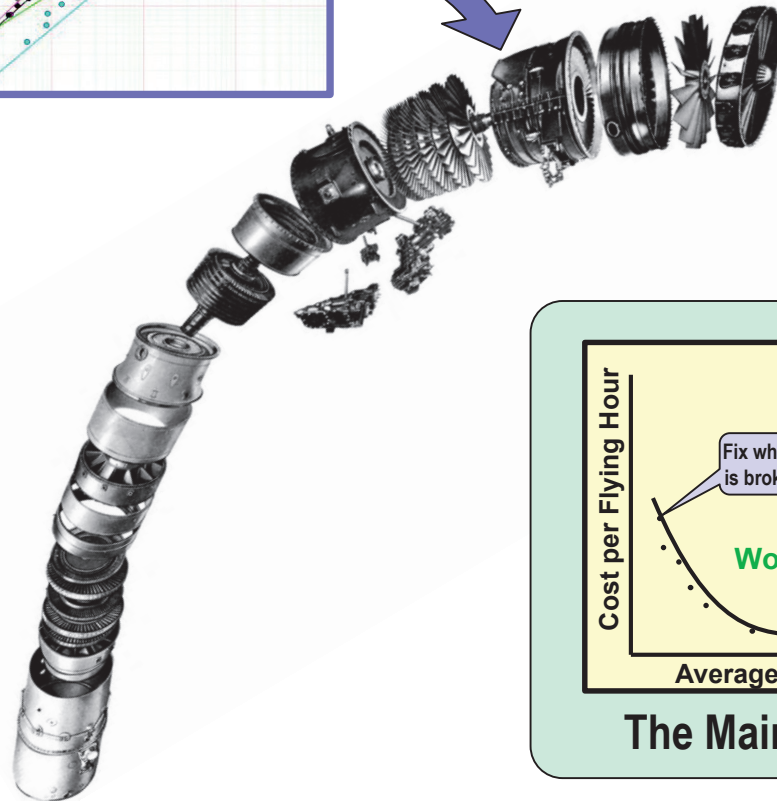
**Change Unscheduled Removals Into Predicted/Scheduled Events**

# RCM Application with ML Failure Distributions

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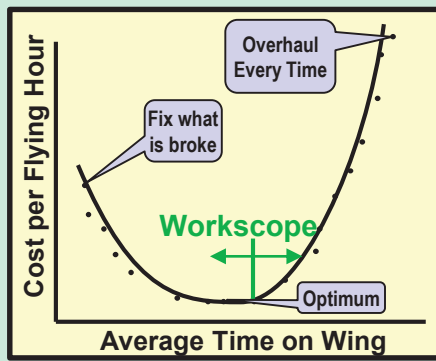


- Apply Machine Learning to find failure distributions more efficiently



Historical and Potential Results

Increase ATOW 15 to 50%	Decrease Cost per EFH 7 to 38%
Reliability	Costs
← Focus →	



Cost per Flying Hour

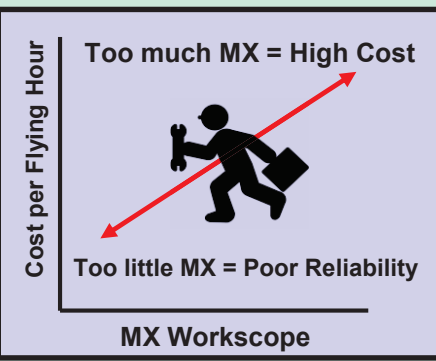
Average Time on Wing

Optimum

Workscope

Overhaul Every Time

Fix what is broke



Cost per Flying Hour

MX Workscope

Too little MX = Poor Reliability

Too much MX = High Cost

**The Maintainers' Dilemma – The case for RCM**

**Future Challenge To Find 'Best' Balance of Cost & Reliability**

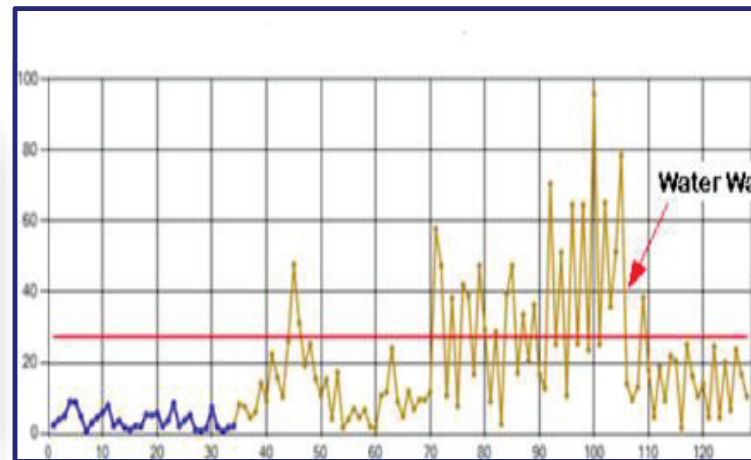


# Predictive Water Wash Algorithm



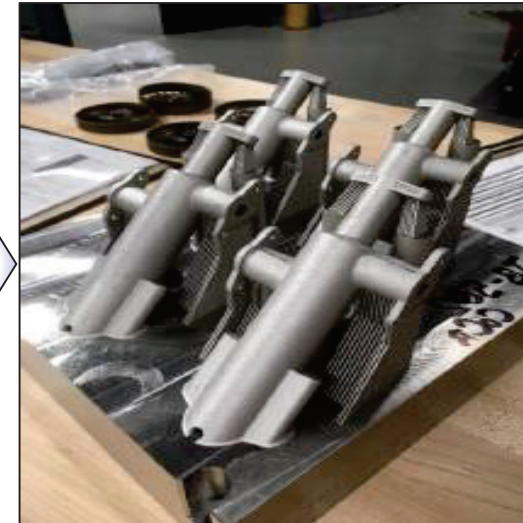
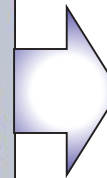
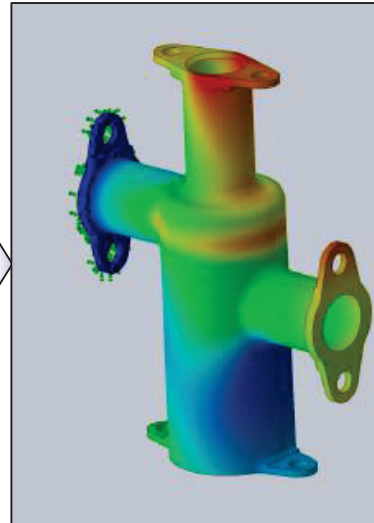
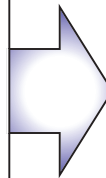
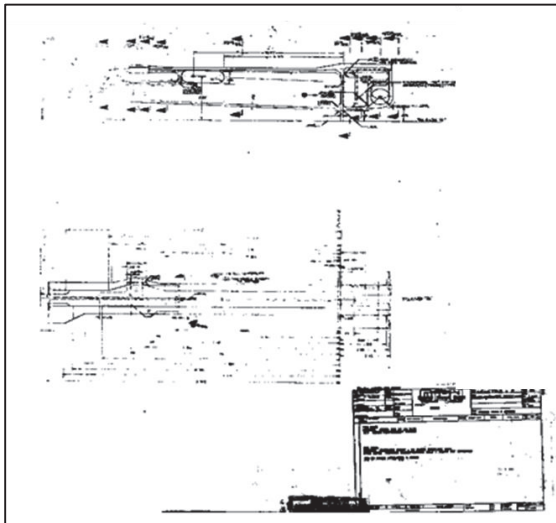
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- **Use data driven analytical approach**
  - Optimize performance and fuel savings
  - Begin with long range cargo fleet
- **FY18 results based on scheduled wash cycles**
  - 474,000 gallons of fuel saved
  - \$2.75 M cost avoidance



**Enhance Active Fleet Management through CBM+ Practices**

- **Convert 2D drawings to 3D**
  - Fill in material or dimensional gaps
  - Update or correct process specifications
  - Add first article inspections & production lot testing requirements
  - Publish drawings to repository



TF34 Pressure Regulator 3-D Printed





# Future Opportunities



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- **A diagnostic/prognostic tool suite will dramatically improve management across propulsion systems**
  - Leading health indicators
  - Health treading for fleets
  - Prognostic alarms for individual engines
  - Automated troubleshooting trees for maintainers
  - Deployment tools for MAJCOMS

**Enterprise-Level Platform Enables Active Fleet Management**

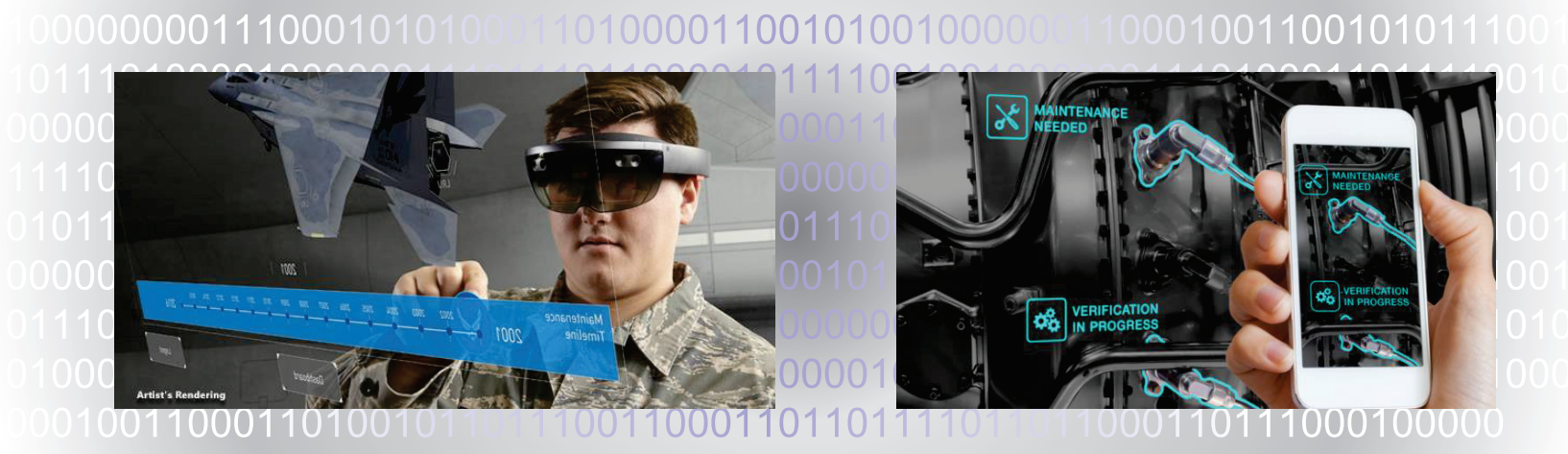


# Summary



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- **Rapid, agile and innovative solutions ensure our Air Force Propulsion is *Ready, Affordable, Safe and Effective***
- **Digital Engineering is key enabler to digitally connect the propulsion lifecycle**



# PROPULSION DIRECTORATE

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# U.S. AIR FORCE