Model-Based Systems Engineering for Future Digital Flight Lines

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LOCKHEED MARTIN

Greetings From Skunk Works®!

S3 Sustainment Success System

High Reliability

Predictive Health
(PHM + Analytics

High-Velocity
Supply System

Condition-Based
Maintenance

Leaders Enabling & Performers Executing | **Standard Work** | **Sustainment Capabilities (Tools)** | **Sustainment Information System**

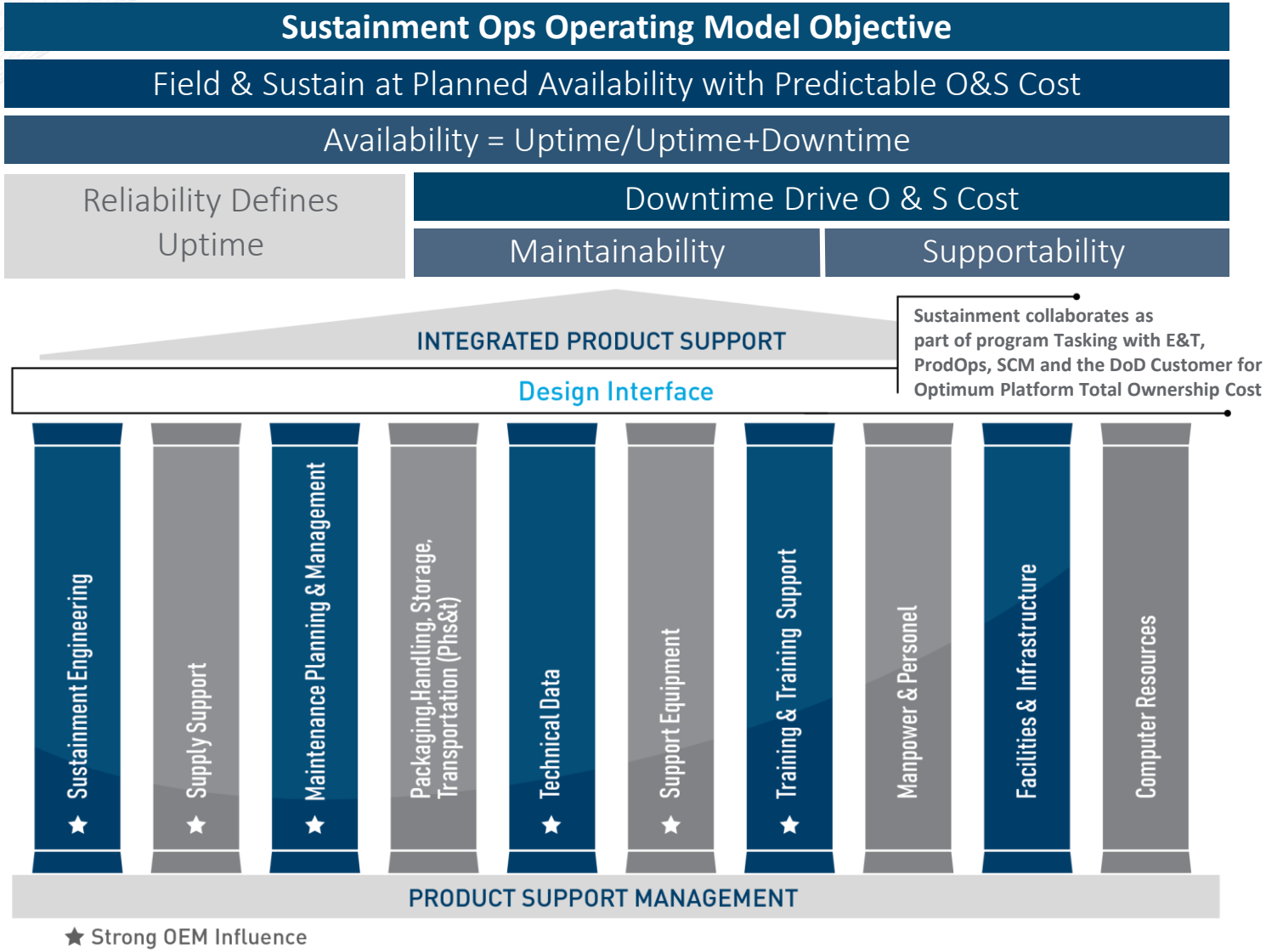
Self-Healing * Self-Diagnosing ENGINEERING FOR SUSTAINMENT Fault Tolerant * Interconnected

THE FLIGHT LINE IS THE CENTER OF GRAVITY

PARTNERSHIPS ENABLING SUCCESS

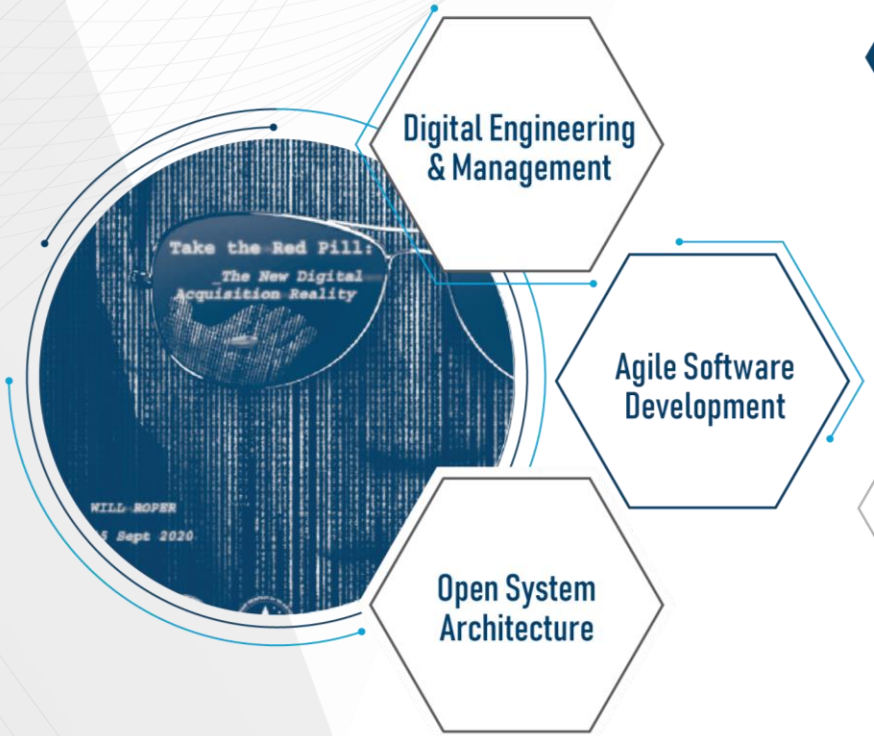
Sustainment Challenges

- Operating and Support Costs (O&S) are the largest component of the DoD budget
- ~80% of the O&S costs are “baked in” by the time a system enters manufacturing
- Our DoD customer must balance between industry and organic solutions
- Current processes lack agility and speed for today’s challenges



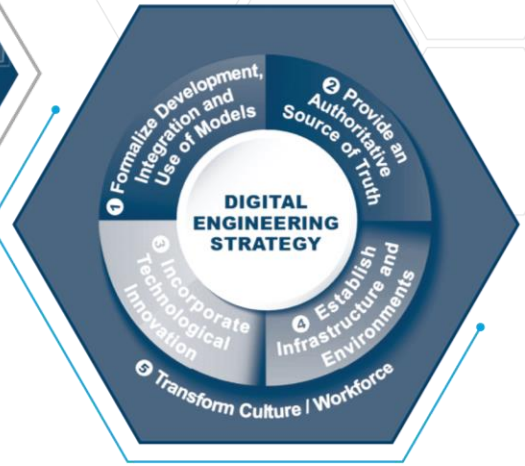
Digital Engineering Drives MBSE Expansion

DoD/USAF/USN have all “declared their intentions” to “go digital”.



Navy & Marine Corps

DoD DE Strategy

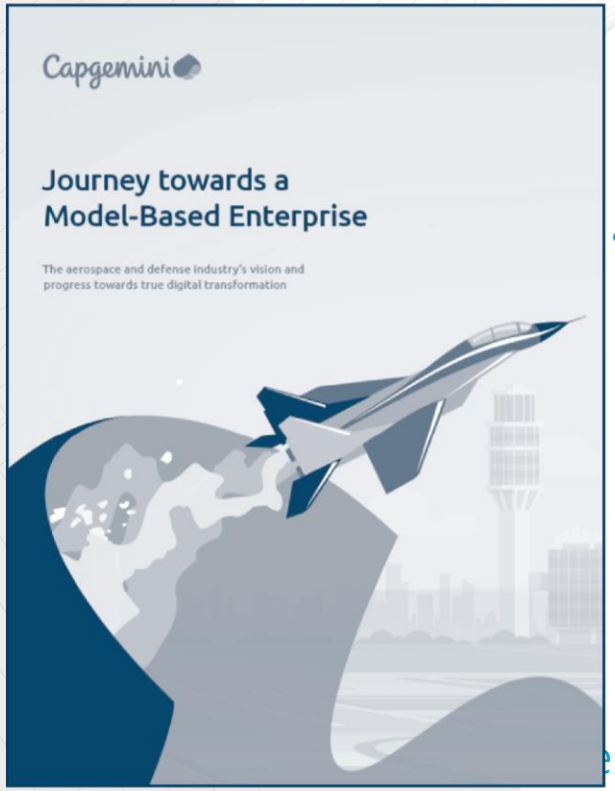


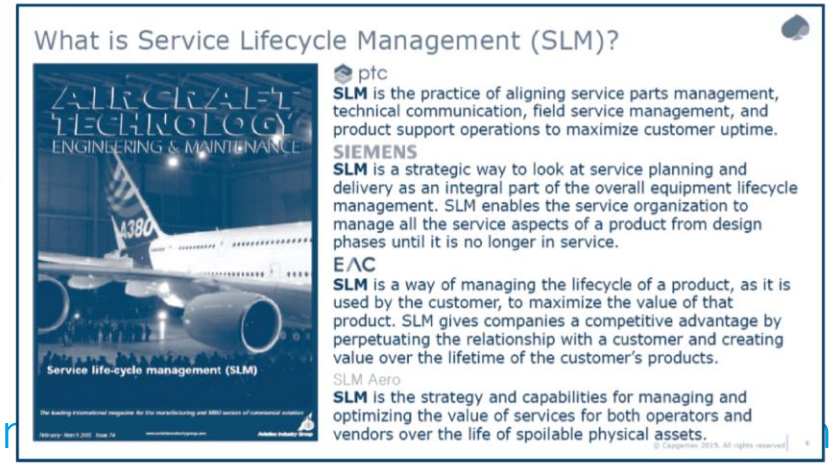
US Air Force

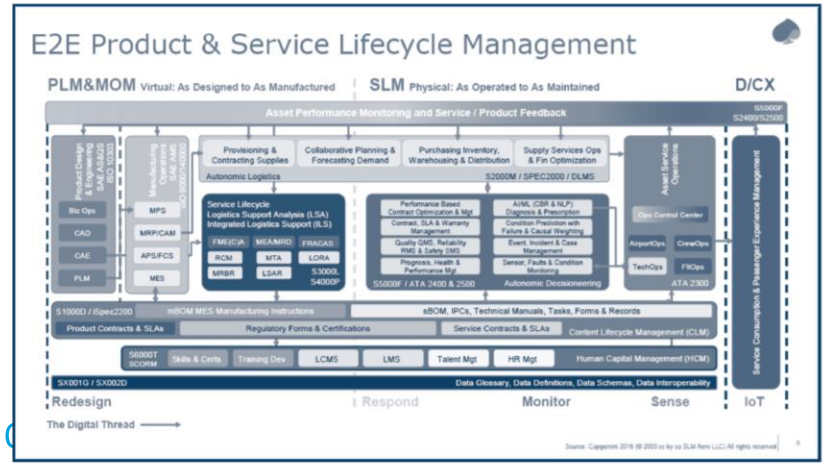
DTO
DIGITAL TRANSFORMATION OFFICE

Sustainment Meets the Model Based Enterprise

Service Lifecycle Management is enabled by tools, standards, and open architecture data exchange



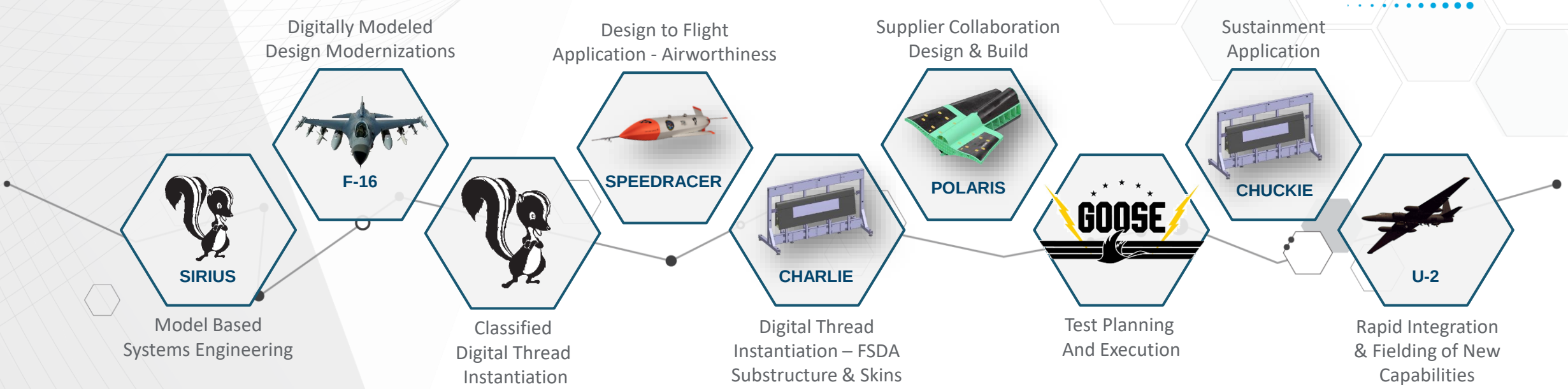




Implementing the Digital Thread

StarDrive Projects Explore New Process Throughout the Program Lifecycle

Process Re-Engineering

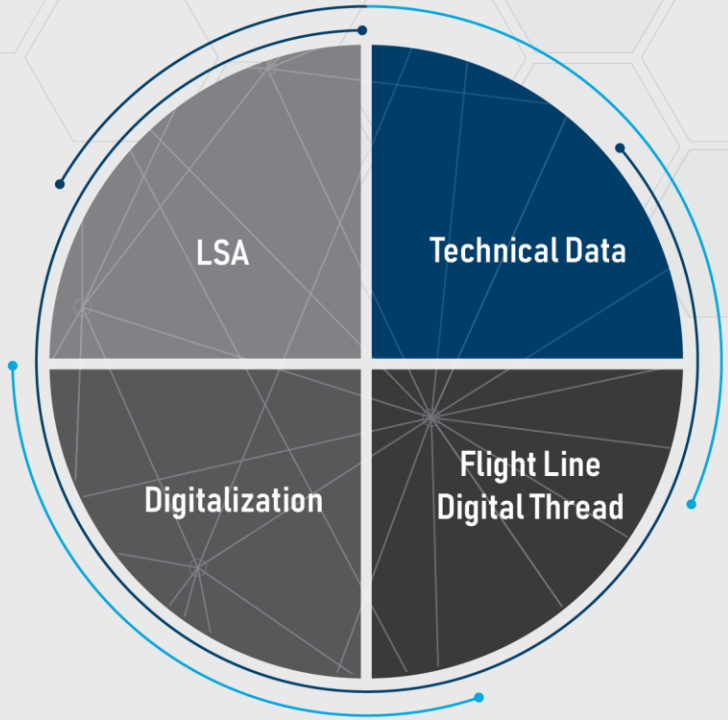


Govt AoA | CoDR | PDR | CDR | SCO | First Flight | LRIP | Full Rate Production | Sustainment

Market Assist | Conceptual Design | Preliminary Design | Detail Design | Demonstrator Fab and Test | EMD | Production & Sustainment

Model Based Sustainment Key Pillars

Logistics Support Analysis (LSA) & Connection to R&M	• Logistics Support Analysis is the structured approach to analyze, optimize, and balance of the sustainment elements to ensure the sustainment solution will deliver the targeted availability at the optimum Operating and Support costs.
Technical Data Presentation	• Leverage Upstream Content in the Digital Thread for Fused Delivery via Multiple Pathways
Visualization	• Influence Design, Train, Maintain, Assess, and Improve our platforms using Visualization, Augmented/Virtual Reality—with connections to Gaming Technology
Digital Flight Line Feedback	• Bi-Directional Feed Back • Digital Twin Genealogy (As-Mx) • Action Request (AR's) / Discrepancy Reports (DR's) • Achievement of Inherent Reliabilities • AI/ML/Analytics Overlay to Assess/Mature Performance



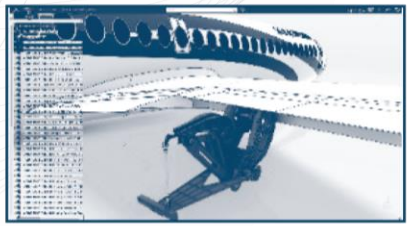
S-Series OAGI Standards
Master Data Management

Chuckie

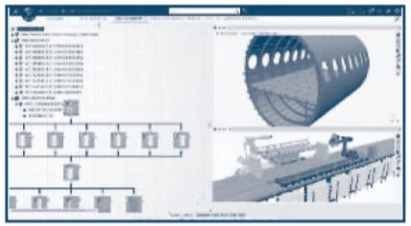
Digital Thread

Model Based Systems Engineering
(Systems Modeling & Simulation)

Model Based Design
(Design in configured Context)



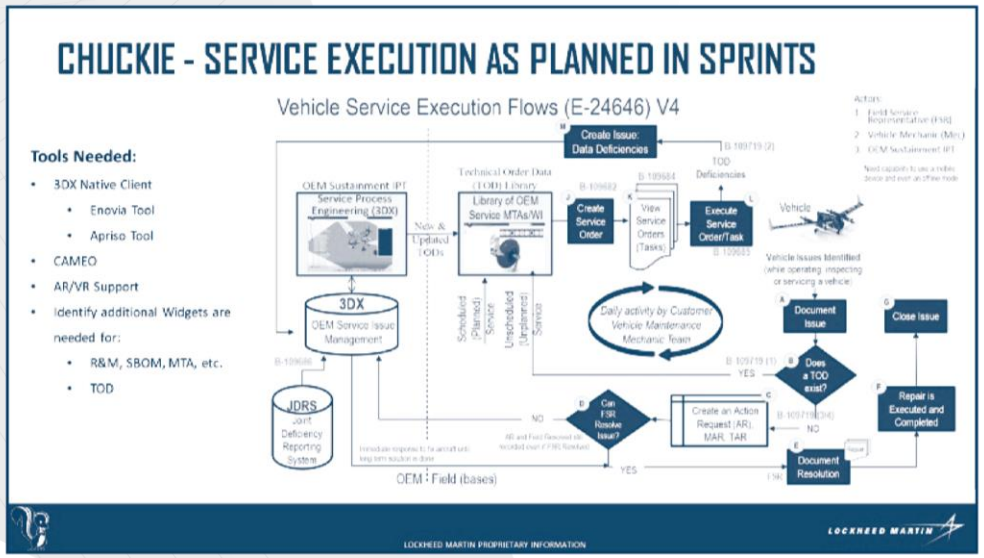
Model Based Manufacturing Engineering
(Process planning & Production Simulation)



Model Based Flight Line Support
(Virtual Commissioning)

Model Based Maintenance & Operations
(Big Data Analytics)

AS SPECIFIED | AS DESIGNED | AS BUILT | AS MAINTAIINED | AS OPERATED



CHUCKIE: As Maintained Digital Twin Use Case Objectives

Define a real-world test article for As Maintained digital thread/digital twin and expand 3DX operating envelope to flight line and back

Current MBSE Lines of Actions

MBSE Strategies and Aspirations

Sustainment Influences

The Majority of the Activity

- MBSE for "The Platform"
- Design for Sustainment
- Design for Affordability

Sustainment Leads

ACTIVE

MBSE for
"The Sustainment Solution"

- Engineering for Sustainment Guides
- Sustainment Capability Delivery System Model™

OPPORTUNITY

MBSE for
"The Flightline"

- Design for Flightline
- Design for Operations

Our Opportunities Are Rich, Our Time is “Now”

MBSE Strategies and Aspirations-Design for Sustainment

MBSE for “The Platform”

Design for Sustainment

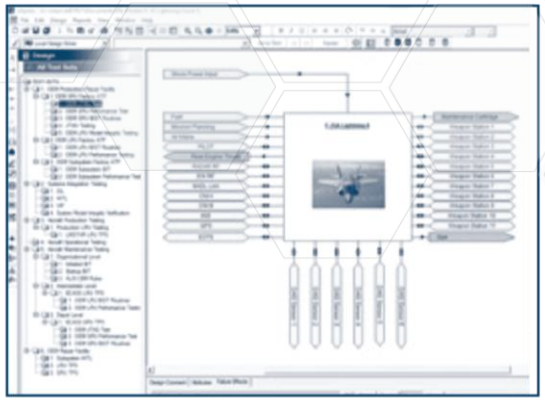
Opportunity Areas for Exploration

- DHM/PHM Reference Architecture
- Tool exploration/implementation/integration:
  - DSI
    - eXpress [CAMEO/ATML aware]
  - Siemens
    - PHM MADe
  - National Instruments
    - Veristand/Teststand

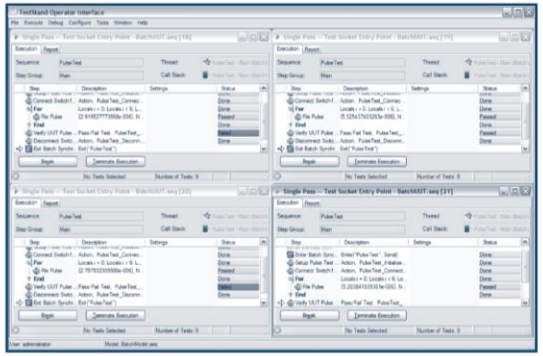
Objectives:

- Connect Design/Test to OEM/SIL/HITL/TPS/Tech Data in Common MBSE Framework
- MBSE to Auto-generation of TPS with Flightline Feedback Loop via Digital Twin

eXpress



TestStand



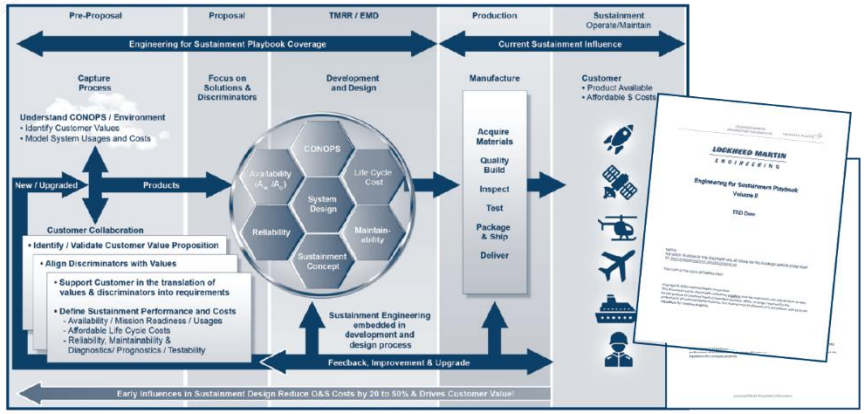
Our Opportunities Are Rich, Our Time is "Now"

MBSE Strategies and Aspirations—Sustainment Solutions

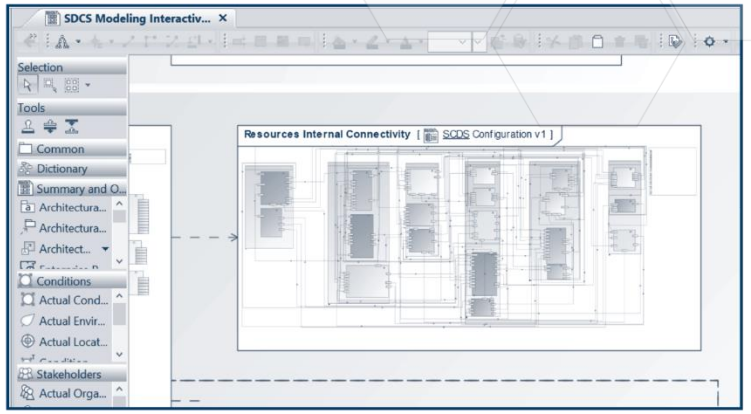
MBSE For "The Sustainment Solution"

- Engineering for Sustainment
- Sustainment Capability Delivery System (SCDS™)

Engineering for Sustainment Playbook



SCDS CAMEO Model



SCDS CAMEO Model linked to Solution Train Enabled by OAGI S-Series Transactions

Teamwork Cloud | CAMEO COLLABORATOR | CAMEO ENTERPRISE ARCHITECTURE | DASSAULT SYSTEMES 3DEXPERIENCE | SIEMENS

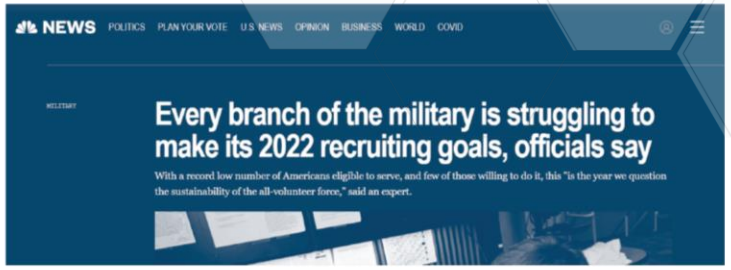
Our Opportunities Are Rich, Our Time is “Now”

MBSE Strategies and Aspirations—The Flightline

The Next Burning Platform: Trained Technicians

MBSE For “The Flightline”

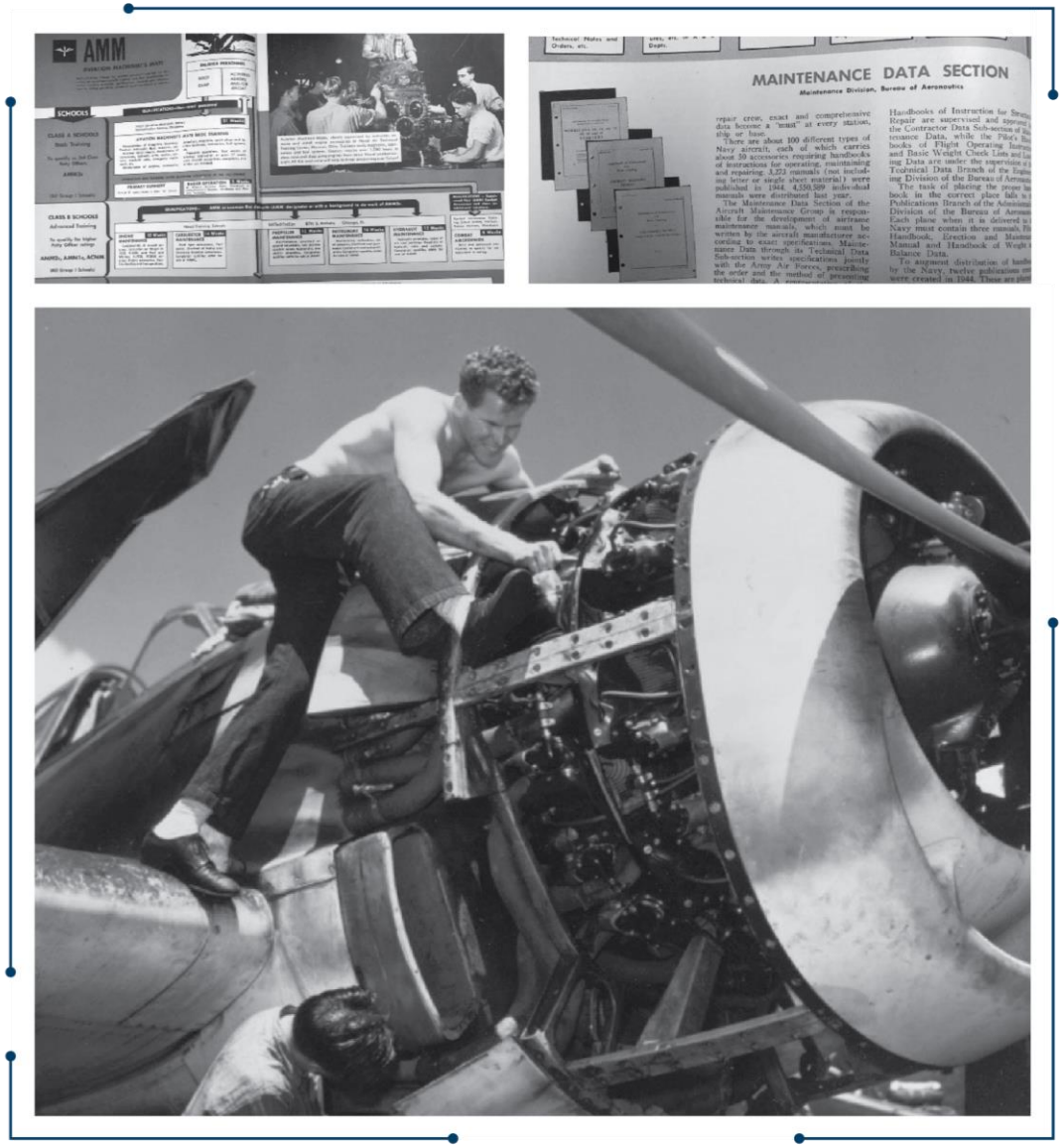
- Design for Flightline
- Design for Operations



Flightline: Then

- **Technicians:**
  - Large Mobilized Labor Pool That Tended to Have Basic Mechanical Awareness
- **Training:**
  - Up to a year of training across “A”, “B”, and “C” schools
- **Tools:**
  - Prolific Availability of Common Tools
  - Forward Deployed Machine Tools
- **Technical Data:**
  - Standard Structural Repair Manuals
  - Broad Range of Technical Data Available
- **Maintenance Plans:**
  - Focused on Hours: 30-60-90-120

Digital Is Years Away

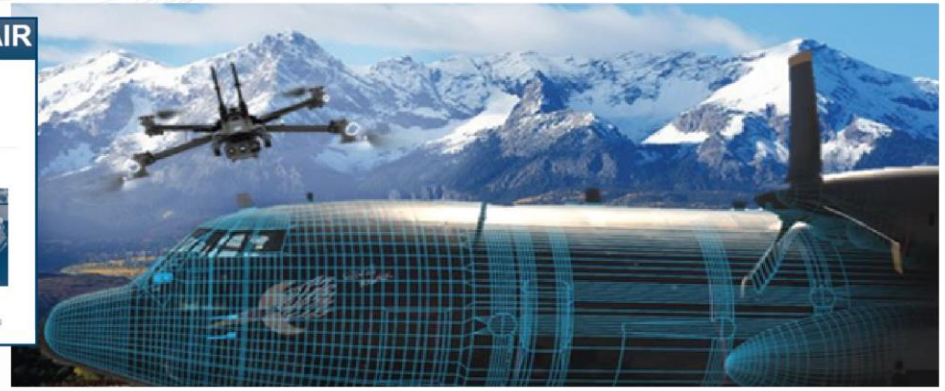


Flightline: Today

- **Technicians**
  - Are Digitally Literate On Mobile
  - Visual Learners
  - Expects Speed In All Processes
  - May Not Have Basic Mechanical Awareness
- **Training:**
  - Focused on Basics
  - Advanced Technical Schools less Prevalent
  - Leadership Focus on Advancement
- **Tools:**
  - Common Tools Standardized
  - Many Repairs Require Special Items
  - Reduced Forward Tooling Footprint
- **Tech Data**
  - Structural Repair Manuals Often Not Procured
  - Data Dispersed Across Multiple IT Systems
- **Maintenance Plans More Complex:**
  - Time/Condition/OML Signature
  - Specialized Dispositions Often Required

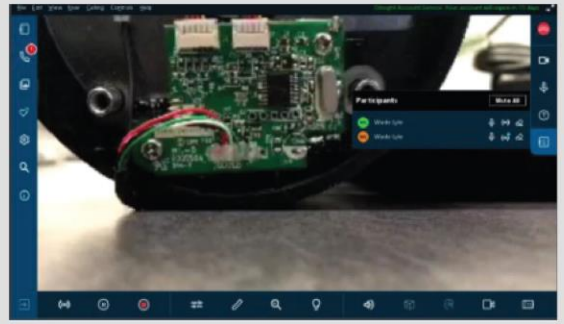
MBSE for the Flightline: Digitally Enabled Technician

Advanced Fleet Management



AAIR

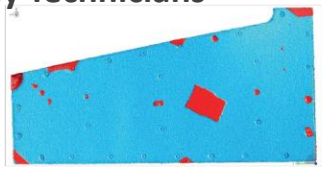
Integrated Remote Assistance



Model Based Technical Data Presentation Fused with Assistive/Additive Layers

AI/ML/NLP

Digitally Enhanced Flightline Mx/Supply Technicians

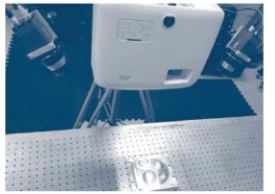


Digital Damage Assessment

IFDIS/IFDP

Digital FSR

iTRAK



NGAS

Bring MBSE to the Flightline Now

- Leverage Relevant Industry 4.0 Trends
  - MBSE + Solution Trains + Servitization + AI/ML/Analytics
- Extend MBSE Architectures to
  - Digital Data Acquisition
  - Test Automation
  - Technical Data Presentation and Information Fusion
    - Authoritative/Additive/Context
    - AR/VR

Call To Action: Establish MBSE Architectures and Frameworks That Include Mx/Supply Personnel as Key Enablers To Enhance Flightline Performance

"Hardware in the loop, Pilot in the loop, Flightline Techs in the loop"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