



Model-Based Systems Engineering for Future Digital Flight Lines

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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

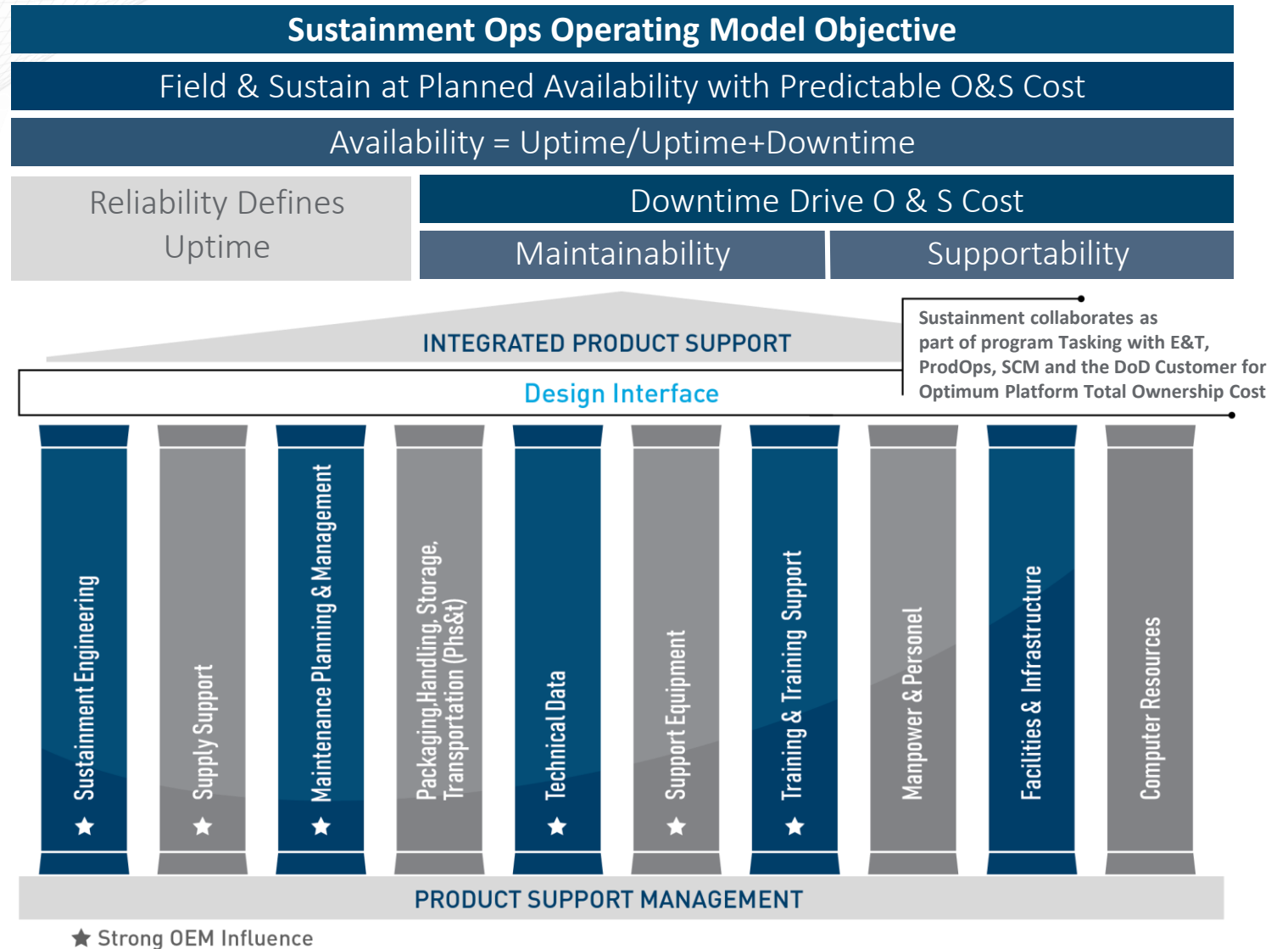
THE FLIGHT LINE IS THE CENTER OF GRAVITY

PARTNERSHIPS ENABLING SUCCESS



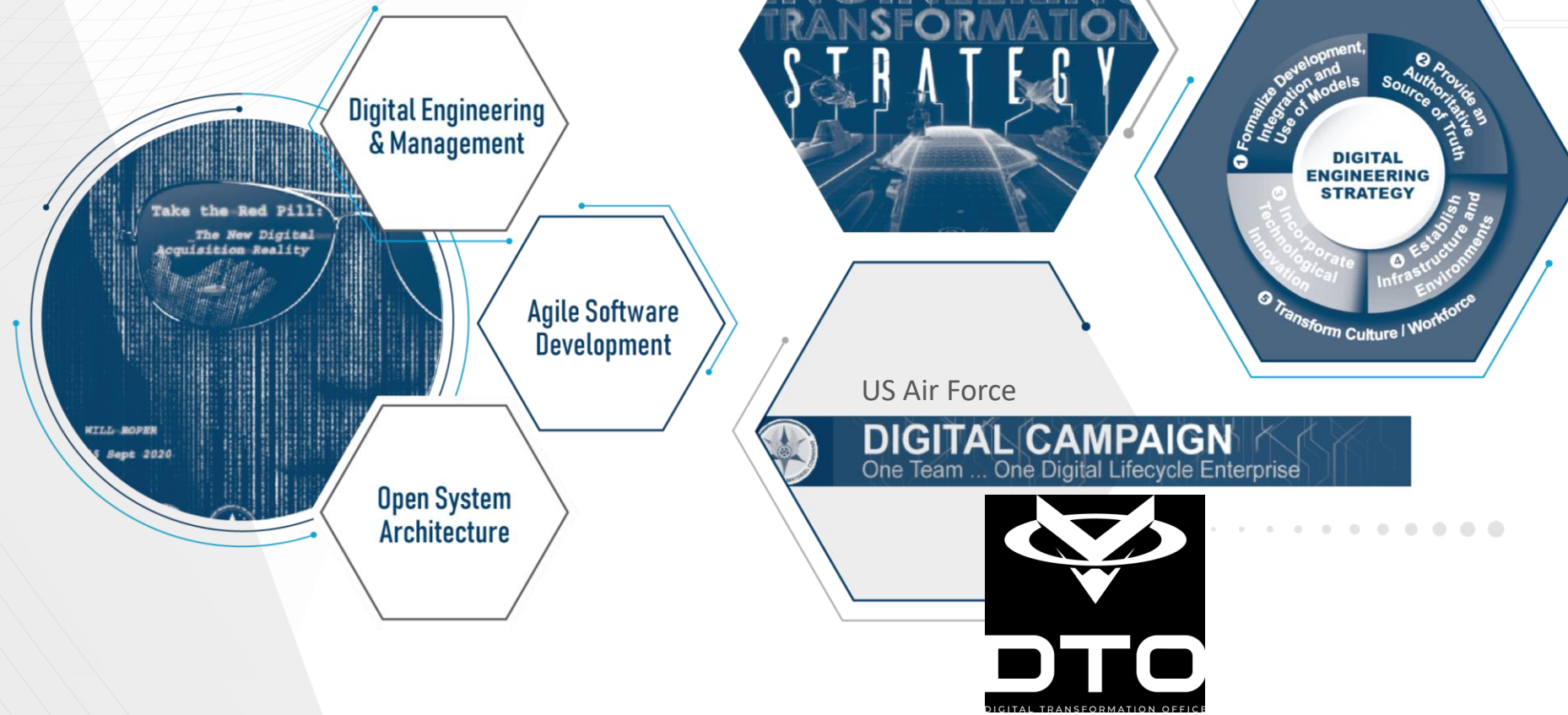
Sustainment Challenges

- 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”.



Sustainment Meets the Model Based Enterprise

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

Capgemini

Journey towards a Model-Based Enterprise

The aerospace and defense industry's vision and progress towards true digital transformation



What is Service Lifecycle Management (SLM)?

ptc
SLM is the practice of aligning service parts management, technical communication, field service management, and product support operations to maximize customer uptime.

SIEMENS
SLM is a strategic way to look at service planning and delivery as an integral part of the overall equipment lifecycle management. SLM enables the service organization to manage all the service aspects of a product from design phases until it is no longer in service.

EAC
SLM is a way of managing the lifecycle of a product, as it is used by the customer, to maximize the value of that product. SLM gives companies a competitive advantage by perpetuating the relationship with a customer and creating value over the lifetime of the customer's products.

SLM Aero
SLM is the strategy and capabilities for managing and optimizing the value of services for both operators and vendors over the life of spoilsable physical assets.

E2E Product & Service Lifecycle Management

PLM&MOM Virtual: As Designed to As Manufactured | **SLM Physical: As Operated to As Maintained** | **D/CX**

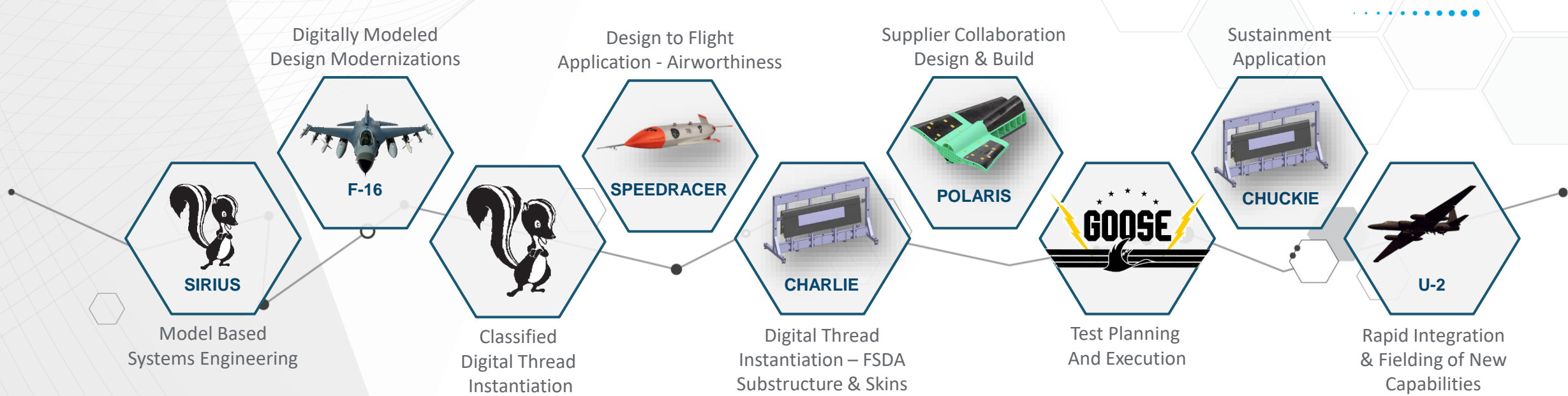
The diagram illustrates a multi-layered architecture for E2E Product & Service Lifecycle Management. It is divided into three main vertical sections: PLM&MOM Virtual (As Designed to As Manufactured), SLM Physical (As Operated to As Maintained), and D/CX (Digital/Cloud/Experience). The top layer is 'Asset Performance Monitoring and Service / Product Feedback'. Below this, the PLM&MOM section includes Product Design & Engineering, R&D, R&C, CAE, PLM, and Manufacturing & Contracting. The SLM Physical section includes Provisioning & Contracting, Collaborative Planning & Forecasting, Purchasing Inventory, Supply Services Ops, and Asset Service Operations. The D/CX section includes Open Control Center, Asset Service Operations, and Service Consumption & Passenger Experience Management. The bottom layer is 'The Digital Thread', which includes Data Glossary, Data Definitions, Data Schemas, and Data Interoperability. The overall process flow is Redesign → Respond → Monitor → Sense → IoT.



Implementing the Digital Thread

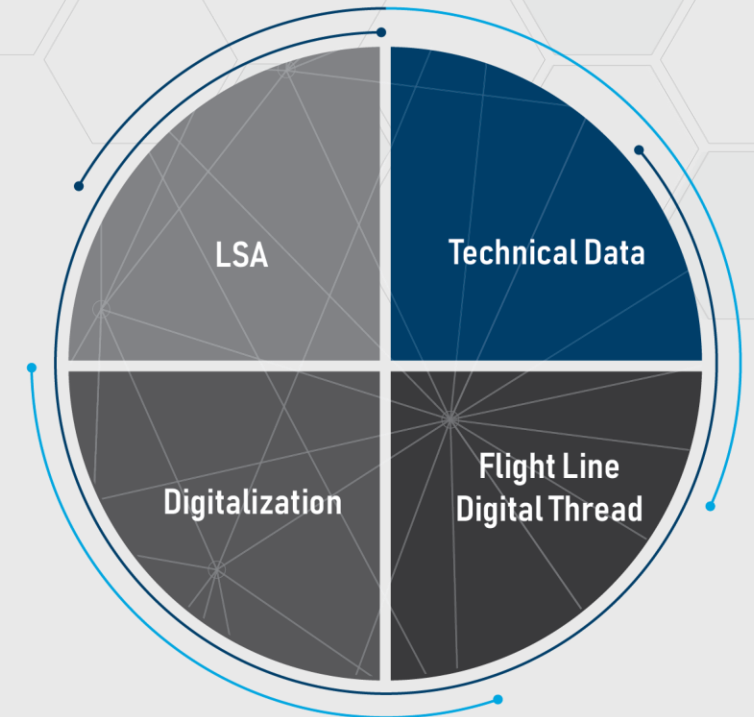
StarDrive Projects Explore New Process Throughout the Program Lifecycle

Process Re-Engineering



Model Based Sustainment Key Pillars

<p>Logistics Support Analysis (LSA) & Connection to R&M</p>	<ul style="list-style-type: none"> 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.
<p>Technical Data Presentation</p>	<ul style="list-style-type: none"> Leverage Upstream Content in the Digital Thread for Fused Delivery via Multiple Pathways
<p>Visualization</p>	<ul style="list-style-type: none"> Influence Design, Train, Maintain, Assess, and Improve our platforms using Visualization, Augmented/Virtual Reality—with connections to Gaming Technology
<p>Digital Flight Line Feedback</p>	<ul style="list-style-type: none"> 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

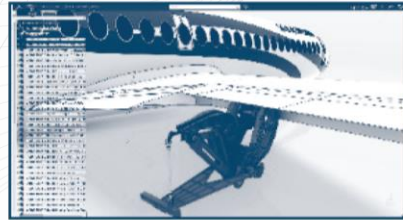
Digital Thread

Model Based Systems Engineering
(Systems Modeling & Simulation)



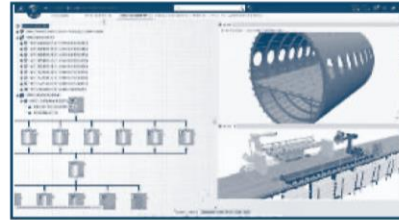
AS SPECIFIED

Model Based Design
(Design in configured Context)



AS DESIGNED

Model Based Manufacturing Engineering
(Process planning & Production Simulation)



AS BUILT

Model Based Flight Line Support
(Virtual Commissioning)



AS MAINTAINED

Model Based Maintenance & Operations
(Big Data Analytics)



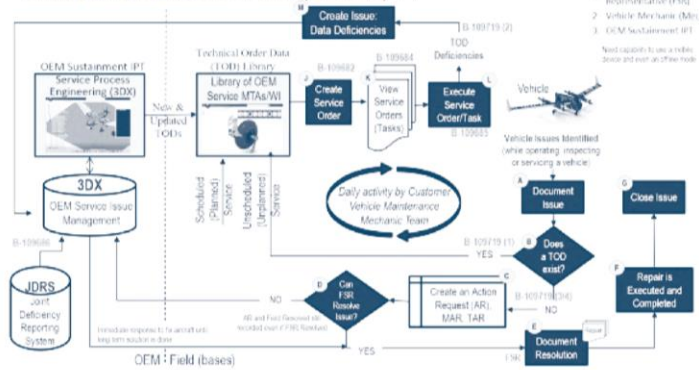
AS OPERATED

CHUCKIE - SERVICE EXECUTION AS PLANNED IN SPRINTS

Tools Needed:

- 3DX Native Client
 - Enovia Tool
 - Apriso Tool
- CAMEO
- AR/VR Support
- Identify additional Widgets are needed for:
 - R&M, SBOM, MTA, etc.
 - TOD

Vehicle Service Execution Flows (E-24646) V4



- Action:
1. Field Service Representation (FSR)
 2. Vehicle Mechanic (Mtr)
 3. OEM Sustainment IPT
- Need capability to view a vehicle issue and view on other mode

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

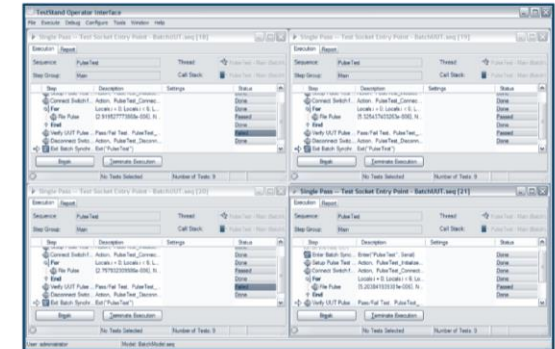
Objectives:

- 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



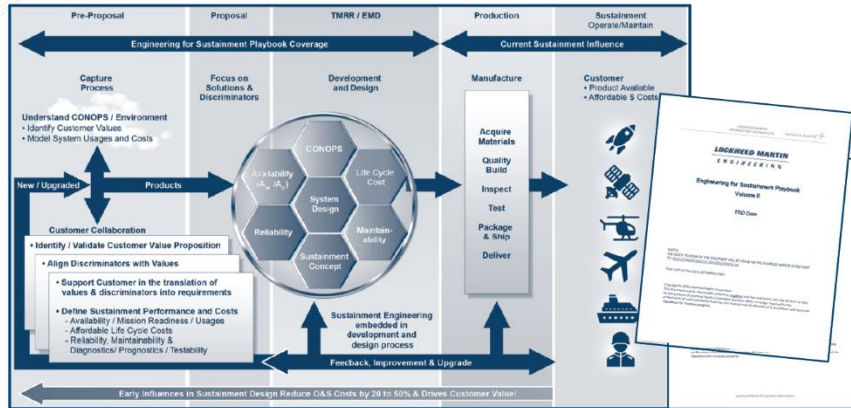
Our Opportunities Are Rich, Our Time is “Now”

MBSE Strategies and Aspirations—Sustainment Solutions

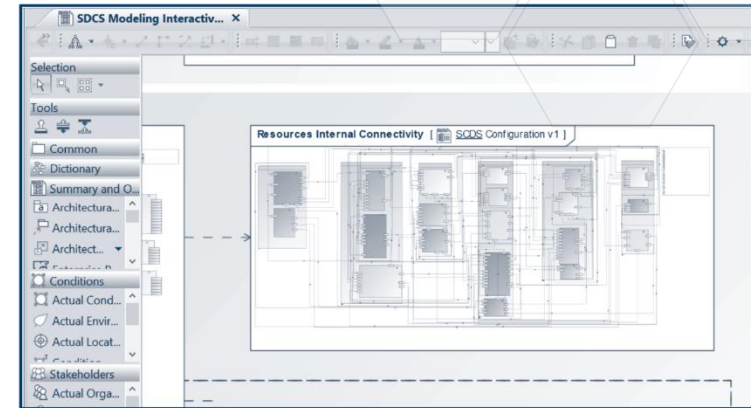
MBSE For “The Sustainment Solution”

- 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



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

AVIATION WEEK
Intelligence
NETWORK

MARKETS DATA TOOLS KNOWLEDGE CENTER USEFUL LINKS

MROs Tap Technologies To Boost Workforce Productivity

Lindsay Bjerregaard August 08, 2022

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MILITARY

Every branch of the military is struggling to make its 2022 recruiting goals, officials say

With a record low number of Americans eligible to serve, and few of those willing to do it, this “is the year we question the sustainability of the all-volunteer force,” said an expert.

BOEING

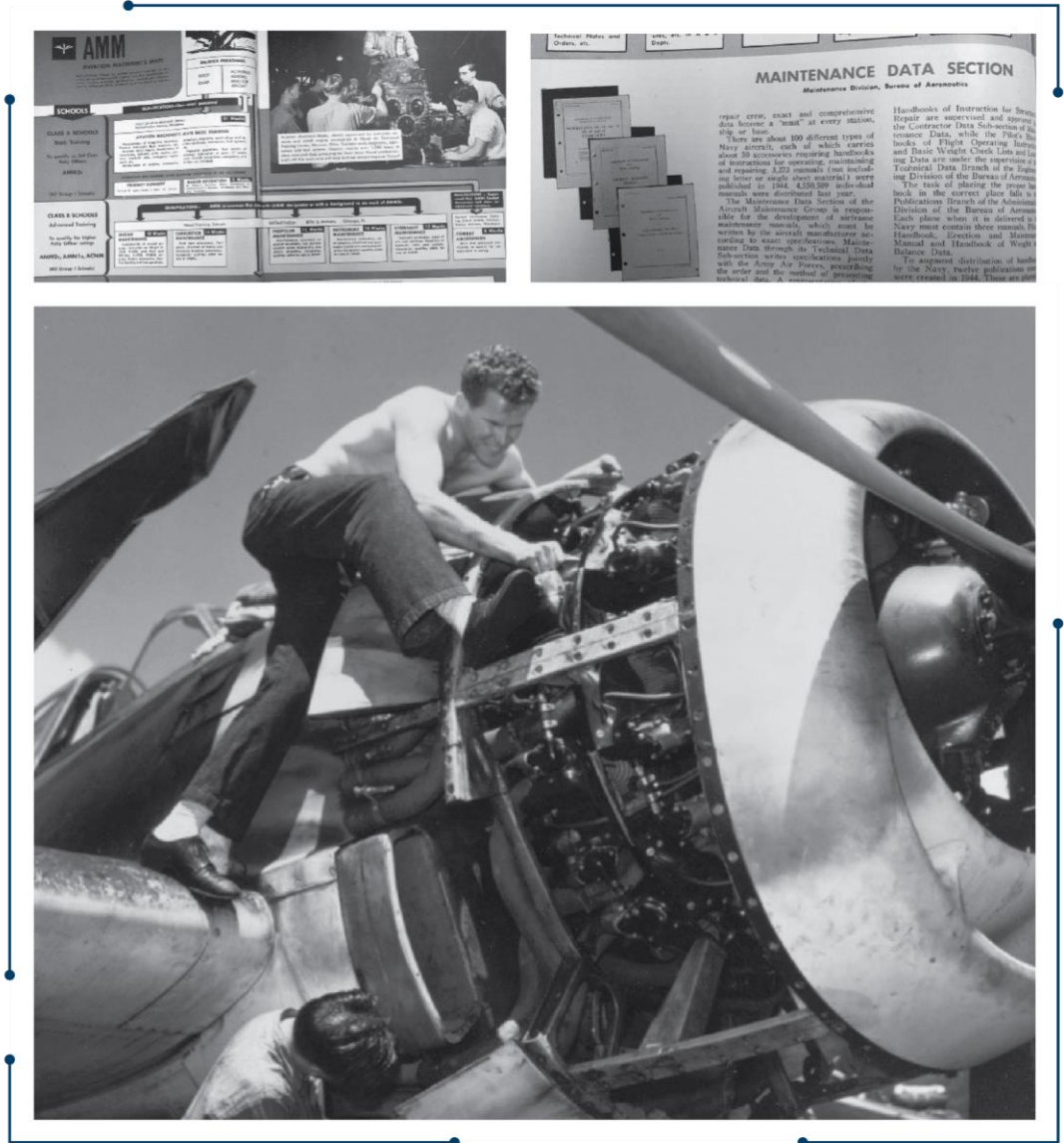
Pilot and Technician Outlook
2022-2041



Flightline: Then

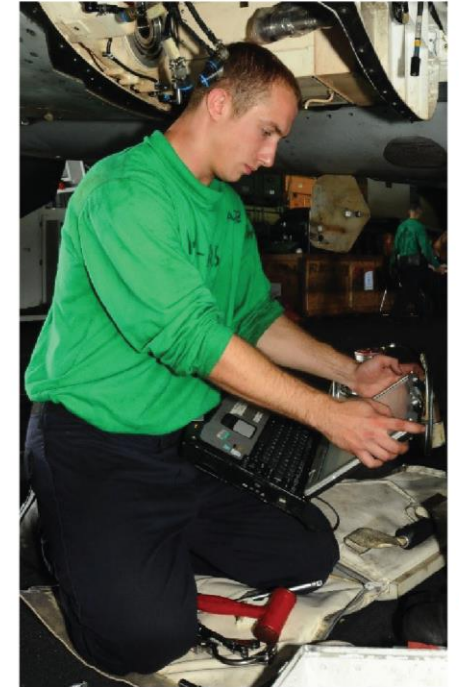
- **Technicians:**
 - Large Mobilized Labor Pool That Tended to Have Basic Mechanical Awareness
- **Training:**
 - Up to a year of training across “A”, “B”, and “C” schools
- **Tools:**
 - Prolific Availability of Common Tools
 - Forward Deployed Machine Tools
- **Technical Data:**
 - Standard Structural 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



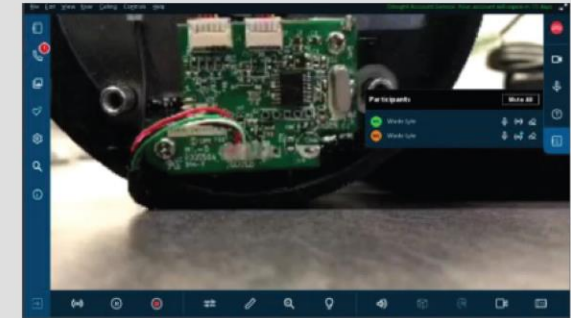
MBSE for the Flightline: Digitally Enabled Technician

Advanced Fleet Management



AAIR

Integrated Remote Assistance

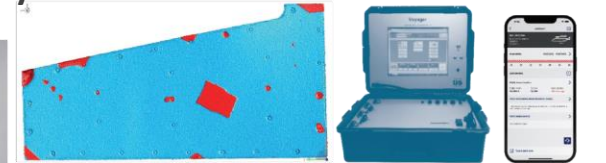


Model Based Technical Data Presentation Fused with Assistive/Additive Layers



AI/ML/NLP

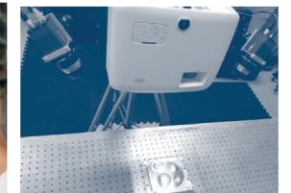
Digitally Enhanced Flightline Mx/Supply Technicians



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](#)”



LOCKHEED MARTIN

