Colonel Paul K. Harmer is the Deputy Director of Engineering and Technical Management, Headquarters Air Force Materiel Command, Wright-Patterson Air Force Base, Ohio. In this capacity he assists in leading the force development, training, processes, procedures, and tool deployment for 14,000 military and civilian scientists, technicians, and engineers who ensure the technical rigor of weapons system programs totaling $60 billion. Additionally, Col. Harmer drives digital enterprise and weapons system cyber initiatives across the Command.

Col Harmer has served the Air Force and Joint warfighting community in a broad array of air, space, and cyberspace assignments. He holds a BS and PhD in Electrical Engineering and an MS in Computer Engineering. Additionally, he is a graduate of the U.S. Air Force Test Pilot School. Col Harmer has flown over 35 aircraft types including F-15D/E, F-16B/D, T-38A/C, B-17G, B-52H, and KC-135R.
Dr. Paul L. Hartman is Executive Vice President, RGBSI Federal. In this capacity, Dr. Hartman is responsible for all RGBSI executive-level client engagement across the United States Federal Government. Dr. Hartman has more than 30 years of professional experience supporting the United States Federal Government, most recently as Director, Center for Operational Analysis where he led a team of more than 100 multi-disciplinary Ph.D.’s and analyst focused on providing quantitatively defensible solutions to some of the United States Federal Government’s most complex issues. Dr. Hartman’s education includes B.S. from the University of Maryland, M.A. from the University of Dayton, both M.S. and Ph.D. from the Air Force Institute of Technology Graduate School of Engineering and Management, and a Certificate in Executive Leadership Development from the University of Notre Dame. Dr. Hartman’s honorarium includes five United States Department of Defense Meritorious Service Medals and the Department of the Air Force Meritorious Civilian Service Award.
Welcome to the Revolution

1st Industrial Revolution
2nd Industrial Revolution
3rd Industrial Revolution
4th Industrial Revolution

“Artificial intelligence is the future... It comes with colossal opportunities, but also threats that are difficult to predict. Whoever becomes the leader in this sphere will become the ruler of the world.”

-Russian President Vladimir Putin

Industry 4.0

- Cyber-physical systems
- Internet of things
- Cloud computing
- Artificial Intelligence

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OSD’s Digital Engineering Strategy

1. Formalize the **development, integration and use of models** to inform enterprise and program decision making

2. Provide an enduring **authoritative source of truth**

3. Incorporate **technological innovation** to link digital models of the actual system with the physical system in the real world

4. Establish supporting **infrastructure and environments** to perform activities, collaborate, and communicate across stakeholders

5. Transform a **culture and workforce** that adopts and supports Digital Engineering across the lifecycle

https://www.acq.osd.mil/se/initiatives/init_de.html
Digital Engineering Strategy: Five Goals

OSD DE video: https://www.acq.osd.mil/se/initiatives/init_de.html
Paper or Digital Artifacts: Reports & Technical Data

Model-centric Artifacts: Spreadsheets, CAD, CFD, FEM, etc. & Associated Input & Results Files/Reports

Digital Surrogate Artifacts: Interoperable, validated surrogate models of system and subsystems at multiple levels of abstraction

Authoritative Data Source

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Multi-Discipline Analysis & Optimization

Multi-Physics

Multi-Domain Analysis

Source: Ed Kraft, UT Space Institute
Digital Enterprise Ecosphere

- Digital Enterprise
  - Digital Engineering
    - MBSE
    - Digital Thread
    - MDAO
    - MBE
    - Digital Twin
    - Big Data / Data Analytics
    - MS&A
Some On-Going Efforts

- OSD – Digital Engineering Strategic Guidance
- EEEC – MITRE Sprint I, II and III, AFSERC, CREATE Demo
- AFRL – Agile Pod, LCAAT, MRB Process, Tech Data Needs, DTh/DTw
- AFLCMC – DEATHSTARs, AM, CD Sprints, PLM-CI, CBM+
- AFSC – Reverse Engineering and Critical Tooling (REACT)
- AFNWC – Ground-Based Strategic Deterrent (GBSD)
- AFTC – Application of Digital Thread to Flight Test

The future is here. It is just not evenly distributed
- William Gibson
Enterprise DE State of the Union

Informed Flightplan for AF Digital Enterprise

Coalition of the Willing

You Are Here

DEE Project Cloud
Discovery, Facilitation

Proj 1, Proj 2, AFRL, OSD
Proj 3, Proj …, XZE, Navy, Army
CREATE Demo

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Digital Enterprise Flightplan

<table>
<thead>
<tr>
<th>FY18</th>
<th>FY19</th>
<th>FY20</th>
<th>FY21</th>
<th>FY22+</th>
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</thead>
<tbody>
<tr>
<td>Manage the Data</td>
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<tr>
<td>Manage the Process</td>
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<td>Provide &amp; Manage Resources</td>
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<td>Provide Standards, Architecture, &amp; Framework</td>
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<td>Address Culture</td>
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<tr>
<td>Desired End State</td>
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- Data is accessible, understood, actively shared across the enterprise, and is sufficiently trustworthy to drive informed decisions
- A data driven process for all acquisition and sustainment decisions enabled by the right data at the right time to all functionals
- Centralized PMO & funding
- Robust flexible, secure, interconnected infrastructure
- Network-accredited tool box
- Staffed with right person doing right job with right skills
- Consistent framework for developing, defining, & evaluating 1-n list digitally
- Architectures allow use of tools across classification
- “We all just do it”
- Common understanding of DE capabilities/risk/terminology
- “On Demand” reviews

**This just in:**
- SAF/AQ Rapid Prototyping Memo, 13 Jun 18
  - Calls for use of Digital Enterprise, Agile SW, etc.
  - Go Faster *with* rigor
- SAF/AQ DoDI 5000.02 and Rapid Acquisition Memo, 10 Aug 18
  - “We get what we reward…”
  - “…reward things like speed and digitization”

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A-10 Multi-Physics Demo

- CFD for external aero loading
- Inertial loads from slat actuation
- Combine loading scenarios for fatigue analysis
- Shape & topology optimization
- Mass from 2.5 to 2.2 lbs.
- Life from 1100 to 9300 cycles, 8x increase
Technical Data Package Demo

Bird Strike Area

Damage to Leading Edge

CAD Model of Repair

Final Installed Repair

CNC Milling of Repair Part

Test fit of 3D Printed Repair Part
Augmented Reality for Aircraft Maintenance

Inside the HoloLens

1. Camera
2. Computer
3. Lenses
4. Vent
5. Sensor
6. Buttons

Augmented reality leveraging a Digital Thread ecosystem to improve maintenance execution & data collection

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Challenges

- Major Primes are implementing model-based processes
- “Dumbing down” deliverables per contracts

Stop Double Work (Creating Models AND Digital Artifacts)
Get Engineers back to doing Engineering
“We live in a time of global access to technology and scientific talent. This easy access is part of the reason we can no longer claim clear U.S. technological superiority within the world. In a world with near equal access to technology, speed is becoming a discriminator. **Not just speed of discovery, but speed of delivery. How fast we can develop, adopt, or leverage technology to meet the warfighter’s needs** and get it into their hands, will determine our ability to outpace our adversaries.”

MS. MARY J. MILLER, PRINCIPAL DEPUTY, ASSISTANT SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING

**Armed Services Subcommittee on Emerging Threats and Capabilities (14 March 2018)**
Digital Engineering Environment
Understanding the DE Landscape
The AFIT of Today is the Air Force of Tomorrow.

1. Develop and maintain a culture and workforce that adopts, supports and applies Digital Engineering across the lifecycle.
2. Formalize development and use of models for providing an enduring authoritative source of truth.
3. Foster the integration of models and data sources across functional disciplines to inform enterprise and program decision making.
4. Establish supporting infrastructure & environments to perform engineering activities, collaborate, & communicate across stakeholders.
5. Leverage advanced tools, computing power, and advanced capabilities to improve system capabilities, automate workflow processes (as applicable) and generate digital artifacts and deliverables using models.

NDIA Systems Engineering Division
M&S Committee
10 February 2011

Final Report of the Model Based Engineering (MBE) Subcommittee

Digital Engineering in Complex Systems: From Leadership Understanding Through Application
Ms. Kristen Baldwin
Acting Deputy Assistant Secretary of Defense for Systems Engineering
INCOSE
January 26, 2016

The COA DE Future-state Prototype Is NOT Another ‘Study’ or ‘Research Report’
The Prototype Answers The ‘How?’ Questions In The White Space Of Previous Documents

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https://www.acq.osd.mil/se/initiatives/init_de.html
**Architecting the DEE Future-state**

**The AFIT of Today is the Air Force of Tomorrow.**

### Prototype Desired Outcomes
1. Identify DOTMLPF-P Implications
2. Inform Scalable Strategy Decisions
3. Develop 1-12 + Production, Deployment, and Sustainment Architecture Integration Plan

### Data Integration
- Structured / Unstructured / Meta; Dissimilar File Structures; Open Source Models;
- Real-time Collaboration; Discoverable – Publishable; Authoritative

### Tool Integration
- AUTOCAD
- CATIA
- creo
- NX
- SolidWorks

### Platform Integration
- ANSYS
- DASSAULT SYSTEMES
- ptc
- SIEMENS

### Engineering Workflow Management

### Architecture Integration
- Amazon web services
- Microsoft Azure

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More Challenges

• Cyber Security
  – Need to protect our information

• Data
  – Size – Estimated petabytes at rest for large body aircraft
  – LOTAR – LOng Term Archive and Retrieval

• Personnel
  – Culture
  – Training

• Industry Partnerships
  – Data rights
  – Contracting language
  – Standards
Why we do this
Give ‘em the best! Bring ‘em home safe!