SERC RESEARCH REVIEW 2023 | NOVEMBER 15, 2023

Systems Engineering Modernization Acquisition with Digital Engineering

WRT-1058 and WRT-1057.18g

Nadine Geier, Kelly Alexander OUSD/RE

David Cadman OUSD/AS

Tom McDermott, Philomena Zimmerman, Molly Nadolski (Stevens)

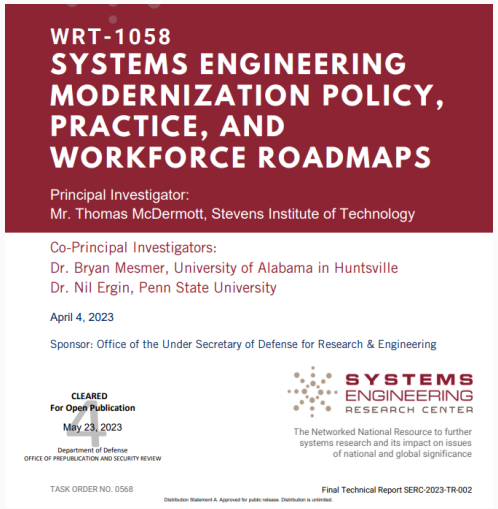
Geoff Kerr, Kelli Esser, Kaitlin Henderson (Va Tech)

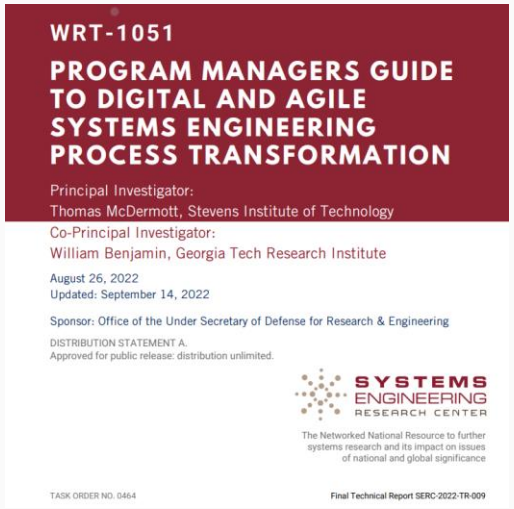
Bryan Mesmer, Kristin Weger, Amy Guerin, Paul Lewis(UAH)

Nil Ergin, Adrien Barb(Penn State)

William Benjamin, Richard Wallace (GTRI)

Publications

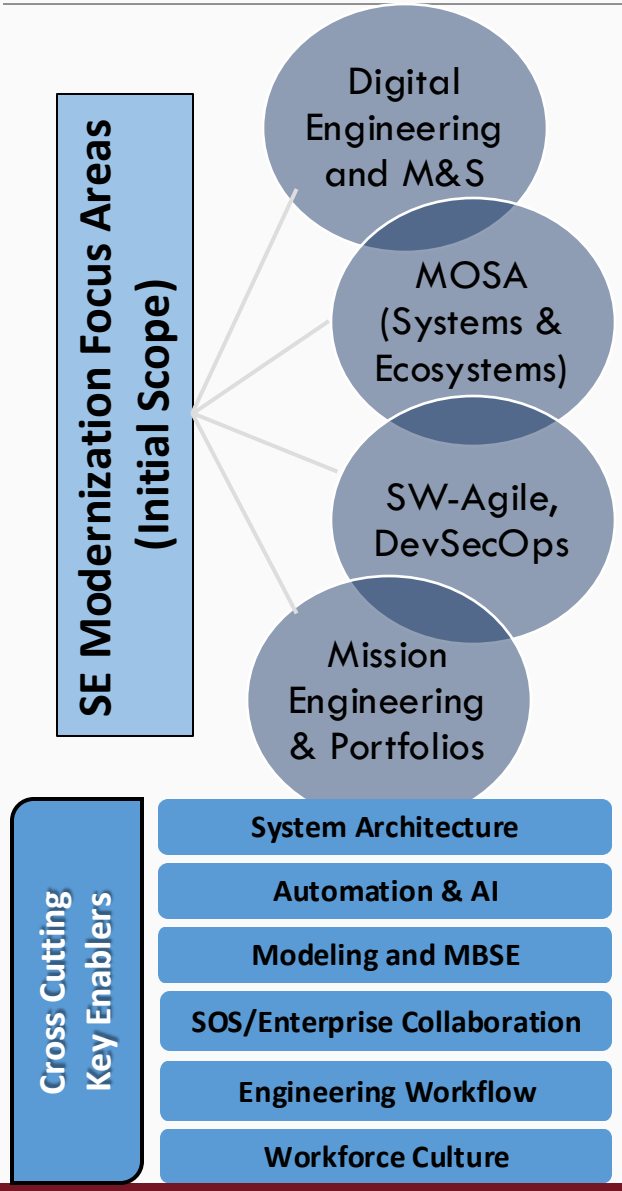




- https://sercuarc.org/serc-programs-projects/project/123
- https://acqirc.org/publications/research/acquisition-with-digital-engineering/
- https://www.cto.mil/wp-content/uploads/2023/06/SERC-WRT-1058-2023.pdf
- https://www.cto.mil/wp-content/uploads/2023/06/SERC-WRT-1058-Excerpt-PainPoints-2023.pdf

- https://incose.onlinelibrary.wiley.com/doi/10.1002/inst.12439
- https://incose.onlinelibrary.wiley.com/doi/full/10.1002/sys.21717

SE Modernization: Broad Synergy Across SERC/AIRC Efforts



- Model Centric Engineering – surrogate pilot project to evaluate details of DE, Navy NAVSEM process model
- DE Metrics – framework for quantifying DE/MBSE benefits, SE community working group
- Digital Data Management & Analytic Strategy – pilot data strategies combining mission engineering, digital engineering, acquisition baseline data, etc.
- Army Common Architecture Strategy support – government reference model/MOSA strategies
- Space Force Agile Transformation – direct experience supporting government agile transformation, metrics
- Agile Program & Project Management – agile processes as applied to systems and hardware intensive programs
- Developing Capability Requirements – improving the timeliness and agility of capability requirements across acquisition pathways
- Digital Transformation in Test and Evaluation for AI/ML, Autonomous, and Continuously Evolving Systems
- Systems Engineering Modernization and Acquisition-Enabled DE
- Workforce – embedding MBSE/M&S competencies, simulations into DAU courseware, DE Bootcamp

Frameworks to Guide Decisions for Program Managers and PEOs

Legend:
SERC/AIRC

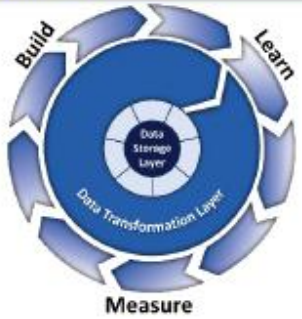
What?

We envisioned a new **mental model** for systems engineering in a fully digital, iterative world that:

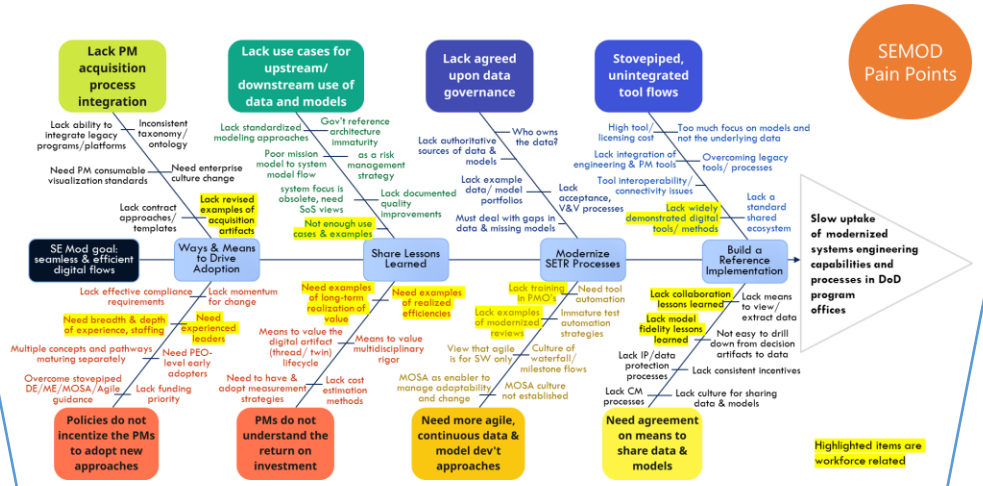
System Engineering Data & Models

1. Converges 3 life cycles

2. Iterates a different order of **Build-Learn-Measure** for each acquisition pathway that relies on shared data



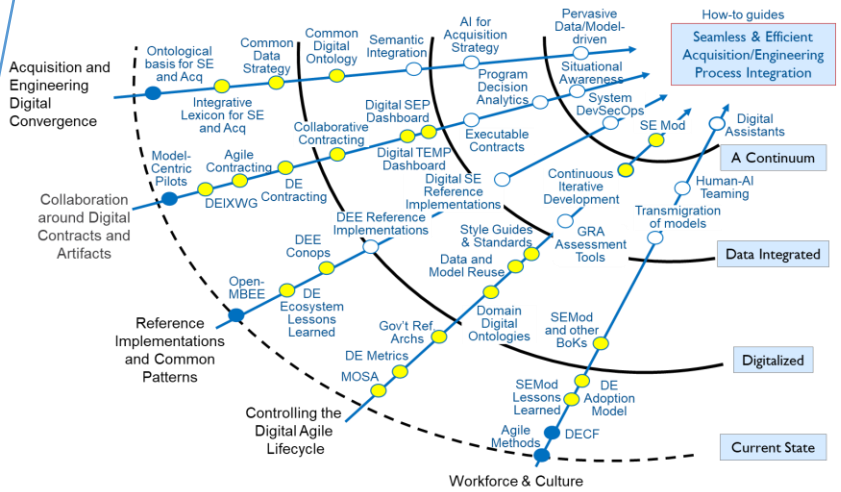
Why?



We captured a set of **interrelated issues/ pain points/ challenges** to implementation of this mental model

How?

We drafted a **roadmap of developmental needs** and recommendations to improve the uptake of modernized systems engineering



So…How Do We Enable **Improved** Acquisition with DE?

Requires **Ontologies** to build common understanding

Systems Thinking

New Mental Models

Agile Mindset → Model-Based → Data Centric → Collaborative

Iterative Approach with **data and models across the lifecycle**

Exemplar Reference implementations will provide templates to help programs get started

The Supra-System
Revised Acquisition Mental-model

- a continuous iterative process
- seamless & efficient transfer of data and models

Here's How…

"Knowledge needs to be liberated from the artifacts"
Dr. Steve Jenkins
JPL/NASA (Retired)

Comprehensive MBSE/DE Pain Points identified, SE Modernization Roadmap

What Does an Agile Mindset Mean to SE and DE Modernization?

Results from the SERC/AIRC and SEI Workshop: Agile for HW-Intensive Systems:

1. Intentionality in Design:

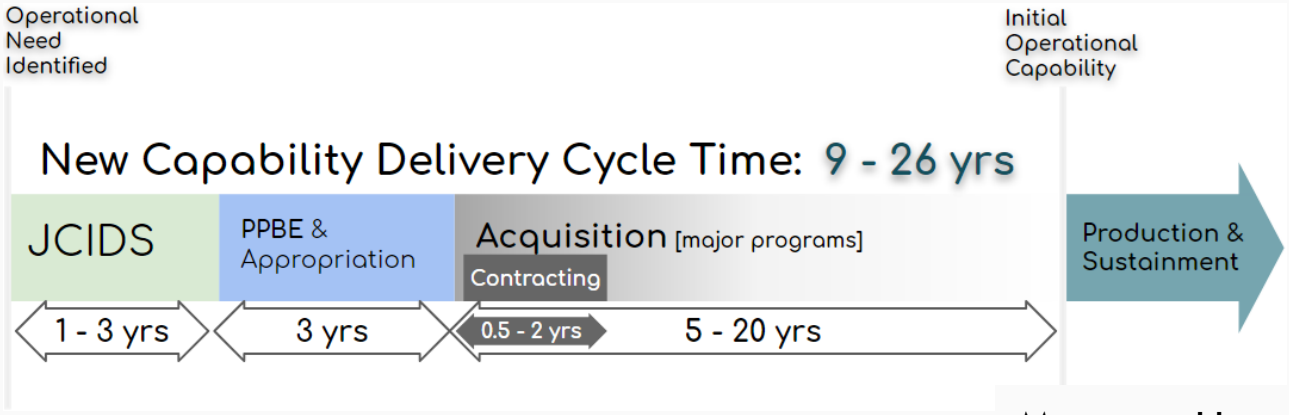
- Thoughtful Decomposition and Partitioning
- MOSA Precedes Partitioning
- Control I/F's and API's

2. Shift Learning Left

- Front-End Investment in Test
- Front-End Investment in Infrastructure

3. Avoid "Single-Batch" Mindset

- Eliminate Stovepiped Acquisition Stages
- Milestone Completion is Buying Down Risk, not Measuring Progress

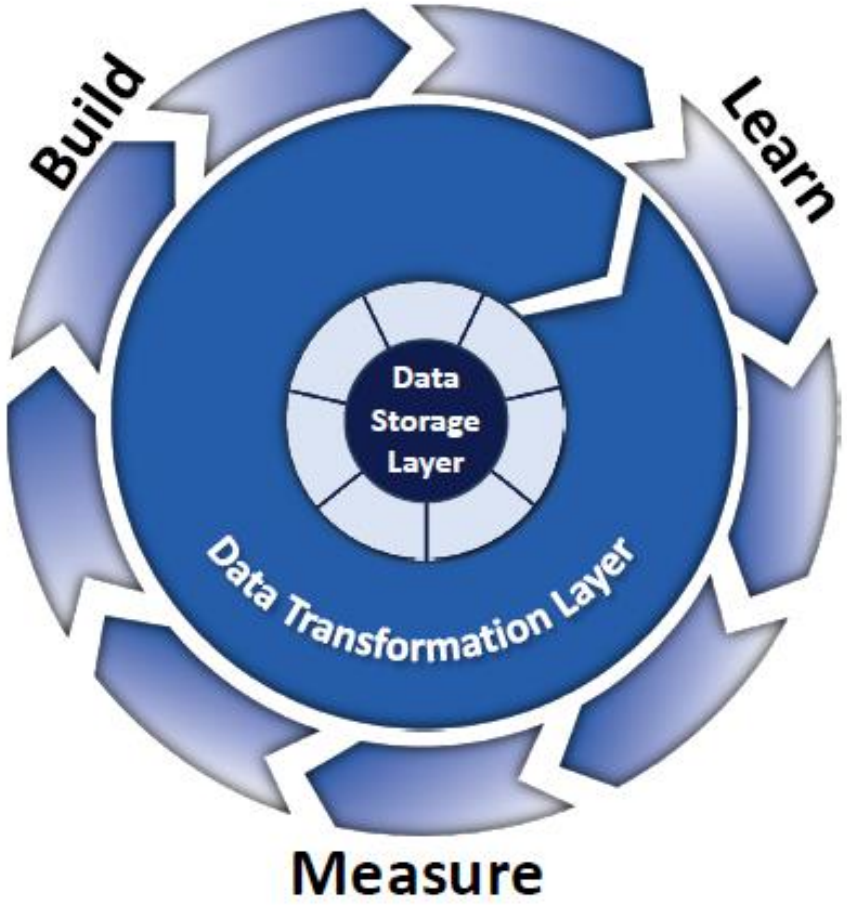


4. Deliver Working Software Frequently

- Refactor Work Steams
- Deploy Dedicated IT/Analytics Teams
- Measure User Satisfaction Like R&M
- Embed Analytics In the Product

Improve Flow from Warfighter Need To Capability

SE Modernization Mental Model



- Cyclic nature of modern SE
- Still milestone-based
- SE core principles in every Acquisition pathway
- Flexible system life cycle entry points:
  Learn-Build-Measure (MCA)
  Build-Measure-Learn (Mid-Tier, SW, UON)
  Measure-Learn-Build (Sustainment)
- Continuous Iterative Development processes (around the circle)
- Continuous Data Management and Transformation processes (at the core)

Use Cases & Workforce development: How- to guides & training

How to retain test data & experience?

How to capture Mission Integration into a Government Reference Architecture?

How to develop a Software Capability Needs Statement that also governs long-term software architecture?

How to do a comprehensive AoA with persistent results into digital modeling for risk management?

How to develop a digital TEMP & get it approved?

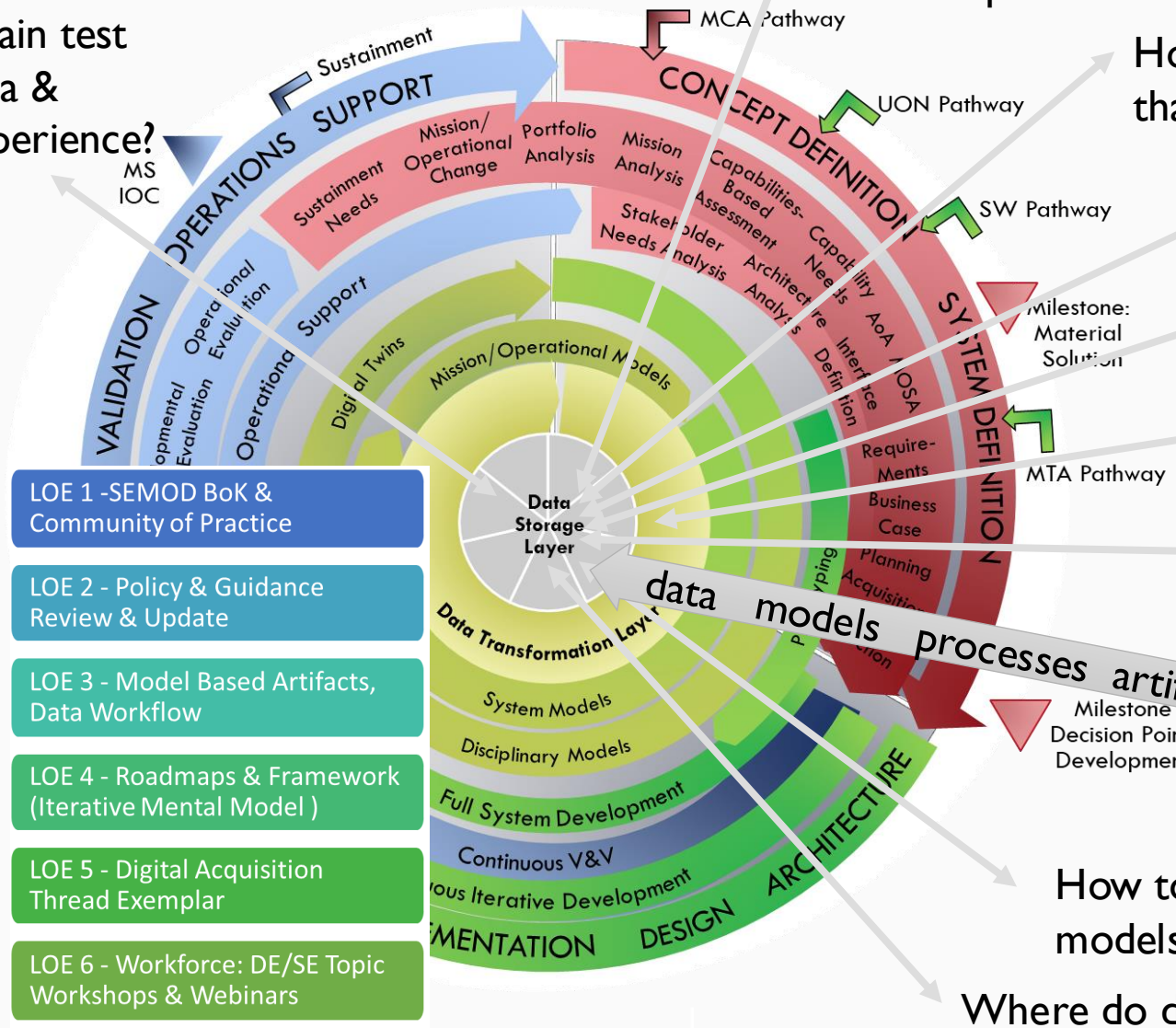
Who owns the data and models?

How to develop a digital SEP & get it approved?

How to develop an RFP for managing the digital data and model design process?

How to government and contractor collaborate around data and models to accomplish appropriate rigor and risk management?

Where do data and models live? Who manages the ecosystem?

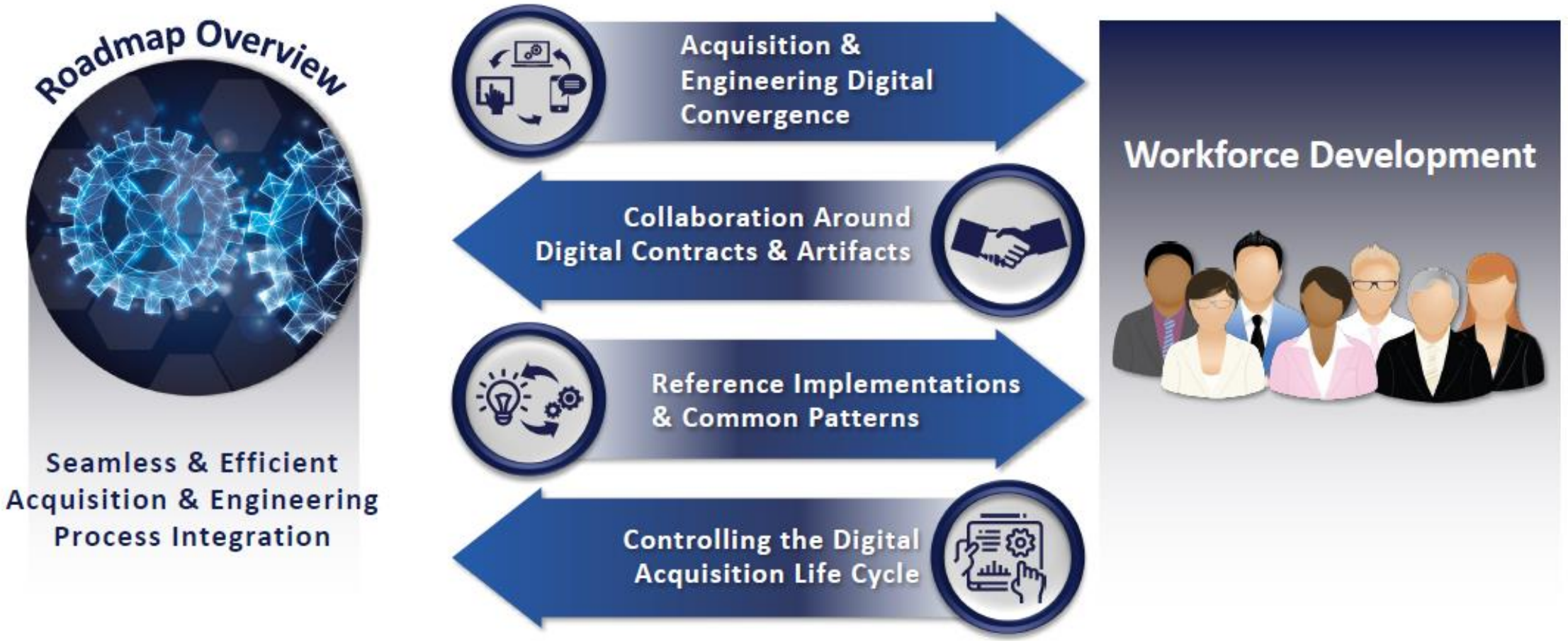


- LOE 1 -SEMOD BoK & Community of Practice
- LOE 2 - Policy & Guidance Review & Update
- LOE 3 - Model Based Artifacts, Data Workflow
- LOE 4 - Roadmaps & Framework (Iterative Mental Model)
- LOE 5 - Digital Acquisition Thread Exemplar
- LOE 6 - Workforce: DE/SE Topic Workshops & Webinars

Interrelated Issues/Challenges/Pain Points

Ways & Means To Accelerate Adoption	• Policy and Guidance Initiatives • Exemplar Implementations
Share Lessons Learned	• Data & Models Throughout the Life Cycle
Modernized SETR Processes	• Data Governance to Support Decisions • Agile Continuous Model Development
Build Reference Implementations	• Uninterrupted Tool Flow • Model Usage/Governance

SE Modernization Roadmap



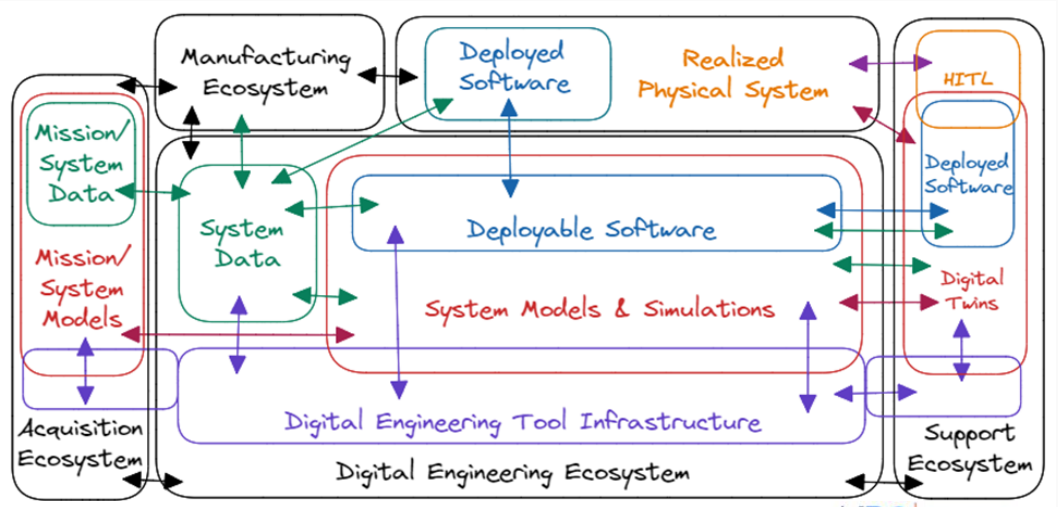
Acquisition with DE Recommendations

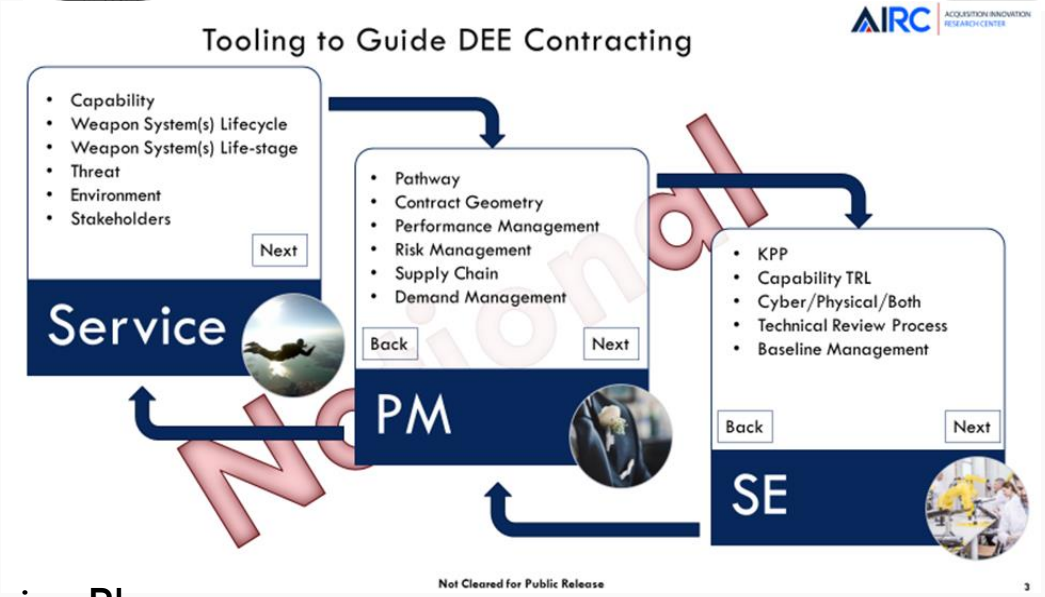
Digital Data and Models are living artifacts not “Technical Data.”

- The central tenet of Digital Engineering is collaboration around data and models. Government and Contractors have shared workflows in development and sustainment programs.
  - The DEAE framework must be planned and managed to ensure configuration management and visibility into authoritative sources of data and models, particularly across the DoD acquisition and contractor boundaries.
- Viewing Contracting for DE as technical data and computer software (per the FAR) is insufficient to meet the intent of the DE Strategy.
  - Further use of pilot programs at the service level necessary to mature this contracting interface. Additional research recommended to consolidate lessons learned and build a “playbook” for standardized approaches.
- Data and Models should be managed as program software components.
  - Recommend development of an equivalent to or update of the Software Development Report (DD Form 3026-1) to include digital data and model identification, resources, and development progress.

Main Element: Digital Engineering and Acquisition Ecosystem (DEAE)

- Must be recognized as a necessary part of the system development, or provided at an enterprise level
- An Enterprise Information System (DoDI 5000.82)
- Must support the full range of functions to which it will be applied, as articulated in the SEP – not necessarily the entire product lifecycle
- Data deliverables must be carefully considered
- Decision analysis framework, when fully articulated, can assist in decision making for data and tools





SEP: Systems Engineering Plan

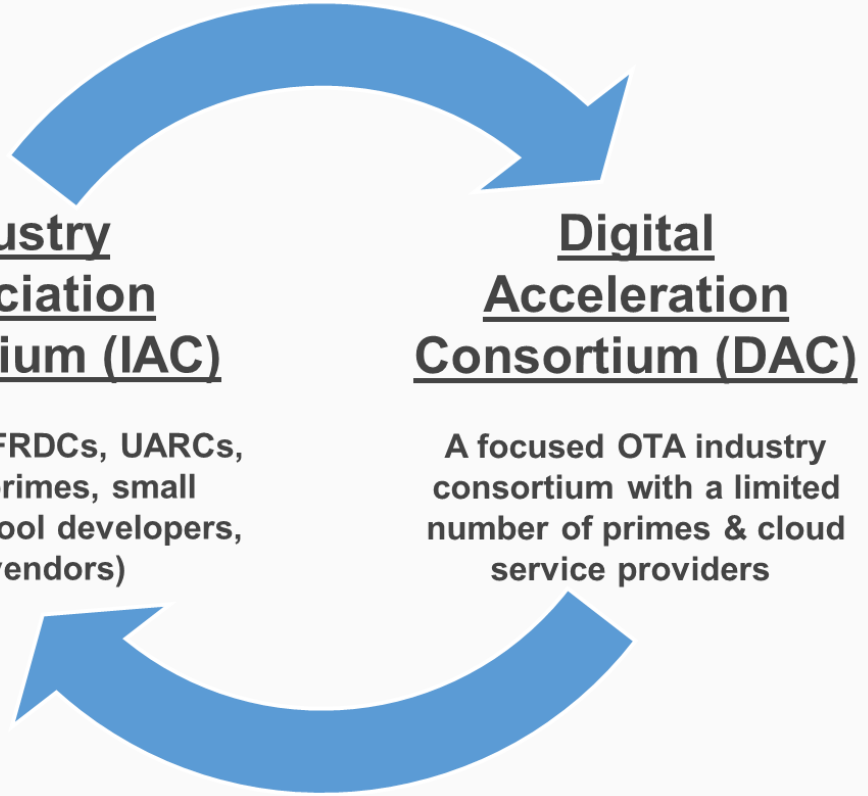
Areas of Near-term benefit (by Acquisition Function)

1. **Life Cycle Logistics:** ensuring that authoritative data and models and their use are included in the product support strategy and made available to the logistics and supply domain
2. **Engineering and Technical Management:** developing the ASOT and associated DEAE
3. **Program Management:** planning and budgeting for data and models, selecting acquisition pathways and defining appropriate DE model-based review processes, staffing the program office with sufficient digitally skilled program office personnel
4. **Test & Evaluation:** V&V requirements and operational assessment with and of models, capturing appropriate digital test artifacts
5. **Business Financial Management/Cost Estimating:** reflecting costs of and potential savings of DE in the complete, executed lifecycle of a system
6. **Contracting:** incorporating data and model exchanges, and digital review processes into the Statement of Work (SOW), defining data and model exchange and delivery requirements
7. **Audit:** ensuring appropriate management of program digital artifacts so curation is possible

Next Steps

- Contracted to the Air Force to accelerate adoption of Acquisition with DE though establishment of an Industry Advisory Council and transformation roadmaps.
- Continue to collaborate across AIRC research tasks to develop an overarching roadmap for digital transformation of the acquisition, and eventually sustainment processes, focusing on the benefits of digital-enabled acquisition.

1. Data Standards/Ontologies/Style Guides to Enable DMM
2. Policy and Enforcement for DMM
3. Integration of Acquisition Functions
4. DMM/DE Infrastructure and Environment
5. Workforce Development and Training for DMM (Impacting Culture)



Backup Slides

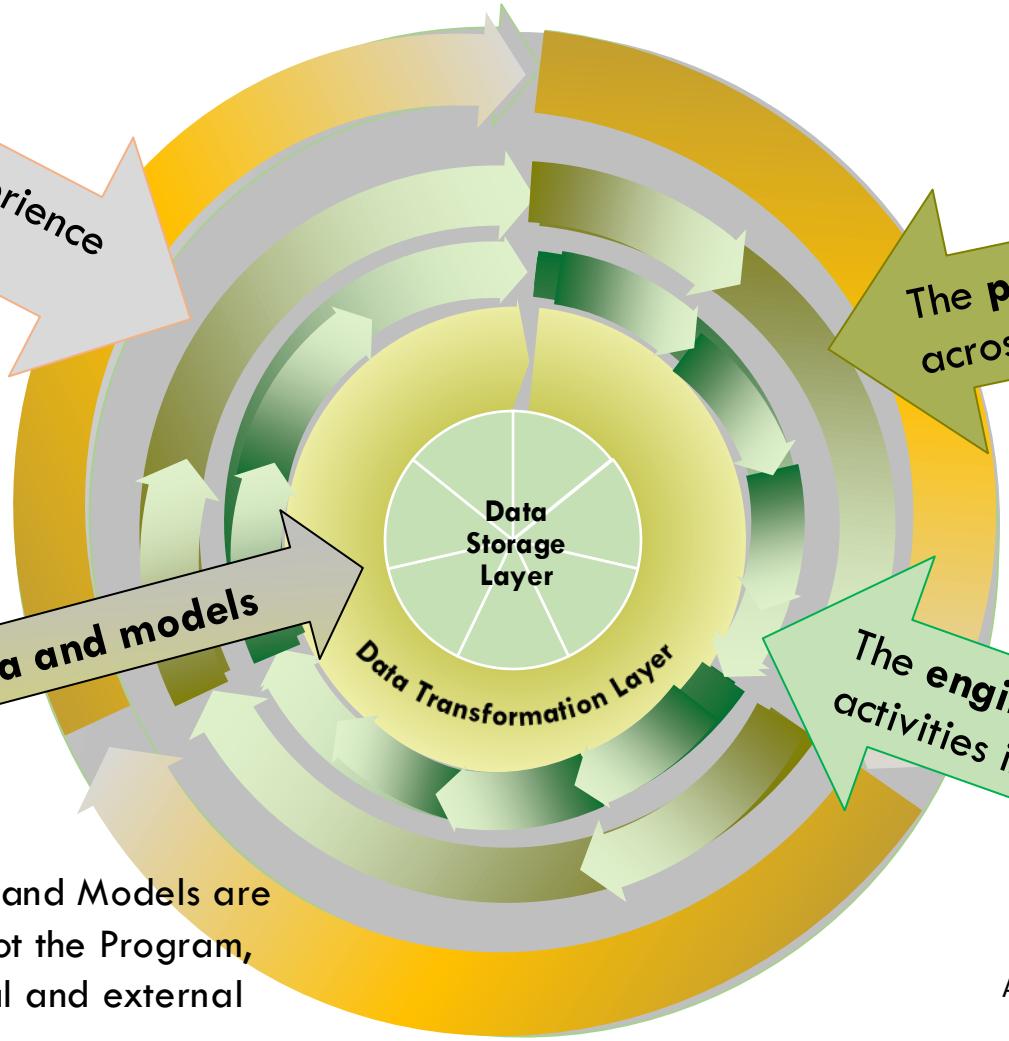
Generalization
The Supra-System Model

Emergence: the experience of the **system** itself

The **program** lifecycle: the rhythm of this project across its development and deployment

"System Experience" should be captured in stored data and used to continually update or remake our models

The **supra-system** lifecycle: what drives the experience of the system



The lifecycle of **data and models**

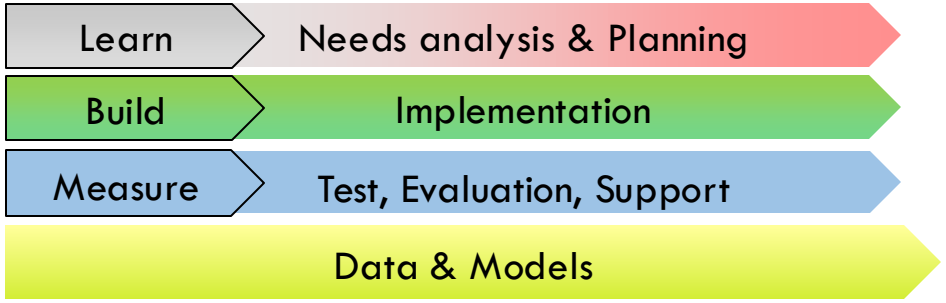
The **engineering** lifecycle: the activities in engineering this system

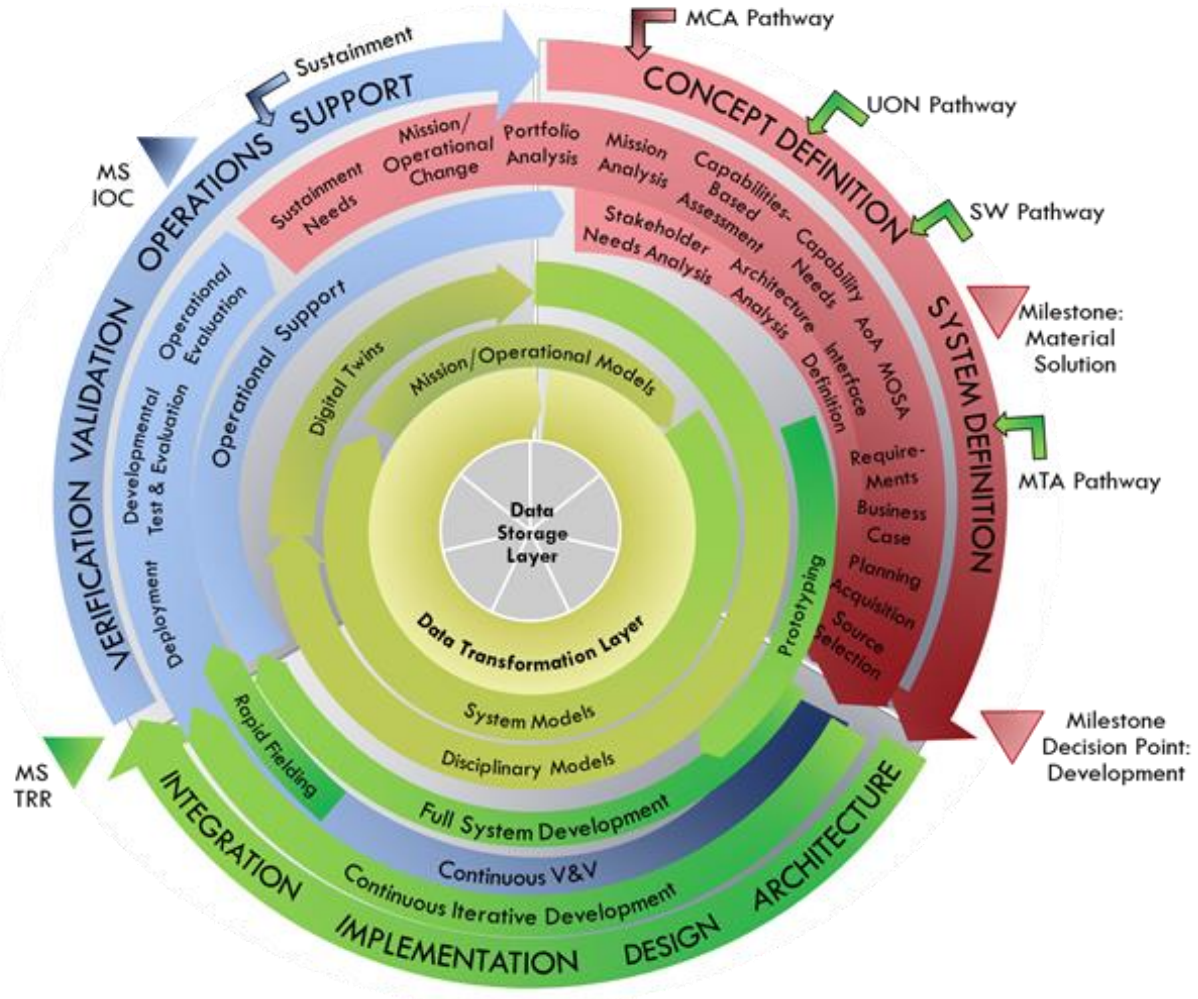
Authoritative Sources of Data and Models are associated with the System not the Program, and must consider all internal and external lifecycle drivers

Adapted from: Thullier and Wippler, Finding the Right Problem, in Large Scale Complex Systems and Systems of Systems, ISTE, 2011
von Bertalanffy, General System Theory, New York: George Braziller, 1968

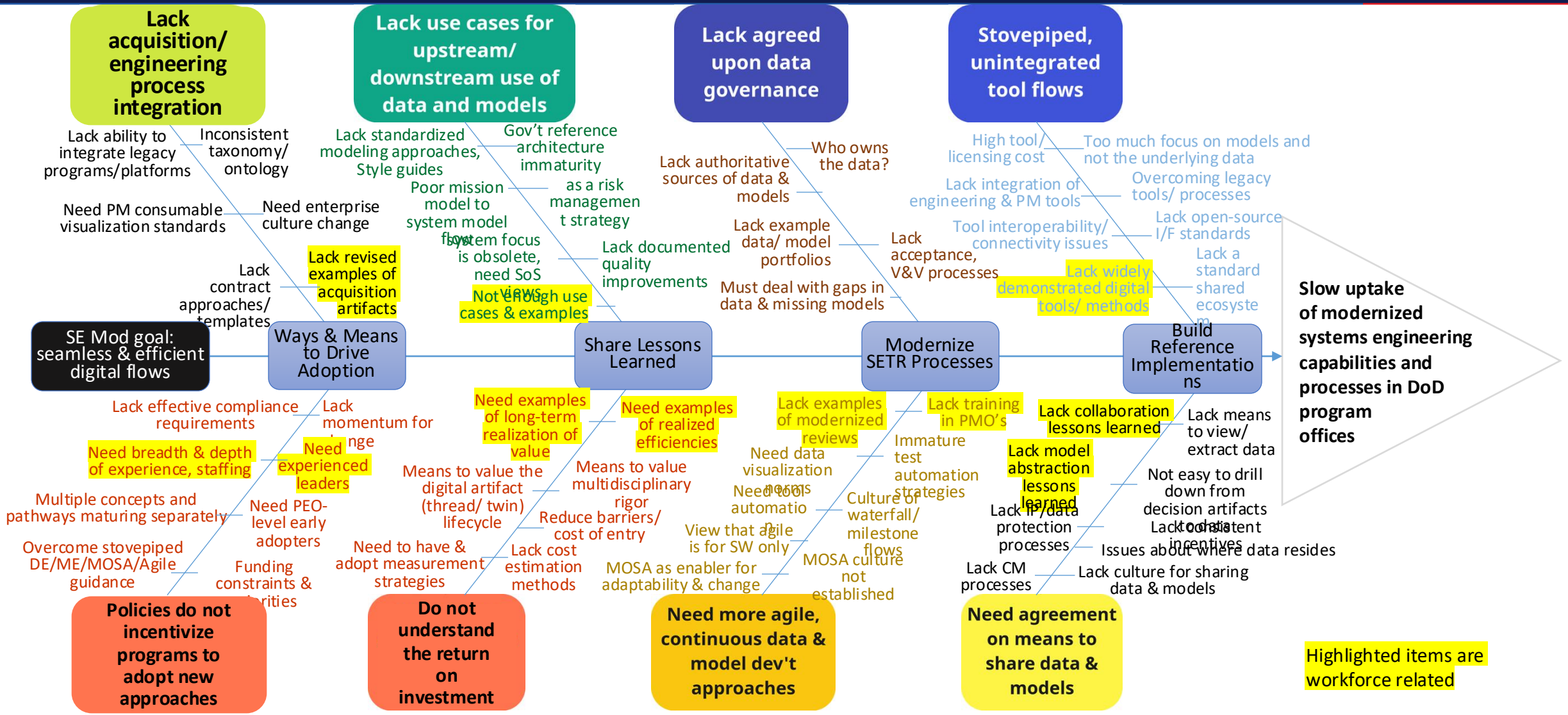
Notional View
Full SE Modernization Life Cycle

- Cyclic nature of modern SE
- Still milestone-based
- SE core principles in every Acq pathway
- Flexible system life cycle entry points:
  Learn-Build-Measure (MCA)
  Build-Measure-Learn (Mid-Tier, SW, UON)
  Measure-Learn-Build (Sustainment)
- Continuous Iterative Development processes (around the circle)
- Continuous Data Management and Transformation processes (at the core)

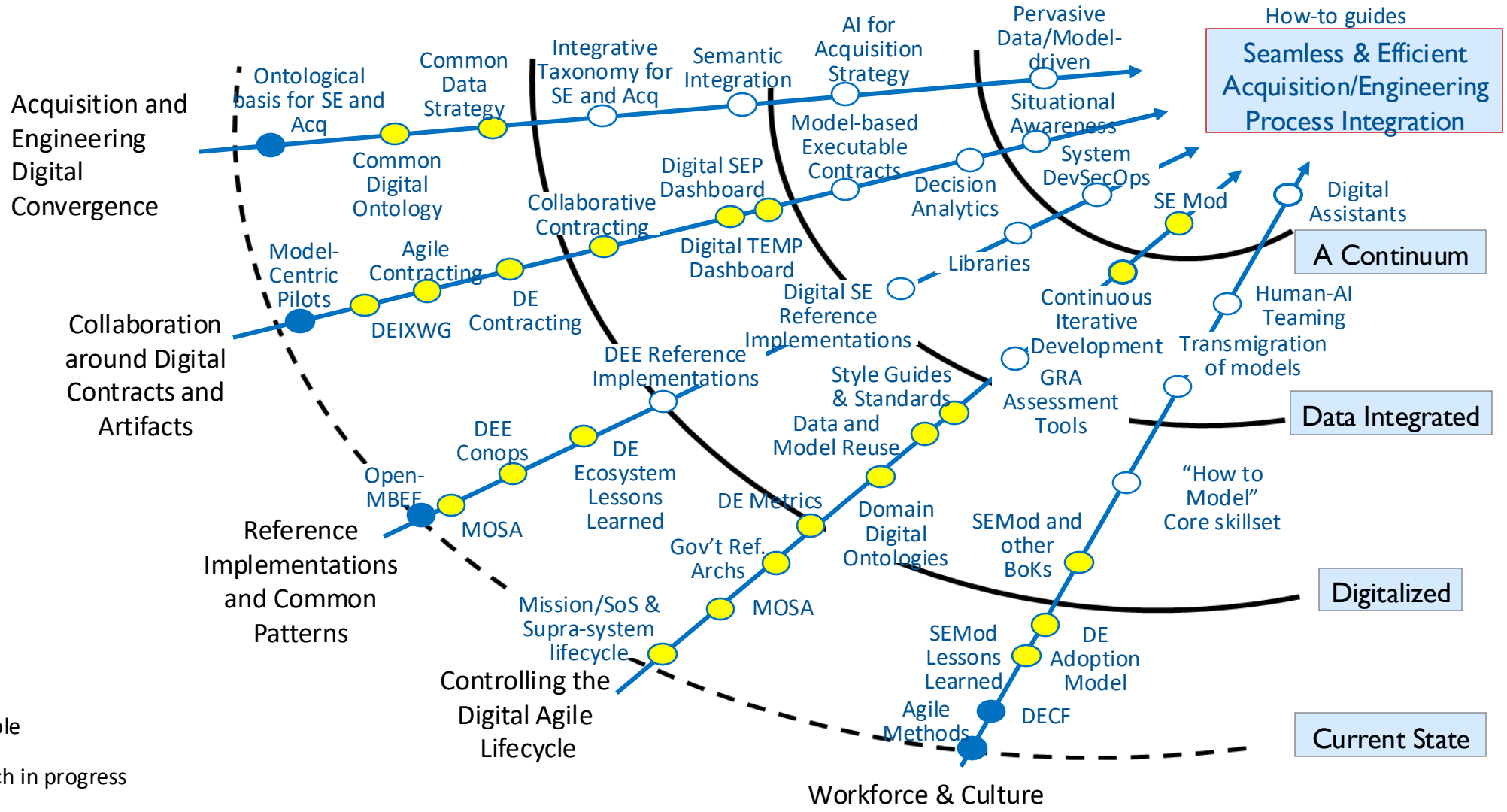




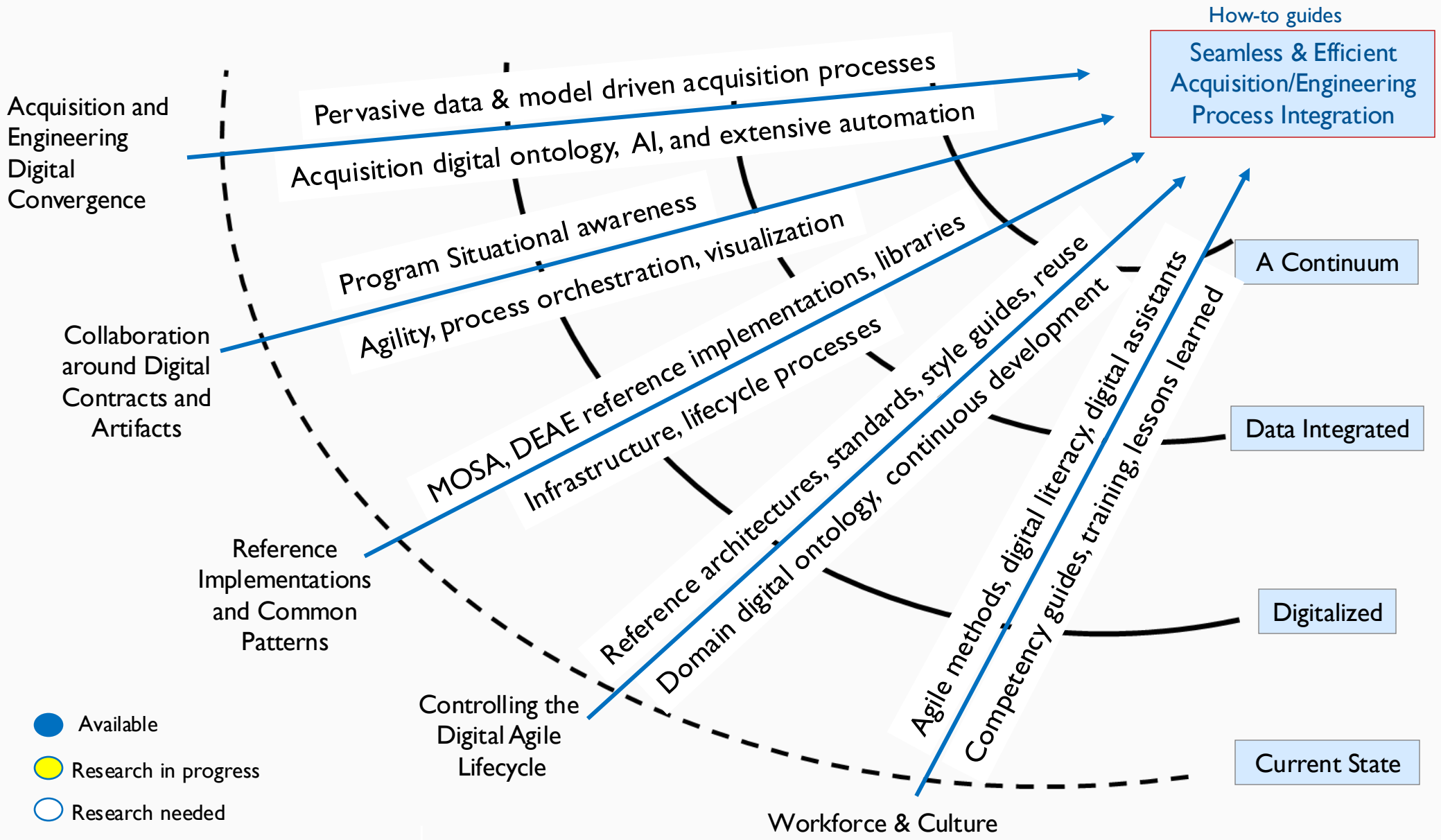
Pain Points Fishbone



Digital SE Modernization Roadmap



Digital SE Modernization Roadmap



Areas of Near-term benefit (by Acquisition Function) -1

Each of the current seven managed acquisition workforce areas, at a minimum, have a role to play in the DE transformation of acquisition and sustainment practices, to benefit from the continuum of digital artifact availability and use:

1. **Life Cycle Logistics**: ensuring that authoritative data and models and their use are included in the system Life Cycle Sustainment Plan (LCSP), lifecycle cost analyses, and the government/contractor product support analyses and strategy and made available to the logistics and supply domain.
2. **Engineering and Technical Management**: developing the ASOT and associated DEAE per the lifecycle management plan, as documented in the program Digital Engineering Implementation Plan (DEIP), as a main part of the Systems Engineering Plan (SEP).
3. **Program Management**: planning and budgeting for data and models across the full lifecycle, defining and managing program office requirements that are consistent with the use and expected benefits of DE, selecting acquisition pathways and defining appropriate DE model-based review processes, staffing the program office with sufficient digitally skilled program office personnel in appropriate functions, defining data exchange requirements for data and models across the spectrum of their use, defining and tracking DE activities in earned value management systems (EVMS) as well as Integrated Master Plan (IMP) and Integrated Master Schedule (IMS), defining a DE measurement plan and inspecting program digital artifacts delivery for completeness and consistency.

Areas of Near-term benefit (by Acquisition Function) -2

Each of the current seven managed acquisition workforce areas, at a minimum, have a role to play in the DE transformation of acquisition and sustainment practices, to benefit from the continuum of digital artifact availability and use:

4. **Test and Evaluation**: defining and planning the verification and validation (V&V) requirements and operational assessment with and of models, using data from live events to update models and the collective ASOT, capturing appropriate digital test artifacts in the ASOT, developing the digital Test and Evaluation Master Plan (TEMP).
5. **Business Financial Management/Cost Estimating**: DE data and models integrated into cost modeling, updating cost estimation models to reflect the relative resource (time, budget, and personnel) costs, cost avoidance and potential savings of DE in the complete, executed lifecycle of a system, including but not limited to development, production, and sustainment.
6. **Contracting**: incorporating DE processes, data and model exchanges, and digital review processes into the Statement of Work (SOW), defining data and model exchange and delivery requirements, defining program DEAE requirements.
7. **Auditing**: ensuring appropriate management of program digital artifacts so curation is possible.

Thank you

Stay connected with SERC Online:

Email the presenter: Tom McDermott

tmcdermo@stevens.edu

Email the research team: