National Defense Industrial Association Systems and Mission Engineering Conference

November 2022

Systems Engineering Modernization Across the Lifecycle

SERC SEMOD Lifecycle Mental Model

Ms. Nadine Geier

Director, Systems Engineering

Office of the Executive Director, Systems Engineering and Architecture

Office of the Under Secretary of Defense for Research and Engineering

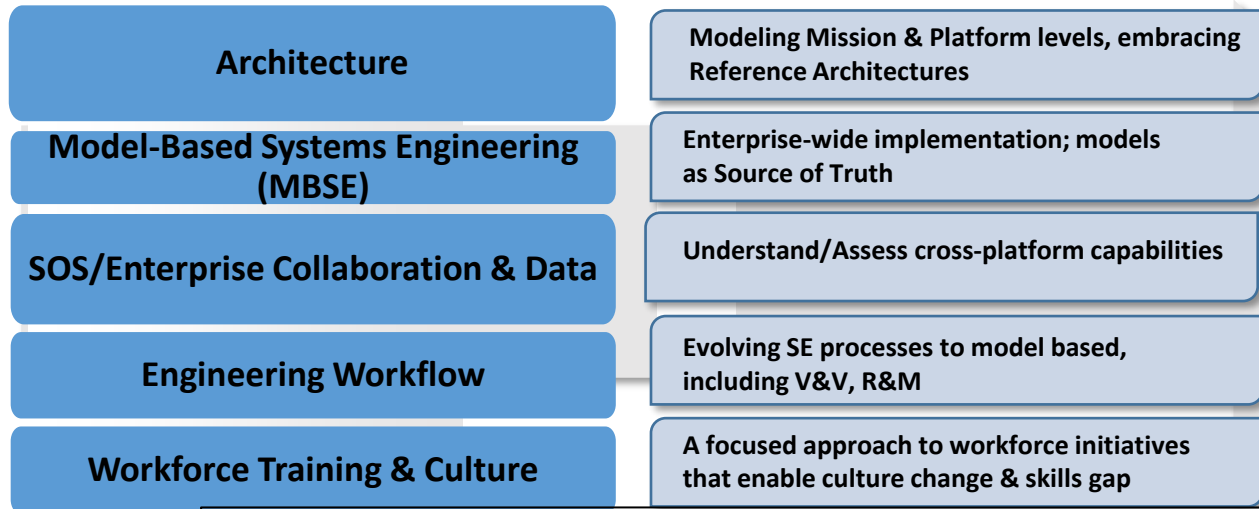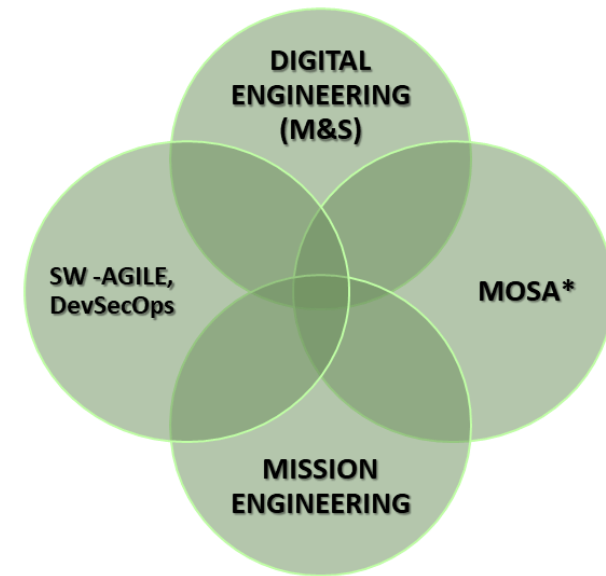# SE Modernization Problem Statement

SE Modernization Problem Statement

"There is a **lack of an integrated approach** to implementation of SE Focus Areas that **is creating a delay in full implementation of the Digital Transformation** which is necessary to ensure the relevant guidance, skills, and training are available to deliver a robust, disciplined approach to weapon systems acquisition."

SE Modernization Focus Areas (Initial Scope)

- DIGITAL ENGINEERING (M&S)
- SW -AGILE, DevSecOps
- MOSA*
- MISSION ENGINEERING

Cross-Cutting Key Enablers

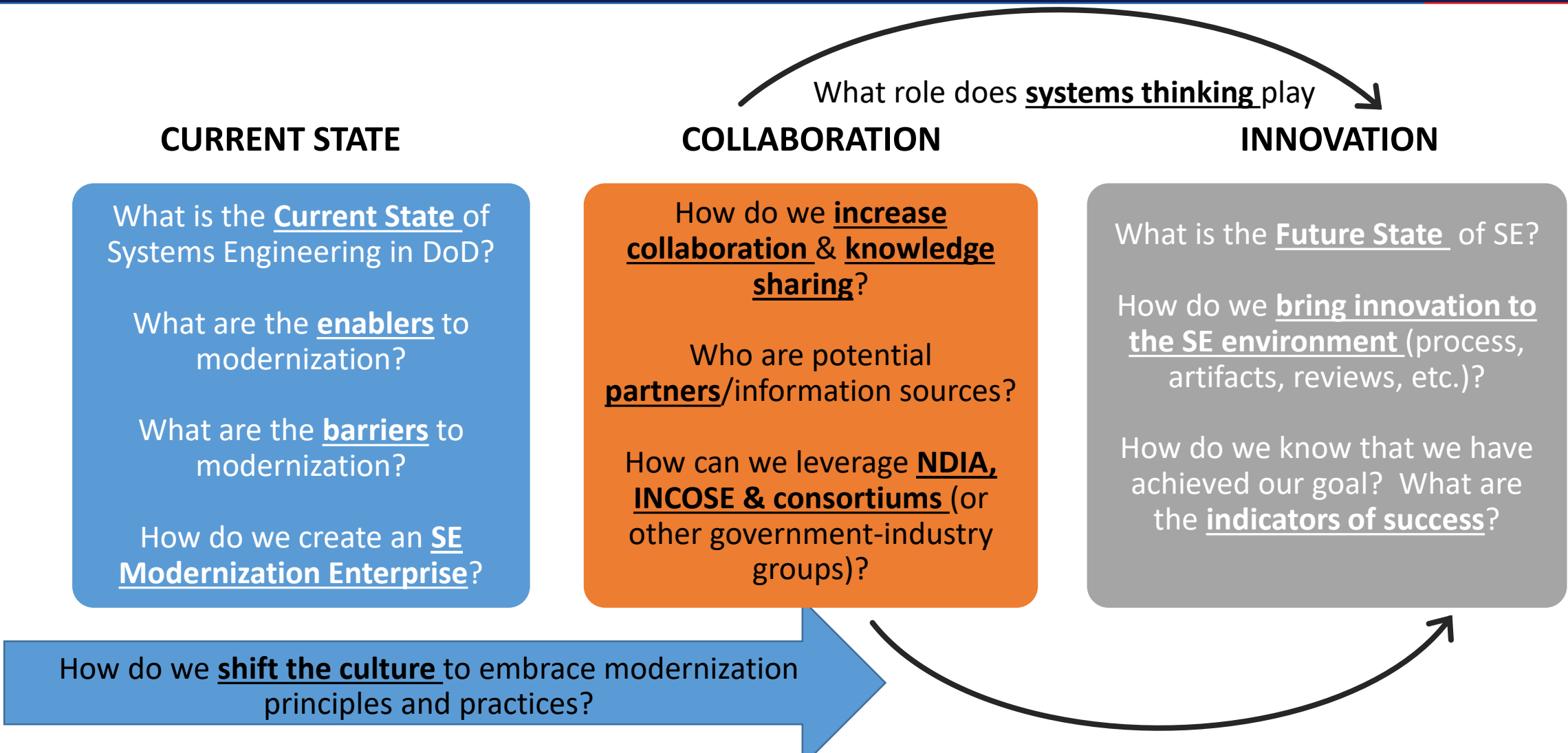| Enabler	Description
Architecture	Modeling Mission & Platform levels, embracing Reference Architectures
Model-Based Systems Engineering (MBSE)	Enterprise-wide implementation; models as Source of Truth
SOS/Enterprise Collaboration & Data	Understand/Assess cross-platform capabilities
Engineering Workflow	Evolving SE processes to model based, including V&V, R&M
Workforce Training & Culture	A focused approach to workforce initiatives that enable culture change & skills gap

Collaborating with Government, Industry & Academia

ENABLERS RESULTED FROM INITIAL OUTREACH/INFORMATION SESSIONS

Questions Used for Phase 1 Information Sessions

What role does **systems thinking** play

CURRENT STATE

What is the **Current State** of Systems Engineering in DoD?

What are the **enablers** to modernization?

What are the **barriers** to modernization?

How do we create an **SE Modernization Enterprise**?

COLLABORATION

How do we **increase collaboration** & **knowledge sharing**?

Who are potential **partners**/information sources?

How can we leverage **NDIA, INCOSE & consortiums** (or other government-industry groups)?

INNOVATION

What is the **Future State** of SE?

How do we **bring innovation to the SE environment** (process, artifacts, reviews, etc.)?

How do we know that we have achieved our goal? What are the **indicators of success**?

How do we **shift the culture** to embrace modernization principles and practices?

Responses from INCOSE Workshops/Information Sessions

CURRENT STATE

- **Lack integration of engineering and other competencies** (science, safety, software, security, programmatic)

- **Lack means & funding for collaboration**

- **Lack of governance** (data and models)

- **Lack change momentum** (status quo dominates)

- **Digital artifacts become static -** lose dynamic content as the design progresses

- **Shortage of experienced practitioners**

- **Lack a digital process flow handbook(s),** a digital workflow with traceability to domains

COLLABORATION

FUTURE STATE

- ✓ **Seamless interoperability and integration** of all engineering disciplines

- ✓ **Greater (digital) integration of SE &** other disciplines including project management

- ✓ **Continuous engineering** across the globe communicating seamlessly and remotely

- ✓ **Digital twin(s) -** holistic for system life cycle

- ✓ **The equivalent of a DevOps revolution** cutting across disciplines & lifecycle

- ✓ **"How to model" is a core competency** for more than just the engineering community

- ✓ **Tool maturity -** more open, interoperable, usable, standardized

SEMOD Focus Areas

- **MOSA**
  - SE Division (SED) produced MOSA White Paper
  - ✓ Developed MOSA Metrics guidance for programs
- **Agile Software/ System Development**
  - ✓ Agile Deliveries for Agencies, Programs, & Teams (ADAPT) Committee focused on promoting Agile System Development and DevSecOps for programs
  - ✓ Joint SED/ Integrated Program Management Division (IPMD) working group on Agile Program Execution
- **Digital Systems Engineering (DSE)**
  - ✓ SED-level working group addressing evolution of MBSE to DSE
- **Mission Engineering (ME)**
  - SED-level working group studying ME implementation
  - ✓ Conducted Survey of Industry's Mission Engineering capabilities
  - Provided review/ recommendations to DoD ME Guidebook update

SEMOD Cross-Cutting Key Enablers

- **Architecture**
  - ✓ SE Division (SED) Architecture Committee leads system architecture focus
- **MBSE**
  - SED Modeling & Simulation Committee leads MBSE focus
- **SoS/ Enterprise Collaboration & Data**
  - ✓ System of Systems (SoS) Committee leads this area
  - ✓ System Security Engineering Committee leads focus on Enterprise Collaboration & Data
- **Workforce Training & Structure**
 - ✓ SED Education & Training Committee leading SEMOD/Digital Acquisition Thread study

> ✓ *Denotes subject of a 2022 NDIA S&ME Conference presentation*

SEMOD FY22/23 Lines of Effort

SEMOD Pain Points

SEMOD Lines of Effort

ALIGNED TO

- SEMOD BoK & Community of Practice
- Policy & Guidance Review & Update
- Model Based Artifacts & Workflow
- Framework (Workflow Mapping & Roadmaps)
- Digital Acquisition Thread
- Workforce: DE/SE Topic Workshops & Webinars
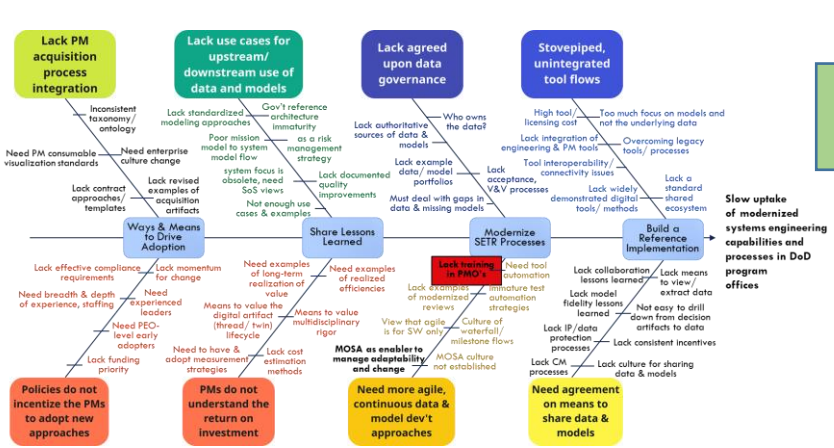
EACH PAIN POINT ADDRESSED BY MULTIPLE LINES OF EFFORT

1. **Build an Integrating Framework** that incorporates key activities across these domains and focus areas.

2. **Align and Integrate Systems Engineering Practices** to specific acquisition pathways.

3. **Develop a set of Artifacts and associated Meta-Data** for a categorization and information framework that captures policy, guidance, and lessons learned into a body of knowledge.

As we developed the integration framework, we realized the "mental models" and related language of DoD systems Engineering were still too rooted in large scale major capability acquisitions and document-driven processes. We needed to re-envision the purpose and goals of modernized "digital" SE practices.

- Causally Related

- Derived from Workshops and Discussions with stakeholders

- Using the Integration Framework

- Address the slow uptake of modernized systems engineering processes

- Shown in the Fishbone diagram (next chart)

- Driven by the goal of seamless and efficient digital flows from data to decision artifacts and from decision artifacts back to data.

PAIN POINTS FISHBONE

SEMOD Focus Areas (Guidance)
- Digital Engineering
- MOSA
- SW Engineering
- Mission Engineering

DoD Digital Engineering Strategy (Jun 2018)

Open Systems Architecture Contract Guidebook (Jun 2013)

DoD Digital Modernization Strategy (Jul 2019)

Mission Engineering Guide (Nov 2020)

Agile Software Acquisition Guidebook (Feb 2020)

Title 10 USC (updated by the NDAAs)

DoDD 5000.01/02 Defense Acquisition & Pathways (2020)

DoDI 5000.88 Engineering of Defense Systems (Nov 2020)

DoDI 5000.89 Test & Evaluation (Nov 2020)

DoDD 5000.59 M&S Management (Oct 2018)

DoDI 5000.84 Analysis of Alternatives (Aug 2020)

Engineering of Defense Systems Guidebook (Feb 2022)

Systems Engineering Guidebook (Feb 2022)

Systems Engineering Plan (SEP) Outline (Sep 2021)

as applied to

DoDI 5000.81 Urgent Capability Acquisition (Dec 2019)

DoDI 5000.80 Middle Tier of Acquisition (Dec 2019)

DoDI 5000.85 Major Capability Acquisition (Aug 2020)

DoDI 5000.87 Software Acquisition (Oct 2020)

Digital Engineering (DE): implement "an integrated digital approach that uses authoritative sources of system data and models as a continuum across disciplines to support lifecycle activities from concept through disposal." Enabler to manage lifecycle efficiency.

Agile/DevOps: begin with a high-level capture of business/ technical needs, continually implement and deploy to define & build value. Enabler to manage risk.

Modular Open Systems Approach (MOSA): use modular design, control interfaces, adopt open standards, measure conformance. Enabler to manage adaptability and change.

Mission Engineering (ME): continually provide engineered mission-based outputs to inform requirements, prototypes, design, and investment. Enabler to manage portfolios.

DoD Data Strategy: "data as a strategic asset"

The 4 focus areas generate a layered, continual, and data-centered model

Human is the "glue" for data sharing

Today this is a "Bunch of soda straws"

Tool

Tool

Tool

PowerPoint

We aspire to a fully integrated workflow

Data model as the "glue" for data sharing
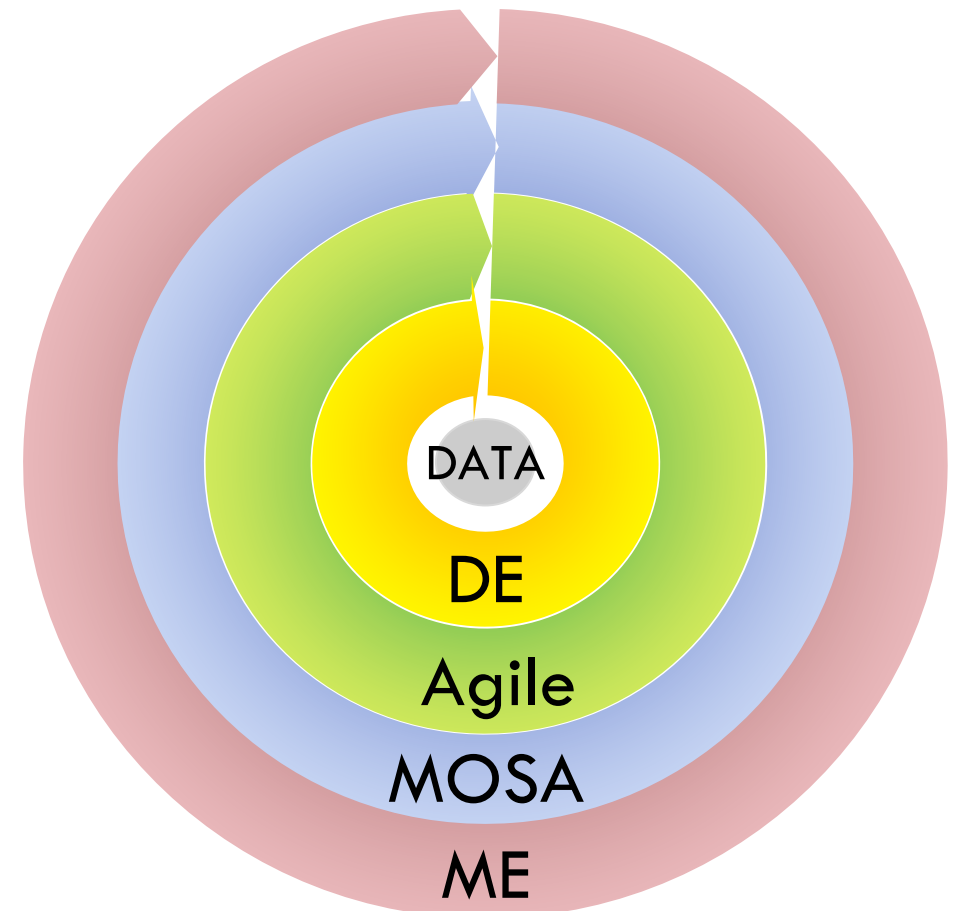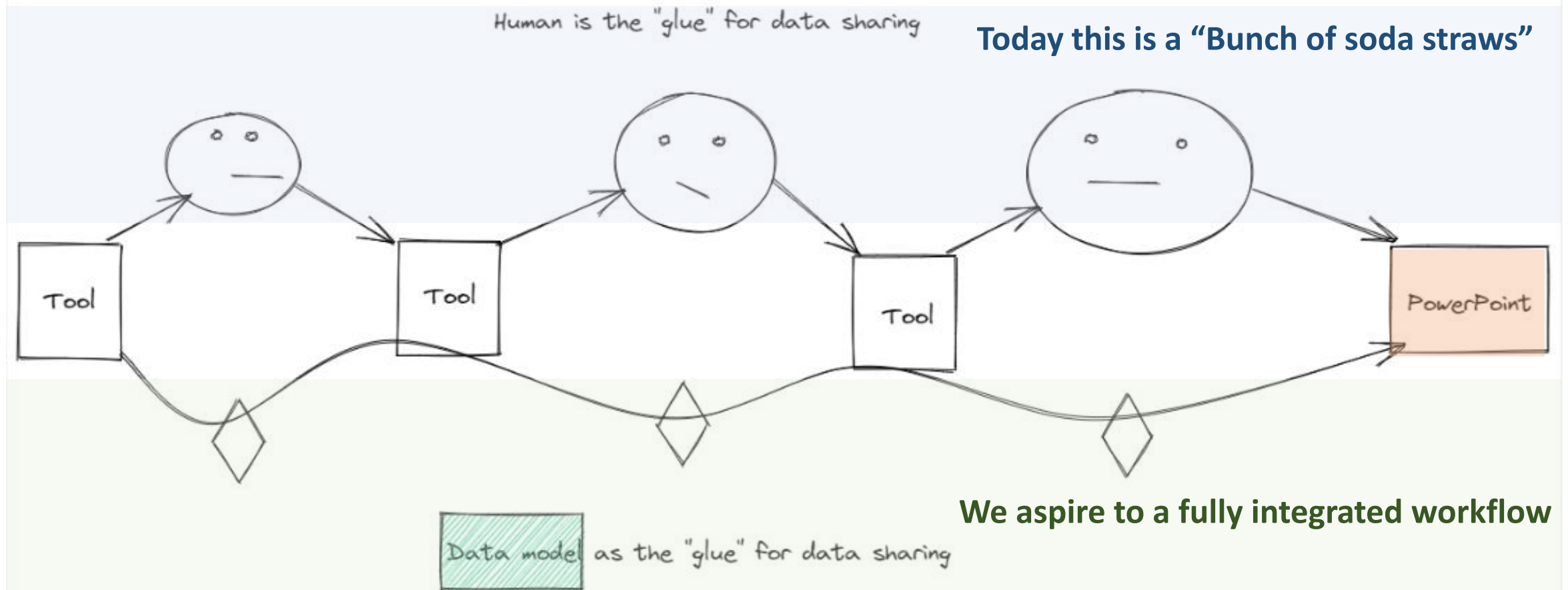
Digital Artifact - An artifact produced within, or generated from, the engineering ecosystem. These artifacts are generated **through transformation of data and models into views** in order to visualize, communicate, and deliver data, information, and knowledge to stakeholders.

SEMOD evolves toward **seamless and efficient** digital flows from data to decision artifacts and from decision artifacts back to data.

Human is the "glue" for data sharing

Easy to drill down: decision to data

Tool

Improved interoperability & connectivity needed

PowerPoint

In a digital transformation: this process is **seamless and efficient**

Data model as the "glue" for data sharing
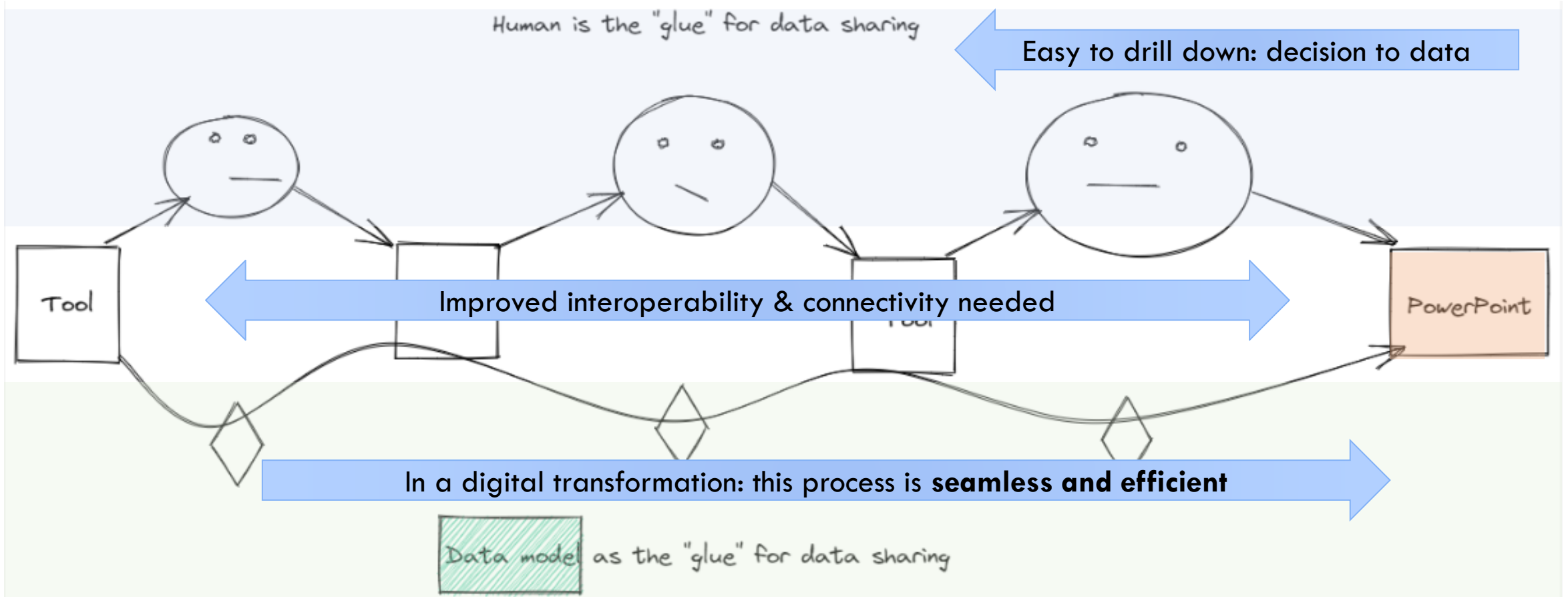
Lack of an integrated approach is creating a delay in full implementation of the Digital Transformation

A Revised Mental Model of the Systems Engineering Lifecycle

- SEMOD redraws the stages of the SE Lifecycle in a circular process to represent it as:
  1) data transformations at the core
  2) layered across disciplines & tasks
  3) continuous processes that could be entered from any point

- Data is transformed through Models into Decision Artifacts

- Data remains accessible via Decision Artifacts
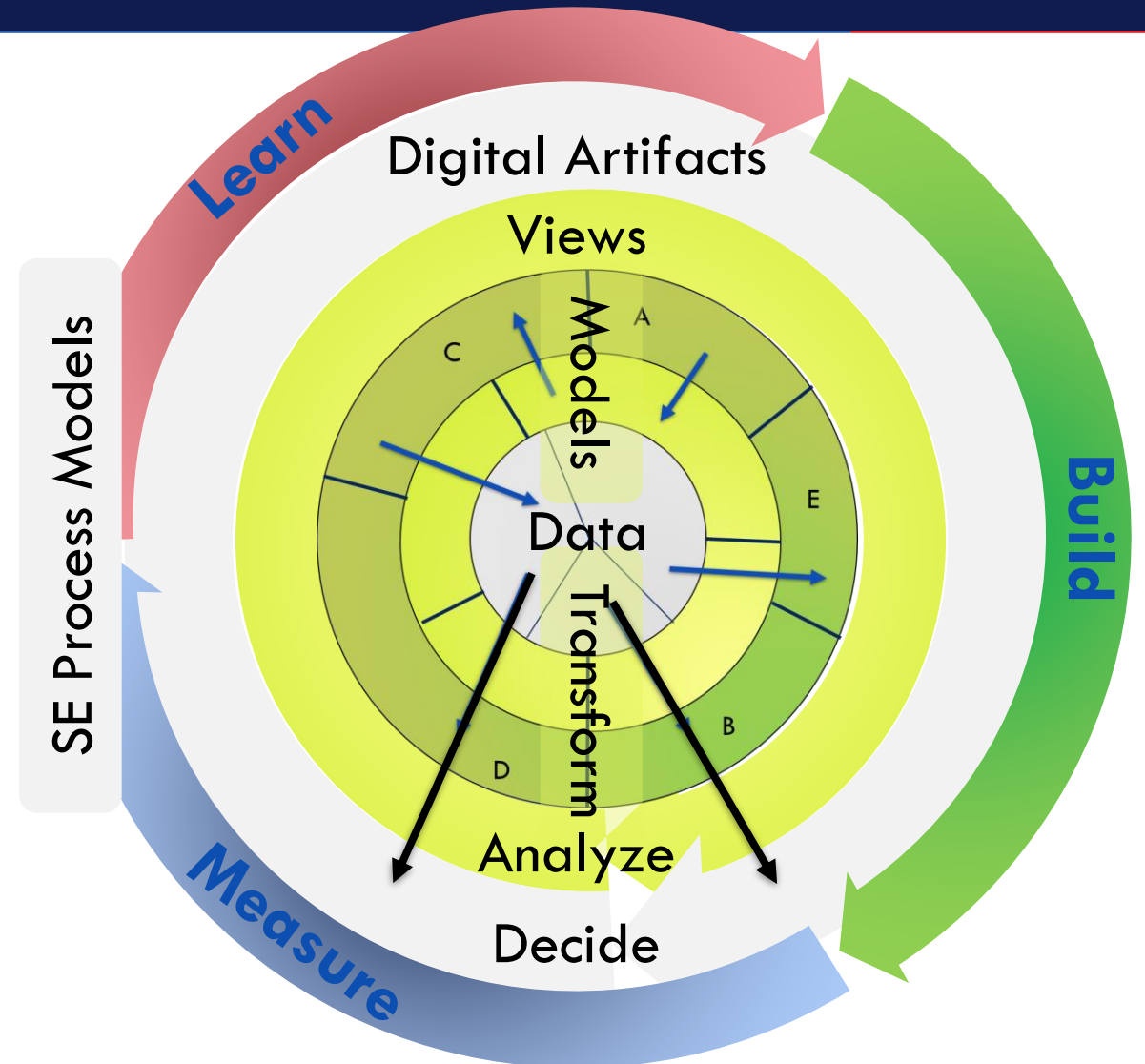
SE Modernization Mental Model

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)
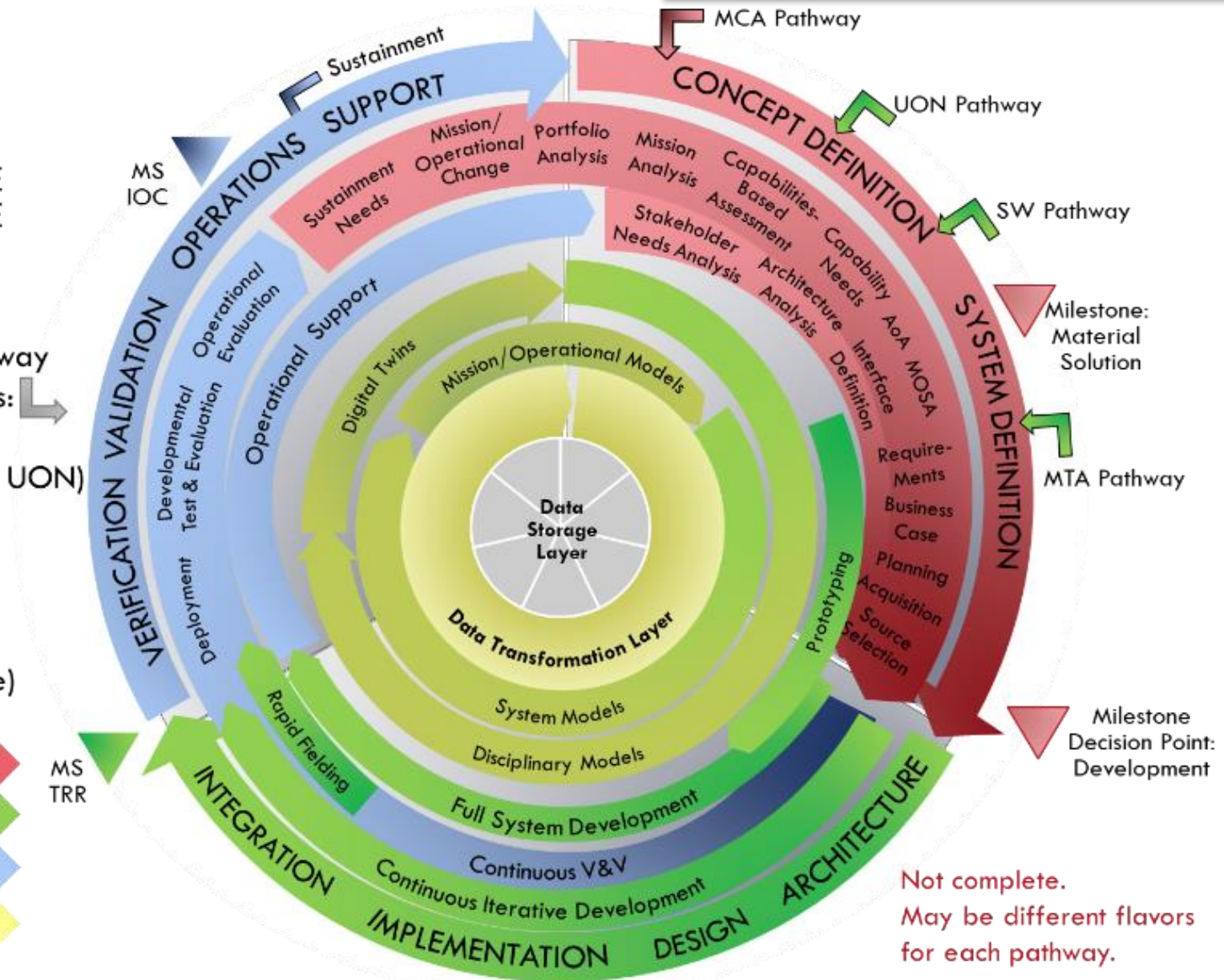
Learn	Needs analysis & Planning
Build	Implementation
Measure	Test, Evaluation, Support
	Data & Models

Distribution Statement A. Approved for public release. Distribution is unlimited. Case # 22-S-3012

Systems Engineering Modernization and Digital Engineering

"seamless and efficient use of data and models...data to decision artifacts and back... continuous and iterative..."

SEMOD Project

"authoritative sources of data and models...continuity across lifecycle...concurrency across disciplines and domains..."

DoD DE Strategy

Improving the "Digital" in Systems Engineering

Improving the "Systems" in Digital Engineering

- SE Modernization and related focus areas represent a more significant shift in acquisition and engineering practices than envisioned by any single initiative

- The integration of these requires new mental models
  - Data at the core – many lessons learned will drive evolution
  - Seamless and efficient process integration – new exemplar standards/tools
  - All lifecycles are continuous and use appropriate iterative methods
  - But SE core lifecycle processes will remain with new practices
  - Significant workforce evolution needed

- Several SERC tasks support the community in this evolution

Specialty – **Focused Topics**: Digital T&E – R&M – Mission Engineering – Contracting for Digital Artifacts – Use of Reference Architecture

SE Boot Camp on Modernized SE Practices – Agile SE.

Implementing **MOSA & Open Standards in a Digital Environment**

Engineering Workflow in a Digital Environment. (DAU Acquisition Thread)

Technical Reviews & Digital SE Artifacts in a Digital Environment

Focused Topics

SE Workforce

Open Standards MOSA

Digital SE Workflow

Digital Artifacts Tech Reviews
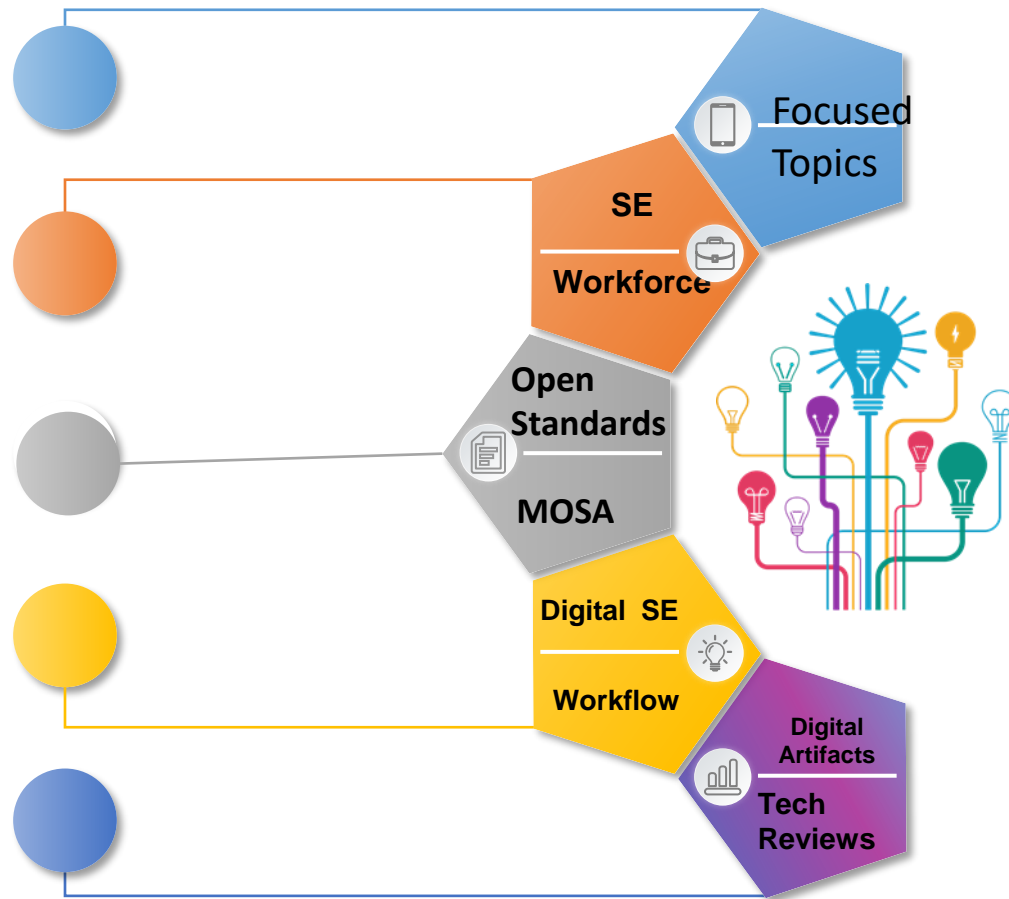
Ongoing collaboration with Engineering Technical Management Functional Integration Team to develop SE Credentials

WORKSHOPS WILL INFORM BoK, UPDATES TO POLICY & WORKFORCE GUIDANCE

SEMOD Path Forward for Phase 2

Complete Phase 1 SERC Deliverables

- ✓ **Lessons Learned Database**
- ✓ **Ontology** guide for SEMOD policy and guidance
- ✓ **Workforce, education and training** recommendations
- ✓ Present **Policy gaps & recommendations**
- ✓ **Recommend** additional focus area integration

SEMOD PHASE 2 GOALS

- Update SE CoP
- Mature SE & Digital Transformation Implementation
- Align MBSE Initiatives – (Test, Specialty)
- Align Workflow Mapping/Road maps with Acquisition Pathways
- Exemplars for the Digital Acquisition Thread SE Artifacts/Data Transformation
- Expand Stakeholder Engagement (Contracting, Legal, Leadership)

Office of the Under Secretary of Defense for
Research and Engineering
osd.r-e.comm@mail.mil | Attn: SE&A
https://www.cto.mil
https://ac.cto.mil/engineering

Backup charts

SEMOD Initial Framework (SERC)

- Digital Transformation introduces digital & model-based information flow into the acquisition lifecycle

- SERC is mapping information items and digital artifacts related to handoffs in 3 acquisition pathways

- Examining (1) IEEE15288/INCOSE Handbook, (2) INCOSE/NDIA SEBoK, (3) DAU guides (new), (4) NAVAIR "Skyzer" DE Pilot effort. Framework will define "What digital info/artifact might be exchanged at each decision point?"

Distribution Statement A. Approved for public release. Distribution is unlimited. Case # 22-S-3012

22
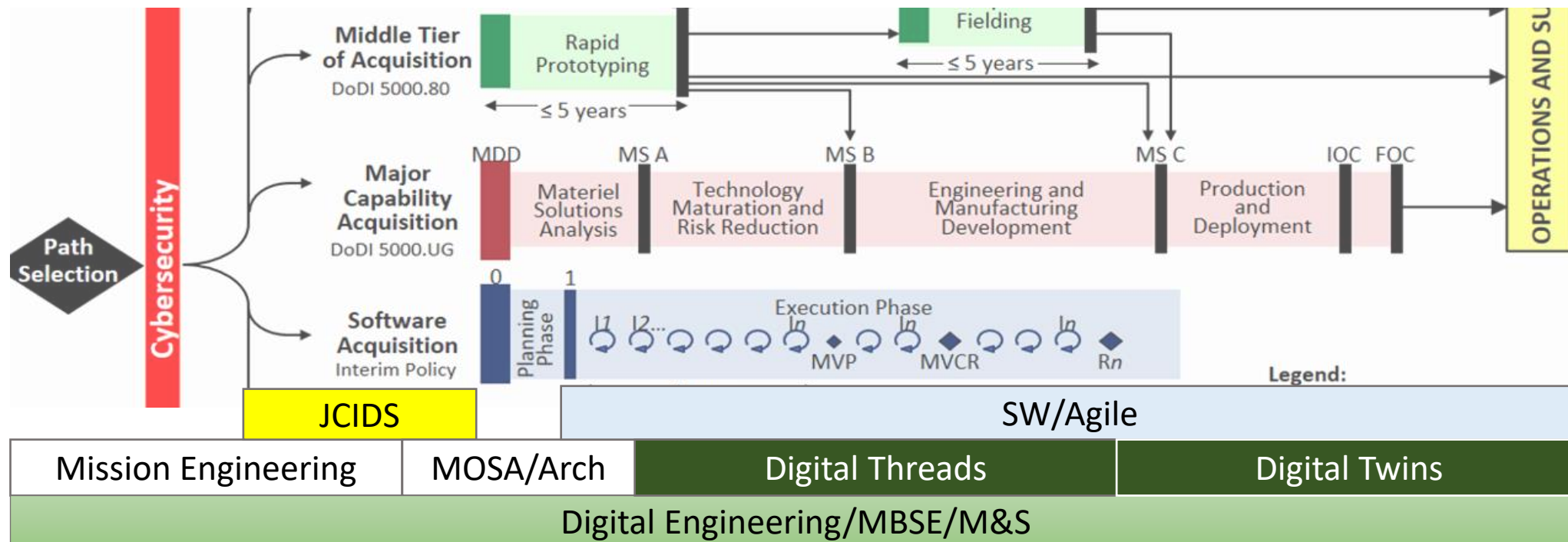
INCOSE IW 2022 Strategy Session Summary (2 Workshops)

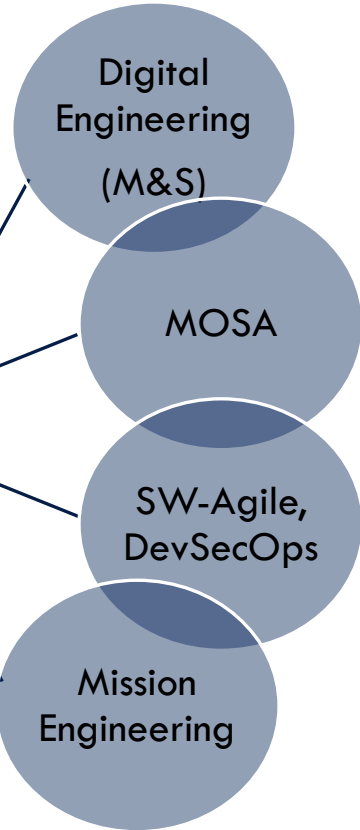| What is the Current State?	How do we increase collaboration & knowledge sharing?	What is the Future State?
Lack integration of engineering and other competencies (science, safety, software, security, programmatics)	Leaders not managers, need to **recognize this is a digital transformation linking SE and other disciplines through data**	**Seamless interoperability and integration** of all engineering disciplines
Hard to create collaboration, continuously, in digital environments; funding is a barrier	**SE job is to communicate**! Funding allocations don't promote collaboration	**Continuous engineering** across the globe – communicating seamlessly and remotely
Lack of governance approaches for data and models, ingrained paper CM/DM mindset	**Apply automation**, remove drudge work, focus on build	**Digital twin(s)** that is holistic for a system over its entire life cycle
Historical approaches dominate, **lack change momentum**	Recognize limits of the digital technologies, **build incrementally & continuously**	**Greater (digital) integration of SE** and other disciplines including project management
Engineers lose dynamic content as the design progresses, **artifacts become more static, stale**	Leverage SW processes that could improve SE; **build iterative, collaborative teams**	The **equivalent of a DevOps revolution** cutting across disciplines & lifecycle
Need to move away from a static view of the system toward **model-based reviews; shortage of experienced practitioners**	**Training and exposure for everyone**	**"How to model" is a core competency** for more than just the engineering community
Need to know system changes are not breaking something else, not seeing full scope **Lack a digital process flow handbook(s), a digital workflow with traceability to domains**	**Interoperability standards, tools, clouds, data across boundaries**, norms for working together Recognize limits of the digital technologies, build incrementally & continuously	**Tool maturity**: more open, interoperable, usable, standardized

Distribution Statement A. Approved for public release. Distribution is unlimited. Case # 22-S-3012

23

- SERC led two strategy sessions to discuss:
  - Is there a strong need to "modernize"?
  - What focus areas should we tackle first?
  - How are emerging and relevant practices integrated into SE discipline?
  - How should the overall practice of systems engineering shift over time? These are all questions that must be addressed by INCOSE.
- Goals of the session:
  - Document the current state of SE with respect to evolving markets and methods,
  - Identify focus areas for INCOSE that we should address with respect to evolving practice,
  - Develop a set of prioritized actions or perhaps simple roadmaps, and
  - Recommend/Identify key enablers that are essential to a modern approach to SE (for example reference architectures, SoS collaboration environments, etc.).

SE Modernization Focus Areas (Initial Scope)

- Digital Engineering (M&S)
- MOSA
- SW-Agile, DevSecOps
- Mission Engineering

Cross Cutting Key Enablers

- Architecture
- MBSE
- SOS/Enterprise Collaboration
- Engineering Workflow
- Workforce Culture
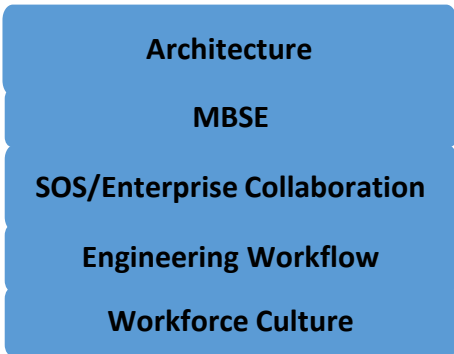
WRT-1036, ART-002 Model Centric Engineering – surrogate pilot project to evaluate details of DE, Navy NAVSEM process model

WRT-1040 DE Metrics – framework for quantifying DE/MBSE benefits, SE community working group

WRT-1047 Digital Data Management & Analytic Strategy – data strategies combining mission engineering, digital engineering, acquisition baseline data, etc.

ART-016 Army Common Architecture Strategy – government reference model/MOSA strategies

WRT-1041 Space Force Agile Transformation – direct experience supporting government agile transformation, metrics

WRT-1049 Agile Program & Project Management – agile processes as applied to systems and hardware intensive programs, agile training

WRT-1049 Additive Manufacturing & DE Strategy – DE supply chain strategy, analytic capabilities for acquisition program strategies

WRT-1049 Developing Capability Requirements – improving the timeliness and agility of capability requirements across acquisition pathways

WRT-1043 DAU Simulation – embedding MBSE/M&S competencies, simulations into DAU courseware\

WRT-1058: Program Managers Guide To Digital And Agile Systems Engineering Process Transformation

WRT-1058 Systems Engineering Modernization Policy, Practice, And Workforce Roadmaps
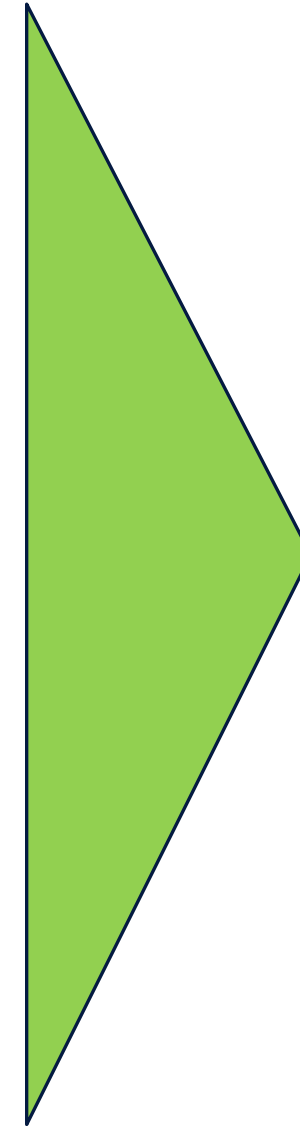
A Framework to Guide Decisions for Program Managers and PEOs

DoD Digital Acquisition Thread Reference Architecture Concept

"Exemplar Digital Acquisition Thread" Challenges and Results

Mission and Purpose	Desired Results	Stakeholders / Sponsors / Collaborators

Why "Exemplar Digital Acquisition Thread" project?
SE Modernization pain points:
A. Digital Processes and Products (Digital Acquisition / E-Programs)
B. Enterprise Systems Engineering approach integrating:
  1. Five key areas: DE/MOSA/SWE/CID/ME
  2. Collaboration and Data Sharing challenges between Government and Industry
  3. Digital Tools / Methods
  4. Role of Reference Architecture
Desired Result: A Digital Acquisition Thread Reference Architecture and Examples with Digital Artifacts for each RA Element.
	GOALS:
	A. Create a government reference architecture for a cross-continuum digital acquisition thread.
	B. Collect exemplar reference architecture elements from mission partners, industry, and academia.
	C. Share exemplar acquisition thread with the community for education, training, and re-use.
	D. E-SEP: native digital systems engineering plan model with mission critical interfaces for data sharing
	SUCCESS STATEMENT:
	A. Deliver a digital acquisition thread reference architecture hosed on DoD web site and incorporated into training materials and workshops for the community.
	B. Reference architecture element models, formats, interfaces, etc. are collected and hosted on appropriate sources of truth.
		Customer: OUSD R&E, Nadine Geier
		Who Benefits? DoD Acquisition Teams, ASD(A), DoD CIO
		Team: OUSD R&E, SERC, DAU, NDIA SED Committees, Mission Partners, and other DoD Agencies.

Measures of Success	Accomplishments
1. **SERC SEMOD workshops established survey questions and guidance for broader audience offering and feedback** 2. DoD ASoT owners are identified with interface APIs cataloged. (NDAA21 Tasker 804.c.) 3. Digital Acquisition Thread Pilot with exemplar mission partners. 4. NDIA Project Team & OUSD R&E iteratively develops Digital Acquisition Thread Reference Architecture 5. NDIA delivers a digital acquisition thread reference architecture 6. Collected exemplar digital artifacts are hosted by DoD for education, training, and re-use. 7. 25th Annual Systems and Mission Engineering Conference (ndia.org) **Panel Discussion: Systems Engineering Modernization (SEMod) Key Enablers for System Development on DoD Programs"** on lessons learned and next steps for continuous improvement (11/3 1100-1200 Eastern)	1. **DAU** Systems Engineering Modernization (SEMod) - Defense Acquisition University (dau.edu) **Series added to DAU Events for webcasts and training reuse.** 2. **DAU SEMod Key Enabler Workshops:** WSE 028 Mission Engineering (ME) Awareness and Planning (dau.edu) and WSE 027 Modular Open Systems Approach (MOSA) Awareness and Planning Workshop (dau.edu) created in response to mission partner requests. CM workshop in development 3. Exemplar Mission Partners: AFSOC MAC, MCSC, AFC DE Cop, NAWCAD, PEO-IEWS, PEO-EIS, PEO-AVN, NAVWAR, ASA (ALT), ASN (RDA), DISA, … 4. Big challenge for DoD, work around for training provided by NPS sharing their GitLab for "DoD Reuse and Sharing Training Program Artifacts" 5. What needs work? DoD public sharing policy and process. (Update for digital artifacts) 6. OMG UAF Working Group – Model Based Acquisition - RFP and Response plus 7. NPS GitLab: To be shared – Skyzer, Silverfish, CUI WOSA.mdzip, MITRE 5000 model, DAU Bulldog 8. What needs work? NDAA21 tasker: Were interface models considered rather than "documents?

![DAU logo] **Deeper Learning**

![NDIA AT THE HEART logo]

- Defense Acquisition University
- Tools Catalog
- SE Brainbook
- **Configuration Management**

LOG 2040 Configuration Management

MIL-HDBK-61 07APR2020

MODULAR OPEN SYSTEMS APPROACH

DEFENSE STANDARDIZATION PROGRAM
MAKING SYSTEMS WORK TOGETHER

CLE 019 Modular Open Systems Approach

WSE 027 Modular Open Systems Approach (MOSA) Awareness and Planning Workshop

DIGITAL ENGINEERING

CLE 084 Models, Simulations, and Digital Engineering

ETM 1070 Digital Literacy Fundamentals

ETM 2070V Digital Literacy for Practitioners

Digital Engineering (DE) Measurement Framework

SEMod

(CM, MOSA, DE, ME, CID (Agile))

DAU Agile, Cloud, Cyber and DevSecOps courses and workshops

Continuous Iterative Development (*Agile*) Measurement Framework

MISSION ENGINEERING

ETM 1020 Mission and Systems Thinking Fundamentals

ETM 2020V Mission and Systems Thinking for Practitioners

WSE 028 Mission Engineering (ME) Awareness and Planning (dau.edu)
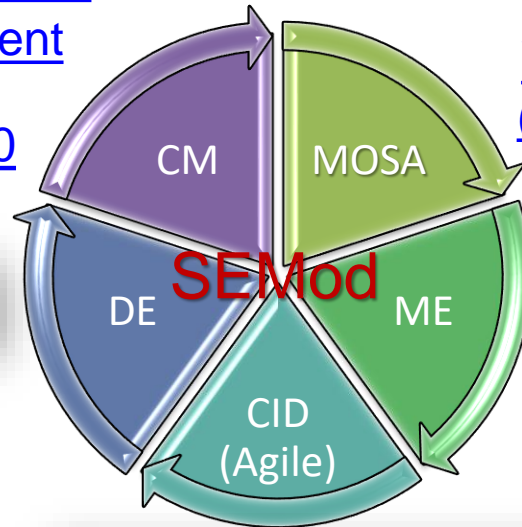
Systems Engineering Modernization Workbook | Rise 360 (articulate.com)

SYSTEMS ENGINEERING MODERNIZATION
June 21, 2022

Systems Engineering Modernization (SEMod) - Join this series to learn about the key enablers to modernize Systems Engineering including digital engineering, mission engineering, modular open systems approach, continuous iterative development, modern software and development methods (Agile, DevSecOps, Scrum, SAFe), and lead systems integrator. Series format is delivered live with attendee questions & answers and discussion from participants and recorded for future use.

- Established April 2022 for first SEMod key enabler, "SCRUM Implementation for Army Lessons Learned," *Linda O. Jones*, Ph.D. PM Defensive Cyber Operations (DCO) Cyber Analytics and Detection (CAD) Deputy Product Manager, CAD

- Second in series, "Government Lead Systems Integrator Benefits and Fundamentals," *Gerald Swift*, Director, AIRWorks, Naval Air Warfare Center Aircraft Division, *Christa Rodewald-Franz*, Deputy Director, AIRWorks, Naval Air Warfare Center Aircraft Division, and *Scott Hoffman*, Chief Engineer, AIRWorks, Naval Air Warfare Center Aircraft Division

- September 29th (1300-1430 Eastern) next in series, "organic Lead Systems Integrator (oLSI)," *David Hager*, Technical Director, Naval Air Warfare Center Aircraft Division Webster Outlying Field, and *Israel Jordan*, Technical Initiatives & Strategy Director, Naval Air Warfare Center Aircraft Division Webster Outlying Field https://www.dau.edu/event/organic_Lead_Systems_Integrator

- Planning: NAVWAR CM Guidance, PEO-IEWS MOSA Guidance, MCSC ME Guidance, Boeing Global Sales BD/Navy-Gov Ops, MITRE

- Contact Robert.Raygan@dau.edu to become a part of the series.

- Systems Engineering Modernization Workbook | Rise 360 (articulate.com)
  - WSE027 Modular Open Systems Approach (MOSA) Workbook | Rise 360 (articulate.com)
  - WSE 028 Mission Engineering (ME) Workbook - Overview | Rise 360 (articulate.com)
  - DAU Agile, Cloud, Cyber and DevSecOps courses and workshops - Overview | Rise 360 (articulate.com)

Distribution Statement A. Approved for public release. Distribution is unlimited. Case # 22-S-3012

29