SYSTEMS ENGINEERING RESEARCH CENTER

Systems Engineering Modernization Across the Lifecycle

SERC SEMOD Lifecycle Mental Model

WRT-1051/1059 Systems Engineering Modernization

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SE Modernization Problem Statement

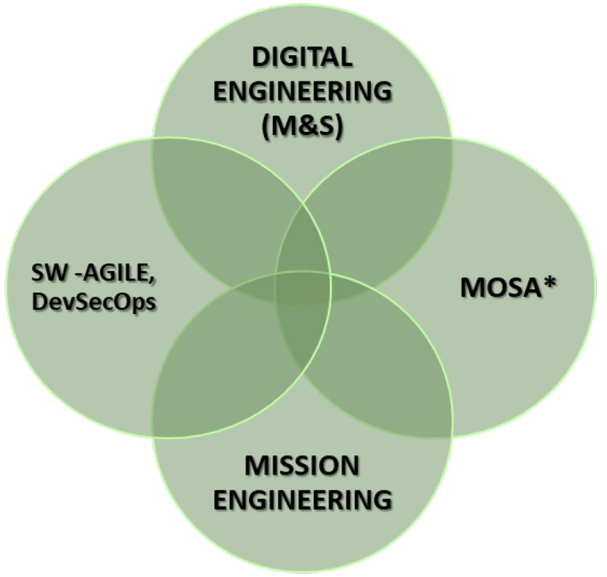
SE Modernization Problem Statement

"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."

Cross-Cutting Key Enablers

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

SE Modernization Focus Areas (Initial Scope)



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

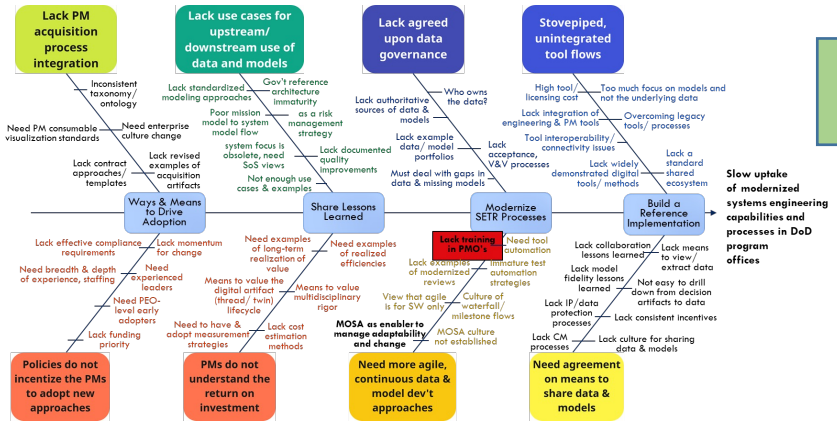
COLLABORATION

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 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

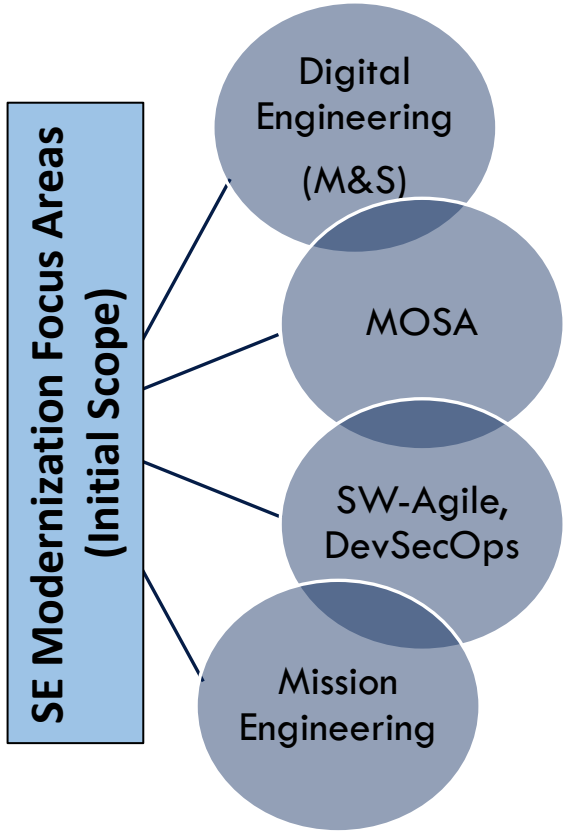
EACH PAIN POINT ADDRESSED BY MULTIPLE LINES OF EFFORT

SERC SEMOD GOALS

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.

SE Modernization: Broad Synergy with Other SERC/AIRC Efforts



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

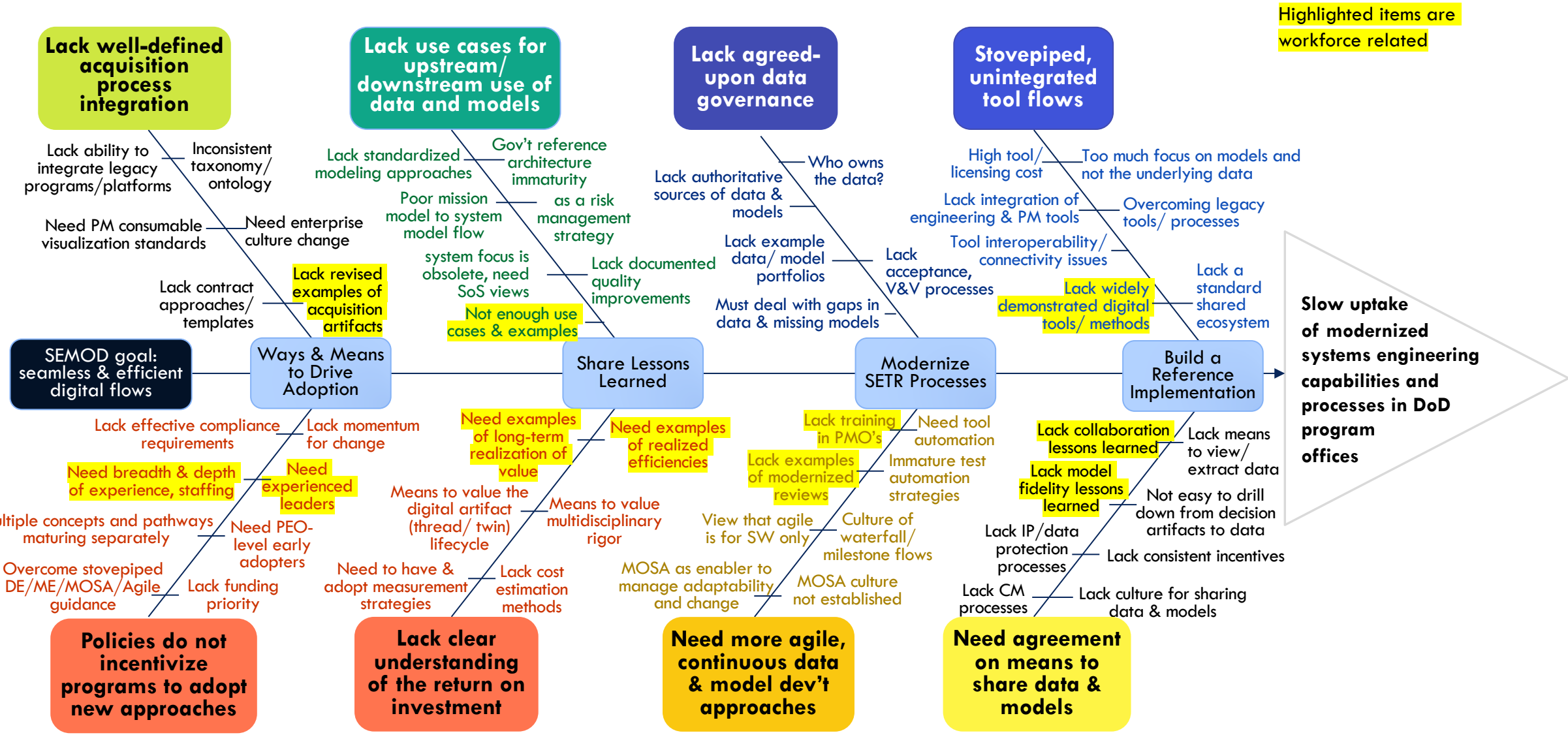
WRT-1058 Systems Engineering Modernization Policy, Practice, And Workforce Roadmaps

A Framework to Guide Decisions for Program Managers and PEOs

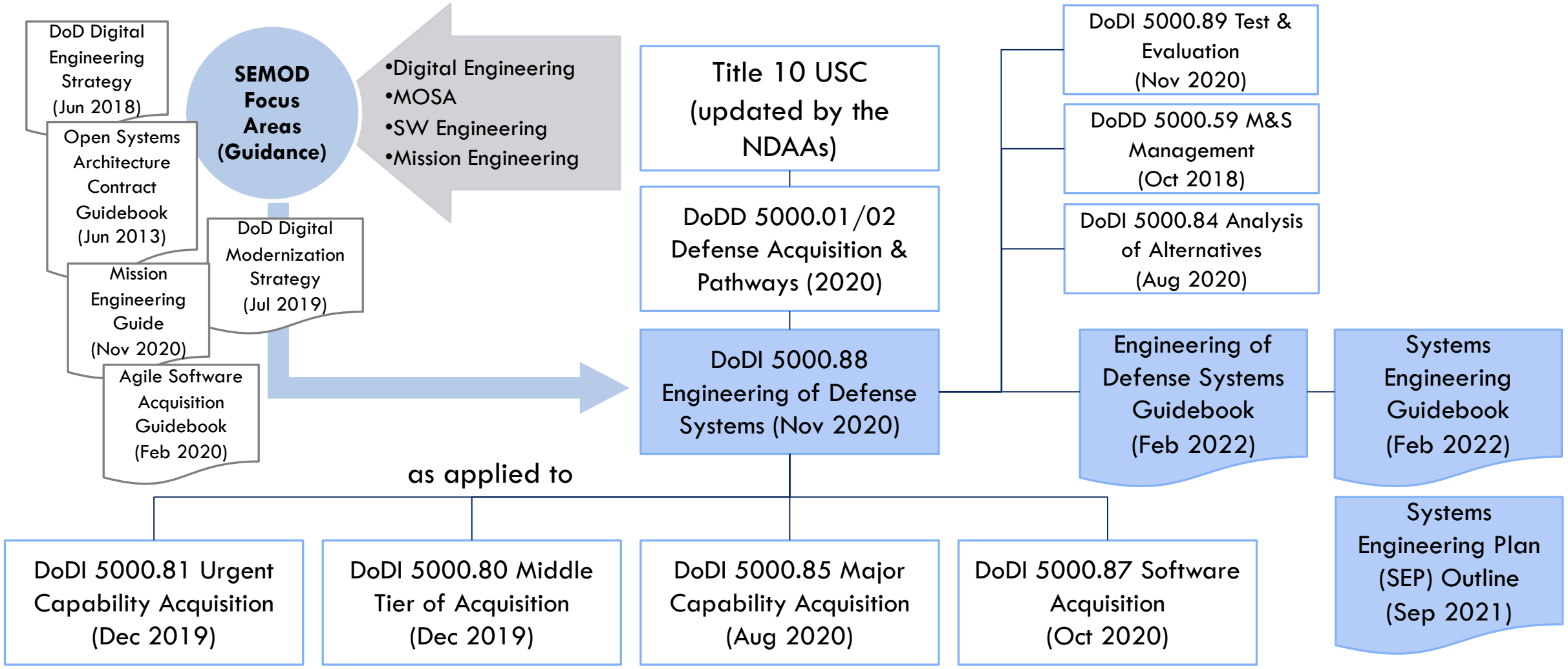
SEMOD Pain Points

- 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



POLICY DERIVATION



FOCUS AREA INTEGRATION – INTENT OF POLICY AND GUIDANCE

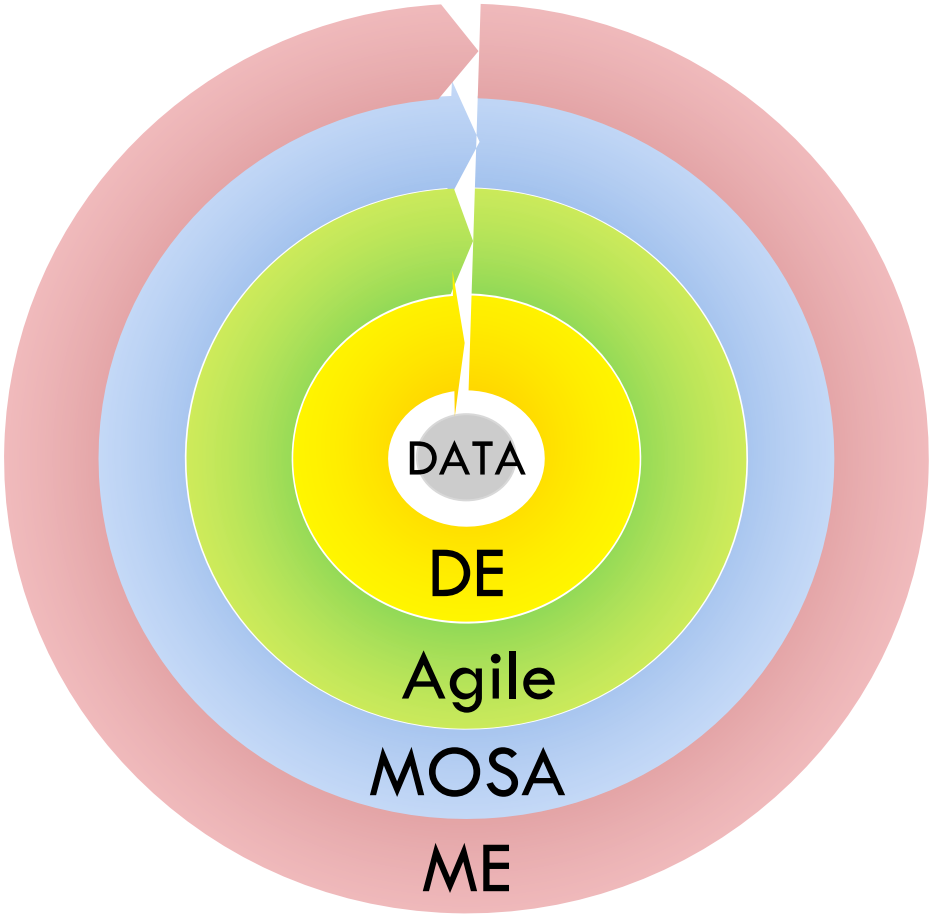
Digital Engineering (DE): implement "an integrated digital approach that uses authoritative sources of system data and models as a continuum across disciplines to support lifecycle activities from concept through disposal." Enabler to manage lifecycle efficiency.

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.

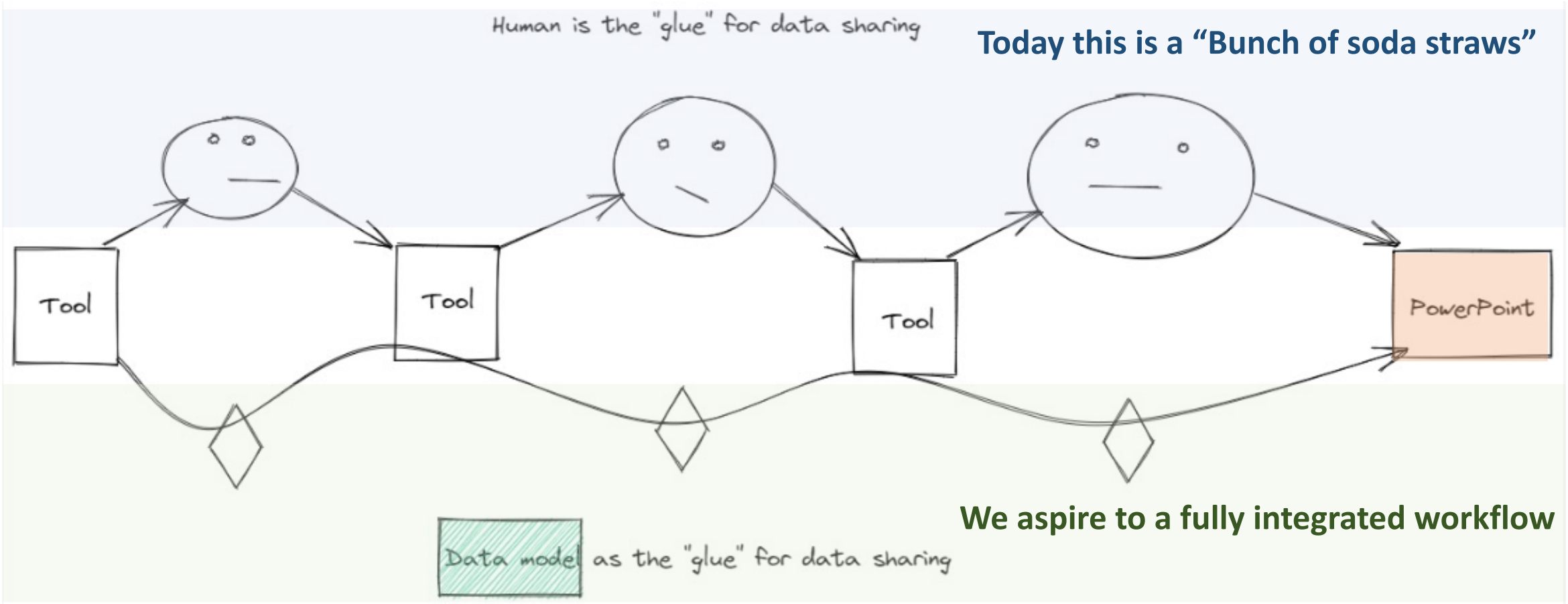
Mission Engineering (ME): continually provide engineered mission-based outputs to inform requirements, prototypes, design, and investment. Enabler to manage portfolios.

DoD Data Strategy: "data as a strategic asset"



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

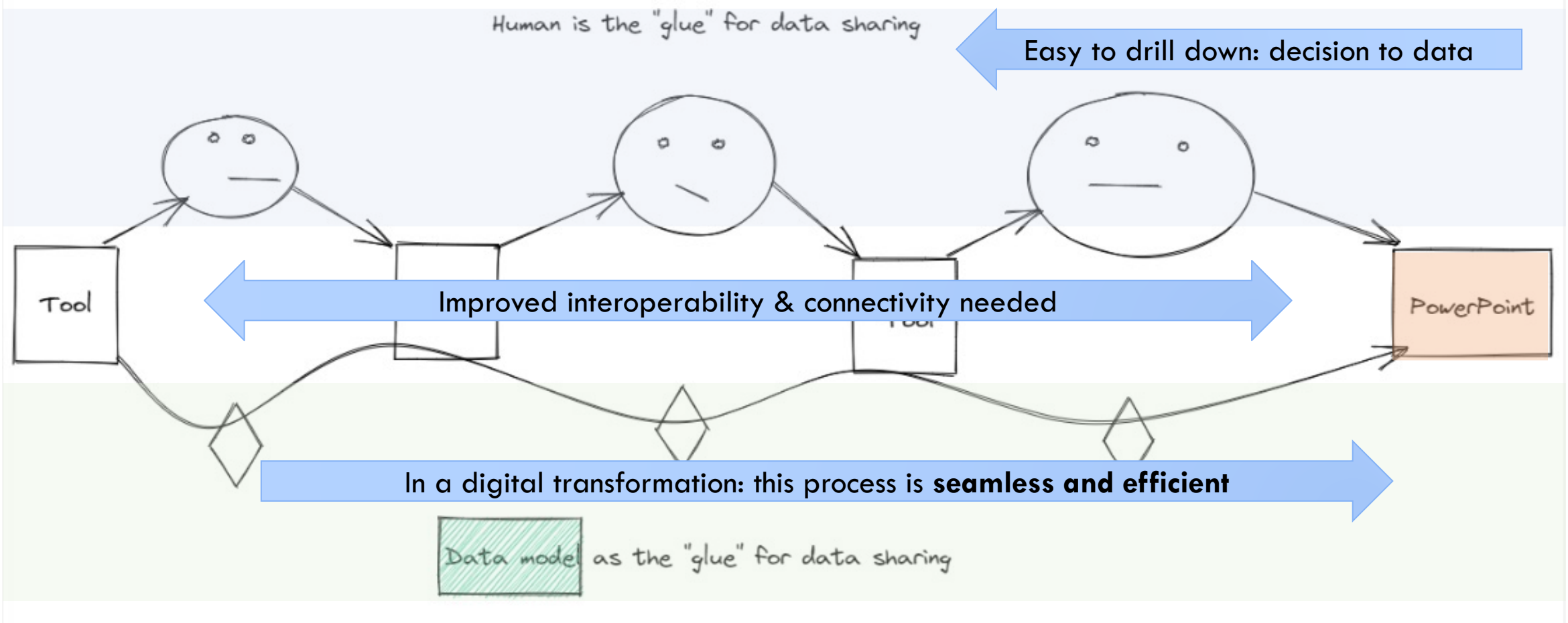
Conceptual View: Digital Artifact Development



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.

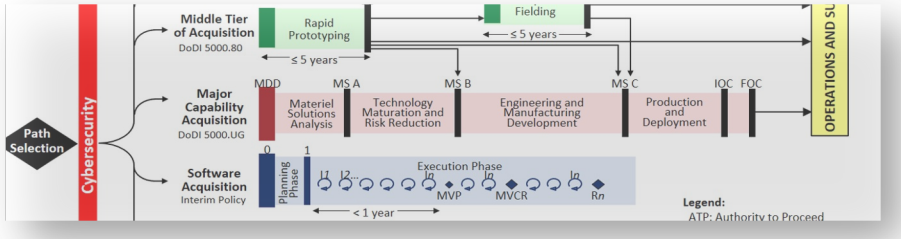
WHERE WE NEED TO BE

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



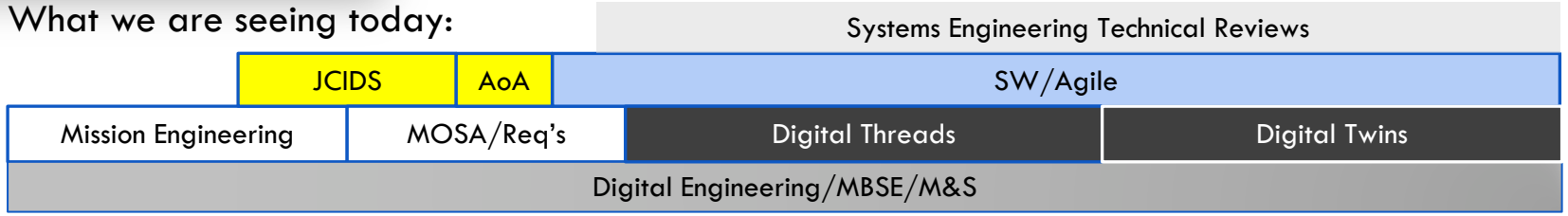
Lack of an integrated approach is creating a delay in full implementation of the Digital Transformation

DATA TRANSFORMATION INTO DIGITAL ARTIFACTS

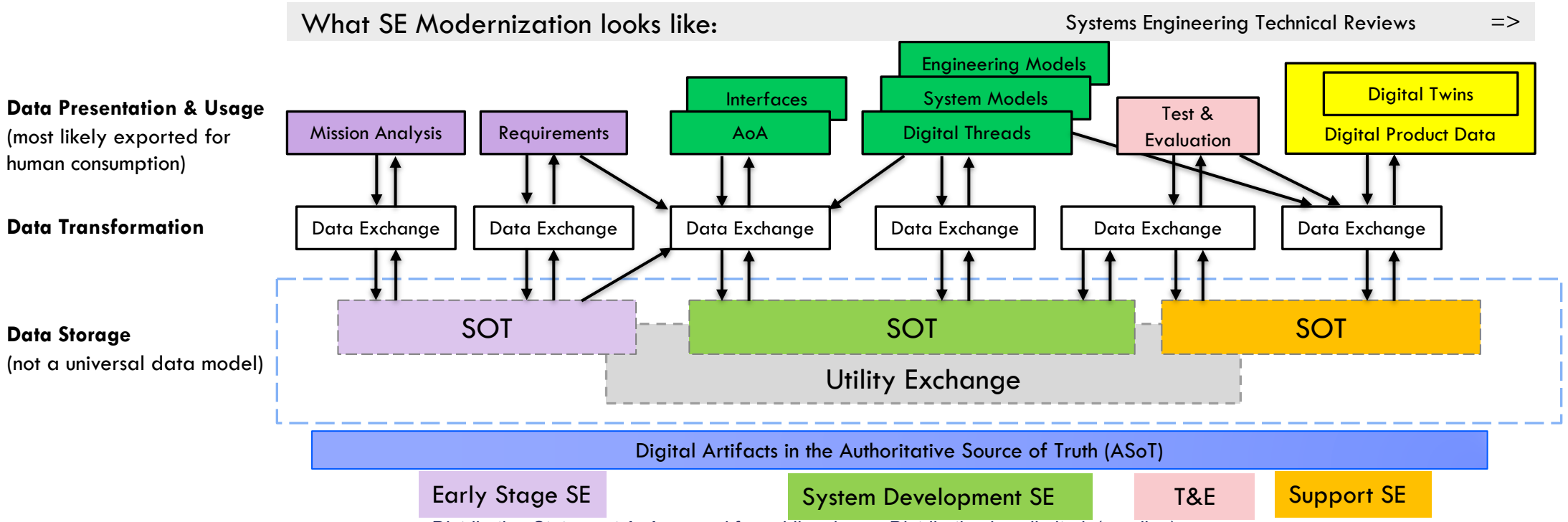


Per the Digital Engineering strategy, this view recognizes data forms the core – but the process view still needs to be continuous

What we are seeing today:



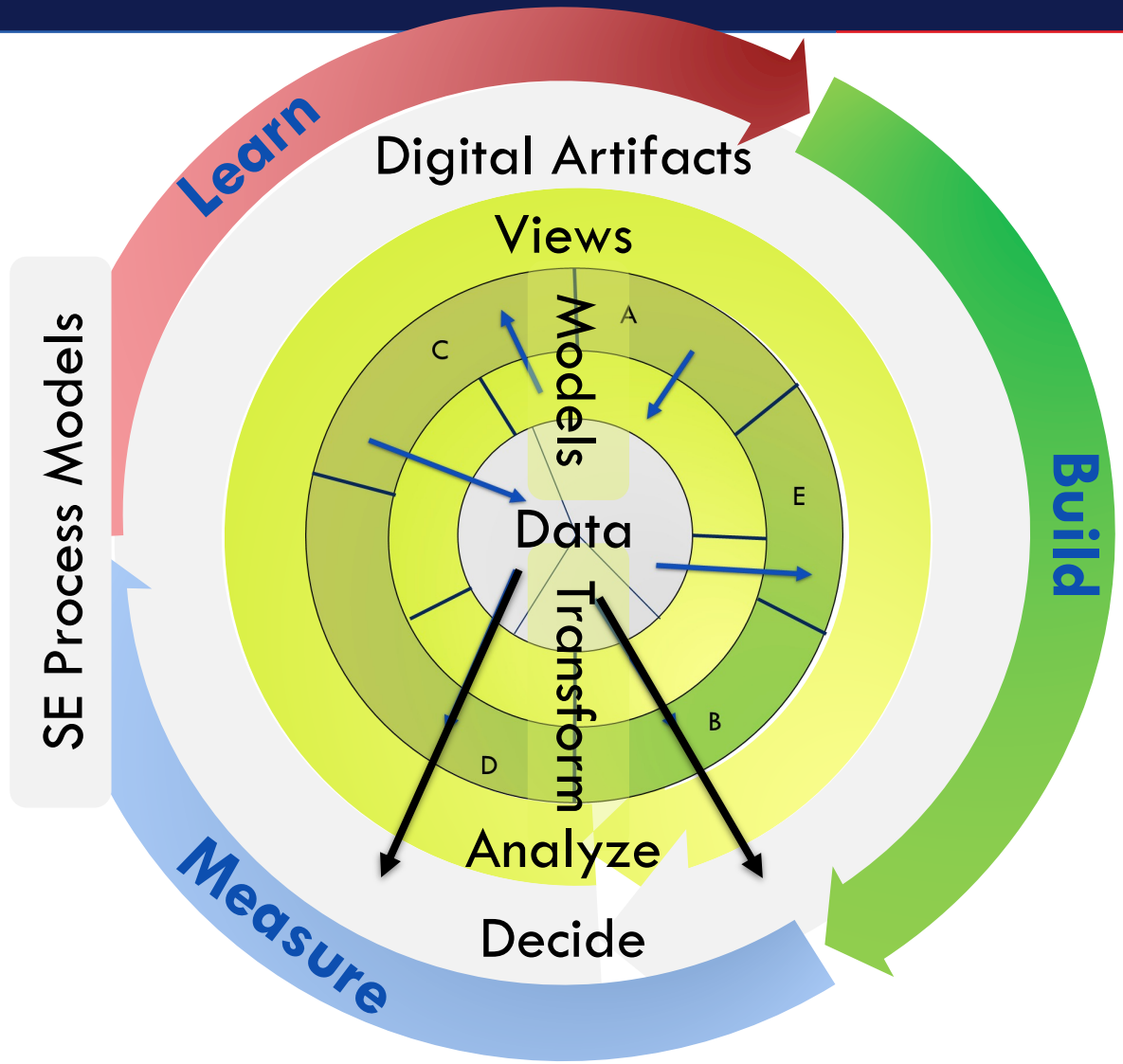
What SE Modernization looks like:



A Revised Mental Model of the Systems Engineering Lifecycle

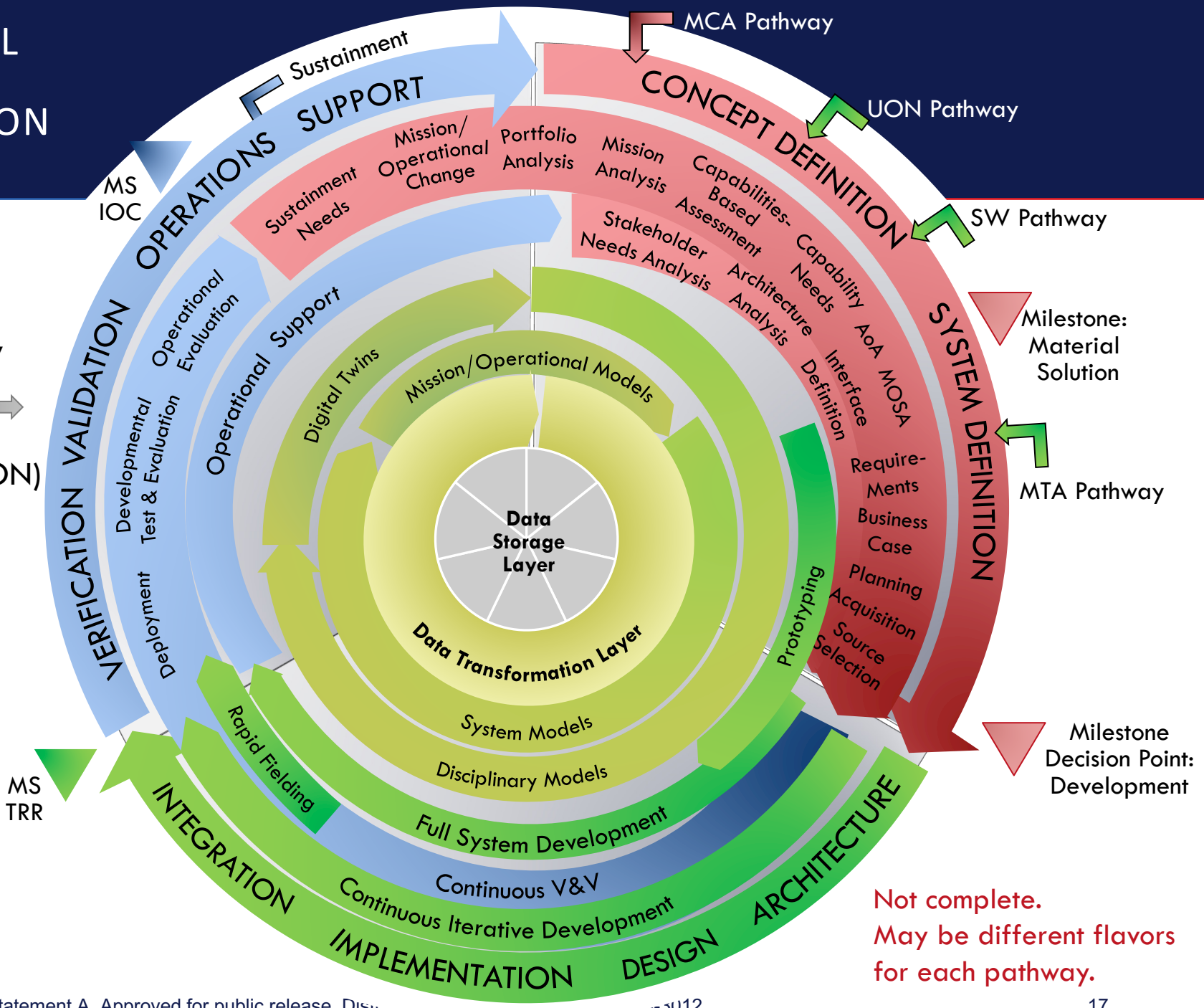
- SEMOD redraws the stages of the SE Lifecycle in a circular process to represent it as:
  1) data transformations at the core
  2) layered across disciplines & tasks
  3) continuous processes that could be entered from any point

- Data is transformed through Models into Decision Artifacts
- Data remains accessible via Decision Artifacts



NOTIONAL VIEW: FULL SE MODERNIZATION LIFECYCLE INTEGRATION FRAMEWORK

- 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)



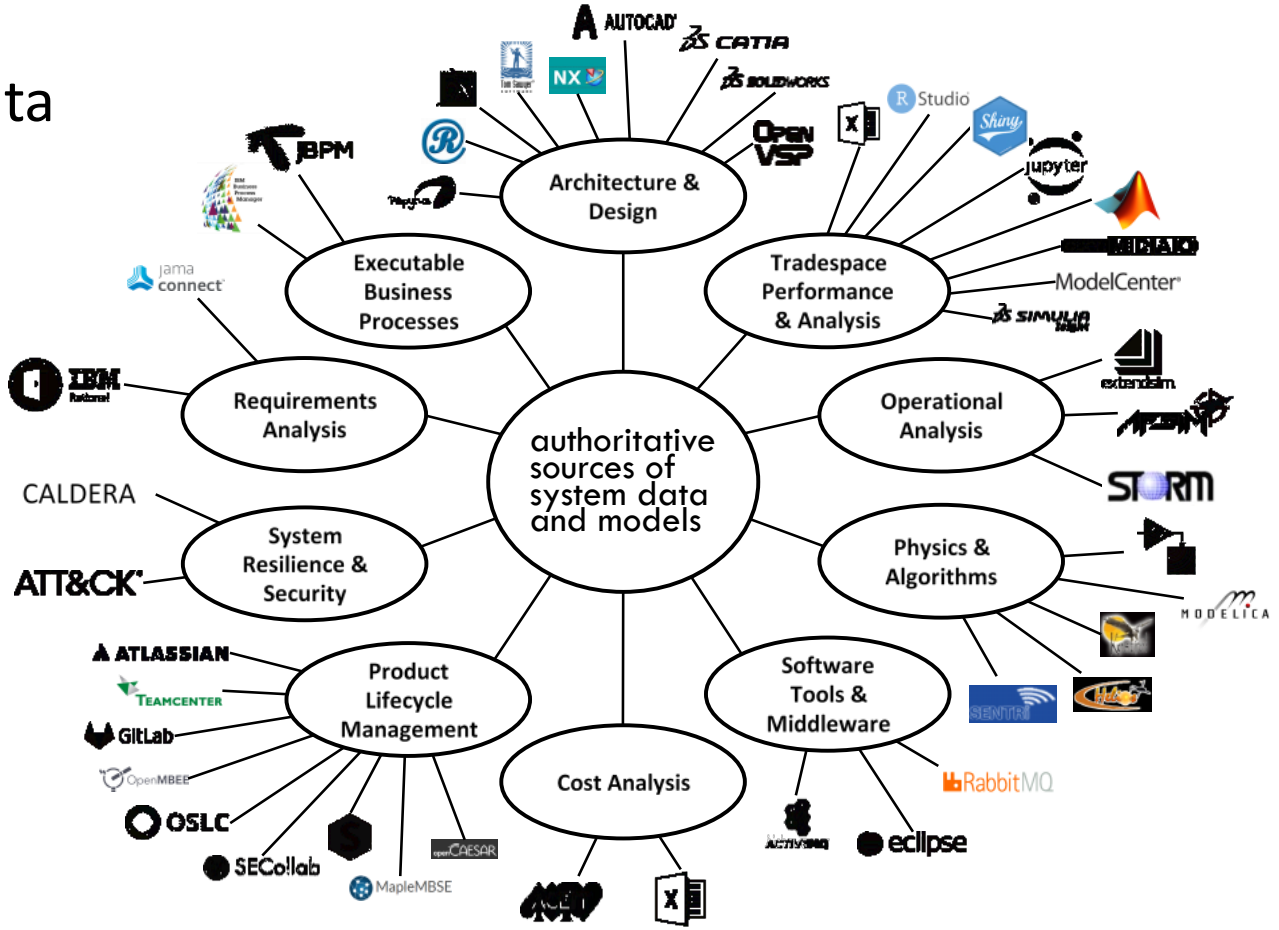
Not complete.
May be different flavors for each pathway.

Need Exemplar Reference Implementations

The DoD's future of genuinely integrated digital engineering modernization will depend heavily on establishing managed authoritative high-confidence data sources, typically known as authoritative sources of system data and models, and the means to have it used throughout the enterprise.

These should use known, standards-based data exchange mechanisms, not peer-to-peer proprietary vendor interfaces.

Recommend establishing exemplar reference implementations producing a physical, digital engineering and acquisition environment to mature data standards, establishing data exchange methodologies between applications, and baselining the needed interface capabilities.



SUMMARY

- 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

Workforce Development
Planned FY22/23 SE Modernization Workshops/Webinars

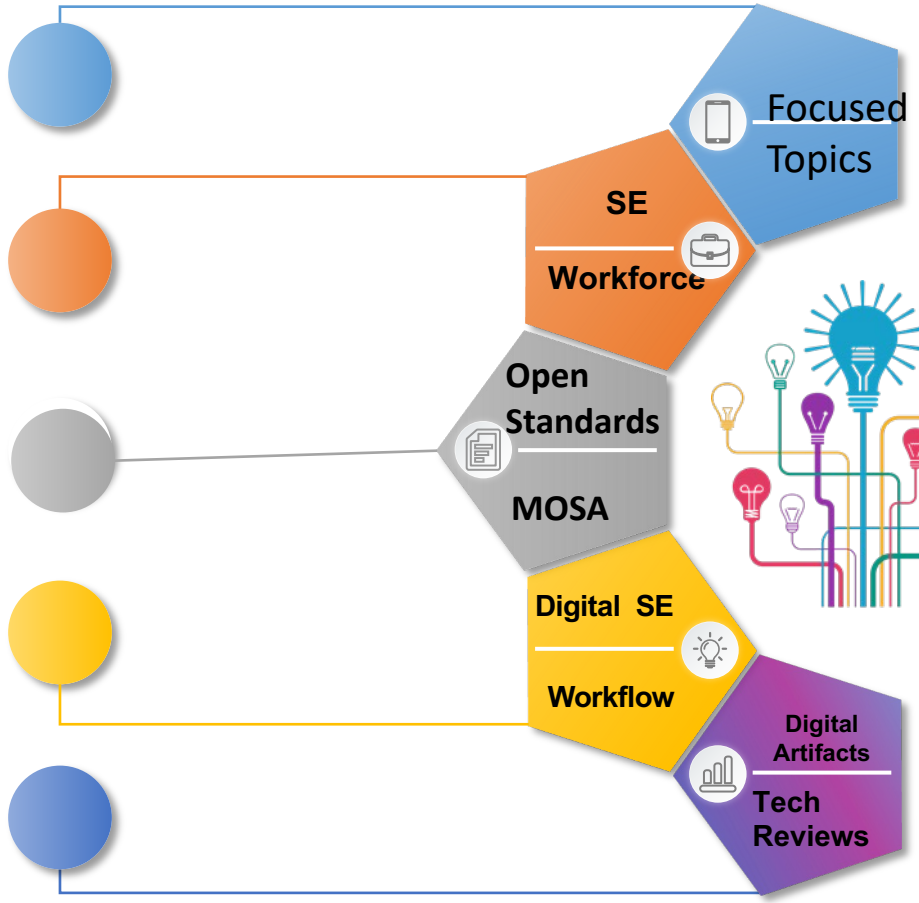
Specialty – **Focused Topics**: Digital T&E – R&M – Mission Engineering – Contracting for Digital Artifacts – Use of Reference Architecture

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



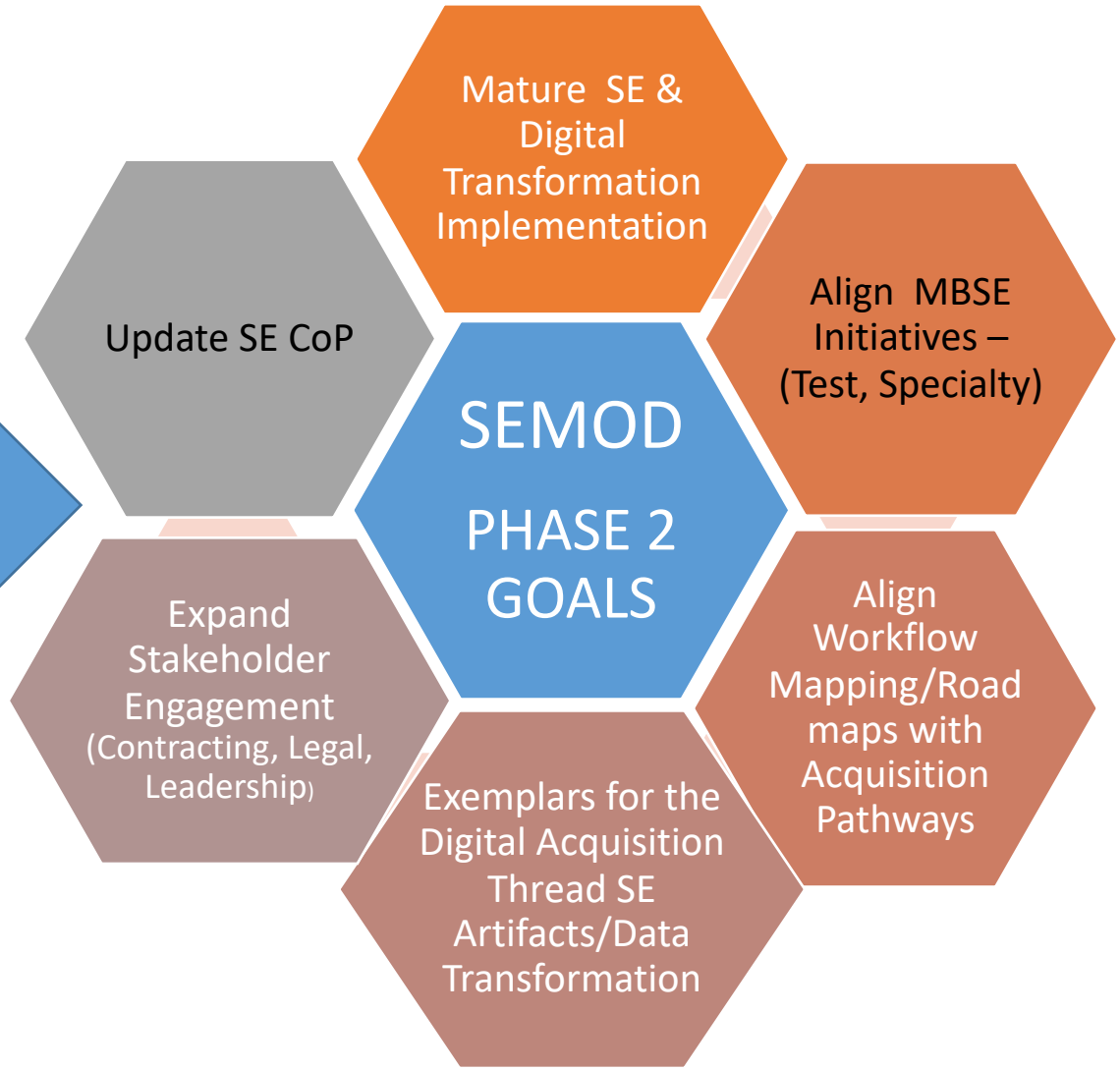
Ongoing collaboration with Engineering Technical Management Functional Integration Team to develop SE Credentials

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



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