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Digital Engineering in Military Systems Integration

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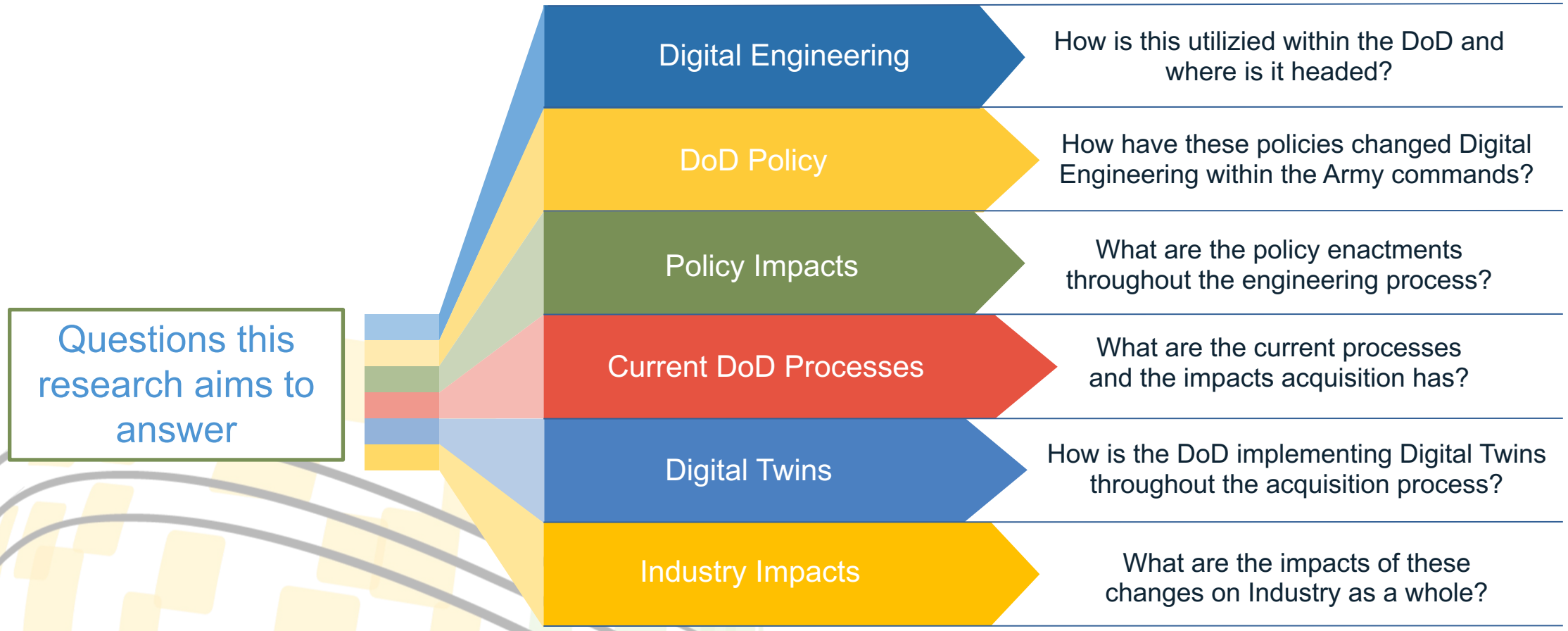
Overview

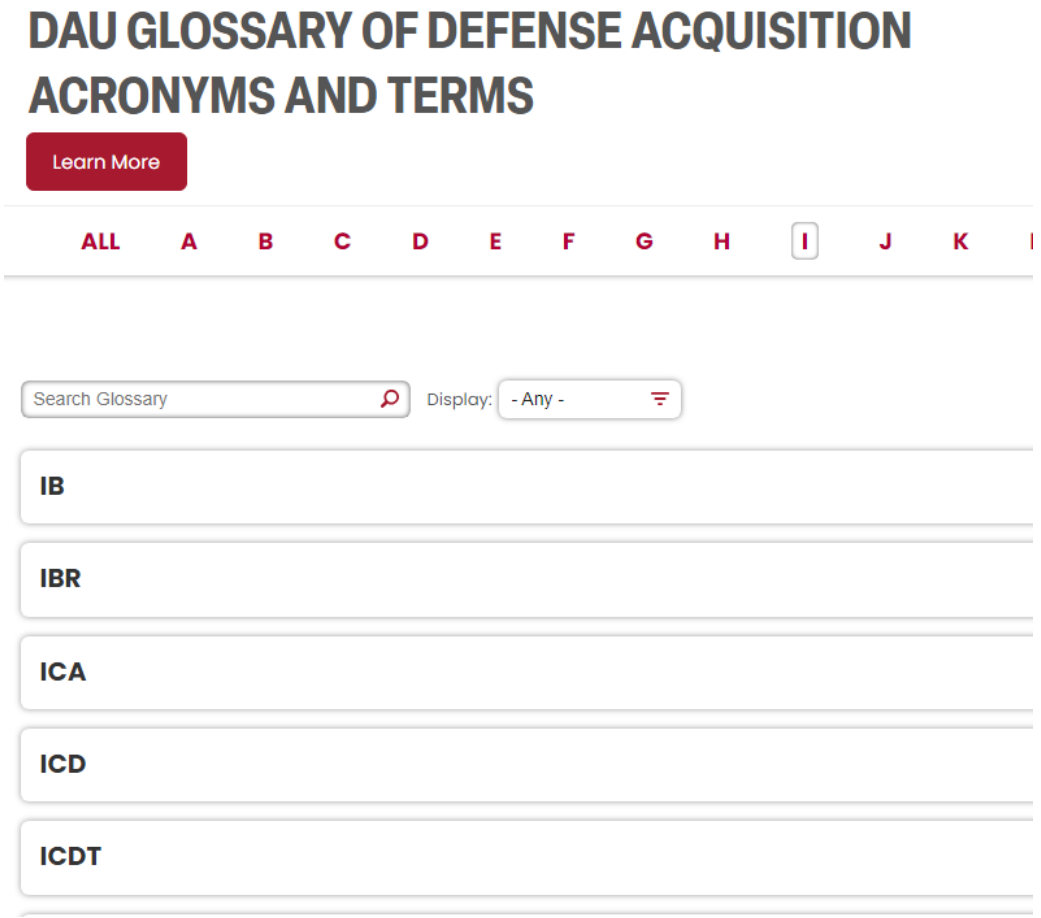
- Introduction and Motivation
- DoD SE Policy
- Digital Engineering within DoD
- Military Systems Integration Labs
- Industry Impacts
- Conclusions and Future Work

Introduction and Motivation



Acronyms

- DAU – Defense Acquisition University
- DoD – Department of Defense
- OSD – Office of the Under Secretary of Defense for Research and Engineering
- SILs – Systems Integration Labs
- MOSA – Modular Open System Approach
- RA – Reference Architecture
- DEWS – Directed Energy Weapon Systems



Source: DAU Glossary, 2024

DoD Policies

Digital Engineering Definitions

- Digital Engineering Strategy

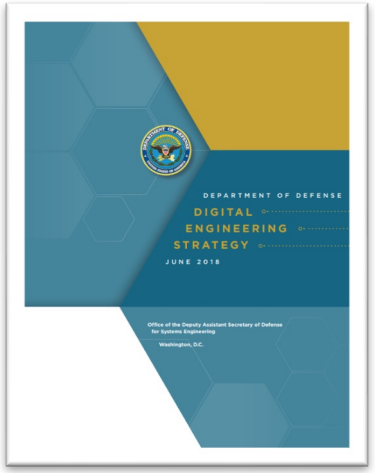
  "An integrated digital approach that uses authoritative sources of systems' data and models as a continuum across disciplines to support lifecycle activities from concept through disposal."

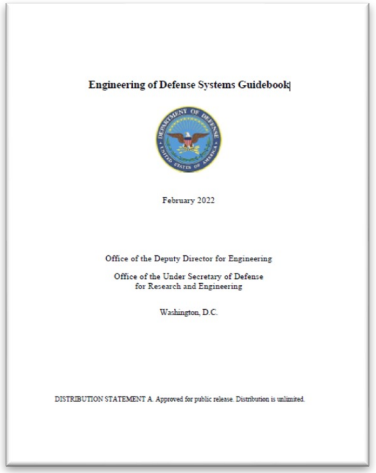
- DoD 5000.97

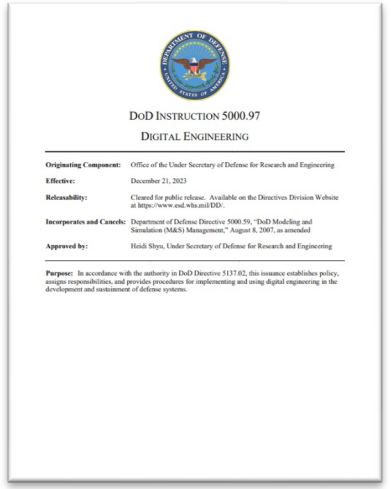
  "Digital engineering is a means of using and integrating digital models and the underlying data to support the development, test and evaluation, and sustainment of a system. The June 2018 DoD Digital Engineering Strategy describes how the application of digital engineering can modernize how the DoD designs, develops, delivers, operates, and sustains systems"

DoD Policy Background

- 2018: Digital Engineering Strategy
- 2019: DoD Digital Modernization Strategy
- 2022: DoD Engineering of Defense Systems Guidebook
- 2023: Digital Engineering Policy for Practice (5000.97)



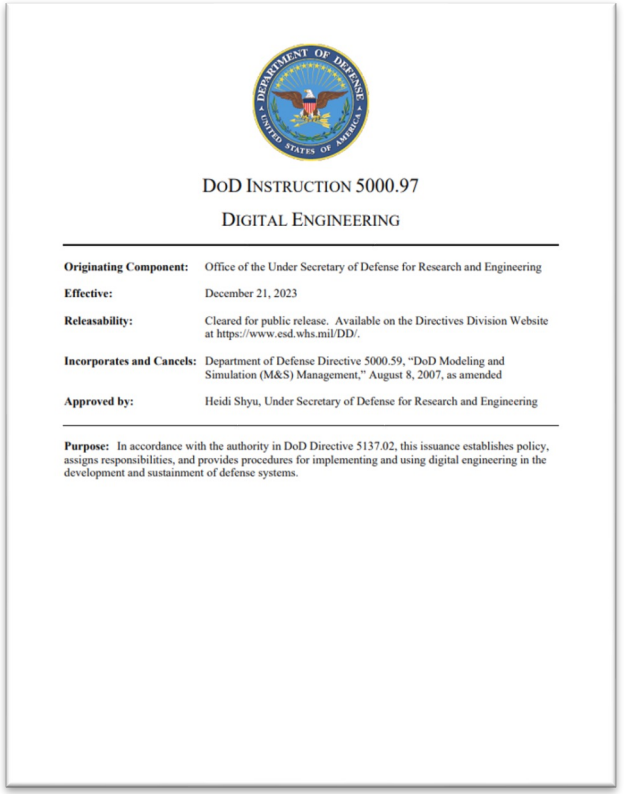




5000.97 Focus

What's changed?

- Updated December 2023
- Expanded on the 2018 DE Strategy
- Outlines DE Capabilities Requirements, Elements, and Implementation



DoD INSTRUCTION 5000.97

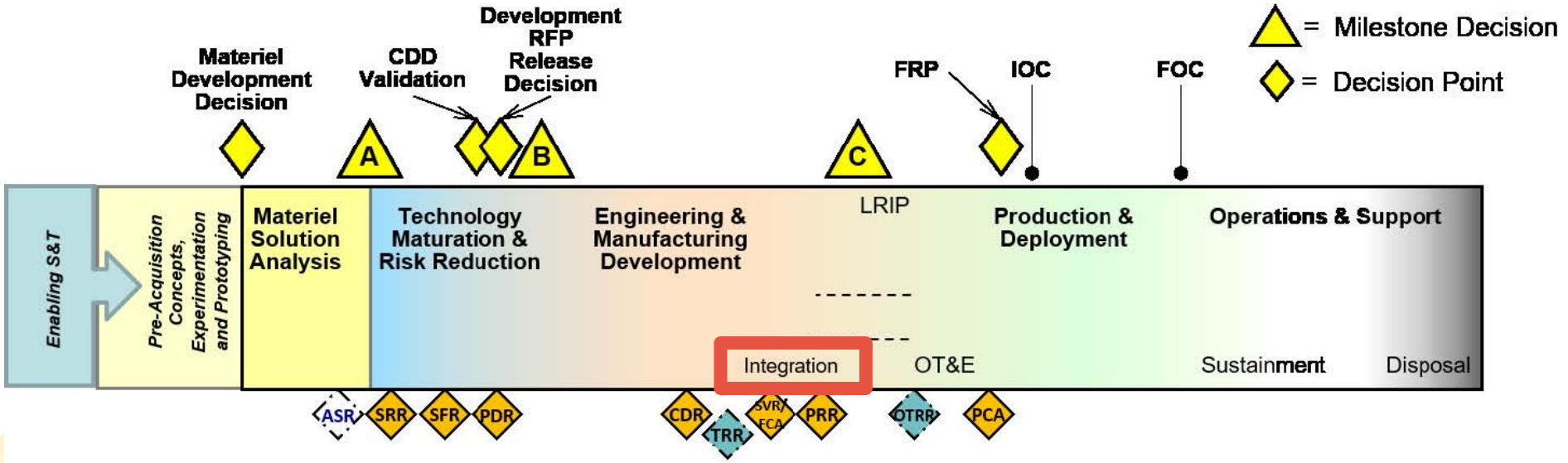
DIGITAL ENGINEERING

Originating Component:	Office of the Under Secretary of Defense for Research and Engineering
Effective:	December 21, 2023
Releasability:	Cleared for public release. Available on the Directives Division Website at https://www.esd.whs.mil/DD/.
Incorporates and Cancels:	Department of Defense Directive 5000.59, "DoD Modeling and Simulation (M&S) Management," August 8, 2007, as amended
Approved by:	Heidi Shyu, Under Secretary of Defense for Research and Engineering

Purpose: In accordance with the authority in DoD Directive 5137.02, this issuance establishes policy, assigns responsibilities, and provides procedures for implementing and using digital engineering in the development and sustainment of defense systems.

Digital Engineering within DoD

Acquisition Lifecycle



ASR - Alternative Systems Review
CDR - Critical Design Review
FCA - Functional Configuration Audit
FOC - Full Operational Capability
FRP - Full-Rate Production
IOC - Initial Operational Capability
OTRR - Operational Test Readiness Review
PCA - Physical Configuration Audit
PDR - Preliminary Design Review
PRR - Production Readiness Review
SFR - System Functional Review
SRR - System Requirements Review
SVR - System Verification Review
TRR - Test Readiness Review

Mandatory technical reviews
Best practice technical reviews and audits
Test reviews (see T&E Guidance)

Notes:
- Derived from DoDI 5000.85, Major Capability Acquisition Model

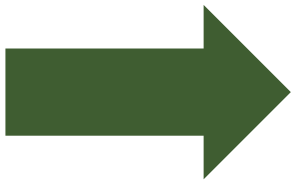
Source: DoD Engineering of Defense Systems Guidebook, February 2022

DoD Acquisition Impacts

- DoD, historically, uses traditional processes for the development of complex systems
- These processes are often linear, involving long cycle times
- The final products are often complicated to update and maintain

DE impacts on DoD systems

- DE strategies aim to transform DoD systems into more affordable, flexible, and effective systems
- Completed through defining and maintaining system architecture using DE
  - System Integration
  - Testing
  - Verification and Validation



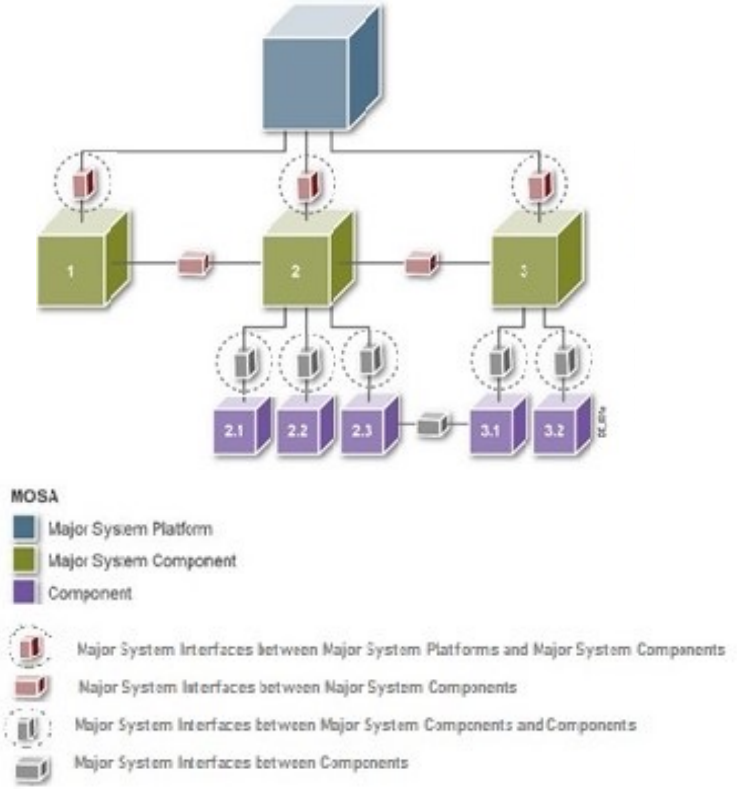
Foster streamlined transitions from early research and design through delivery

- Push for more modernization and readiness, especially in the digital space
- Implementation of DE to allow competition through the use of several vendors and solutions

Source: DoD 5000.97, December 2023

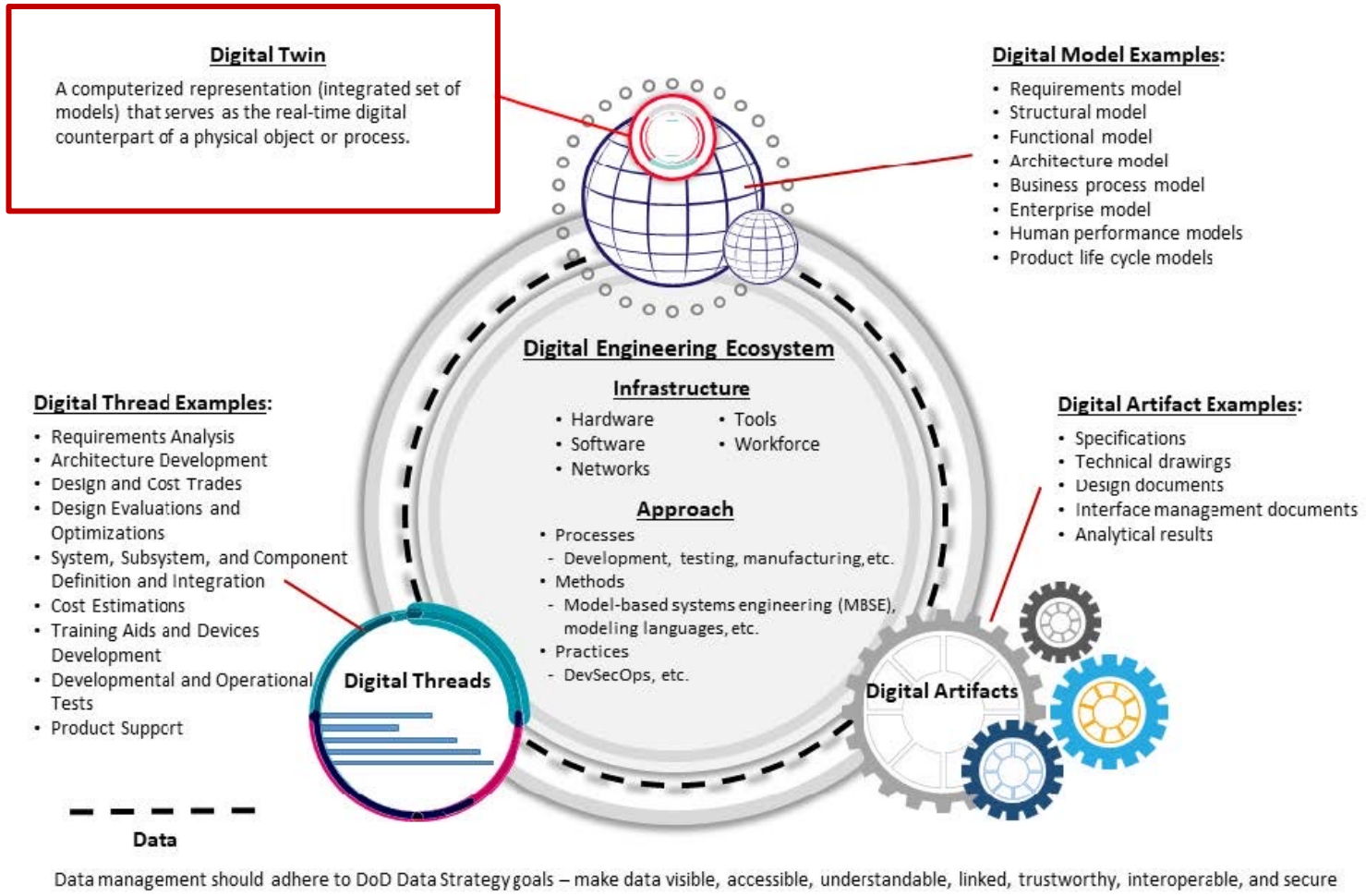
Challenges within DE Implementation

- Set architectures within ecosystems
- Legacy systems take time and resources to initially implement
- Integration of modular systems with legacy systems



Source: DoD Engineering of Defense Systems Guidebook, February 2022

DoD DE Framework



Source: DoD 5000.97, December 2023

- DoD aims to implement DE Capabilities including several integrated elements
- Digital Twins are one of the main integration plans

Systems Integration Labs (SILs)

"The Systems Integration Labs apply subject matter expertise, hardware-in-the-loop, and state-of-the-art modeling and simulation technologies for research, development, and test and evaluation applications supporting the development of prototype systems to mature technology, reduce risks and lower development and test costs"

Source: 2023 USASMDC Global Defender, 2023

Why SILs?

- Allows integration and checkout prior to testing
- Ideal for customers wanting to check-out components for integration
- Allows changes to be implemented easier

The Directed Energy Systems Integration Lab is a 5,400-square-foot facility designed to provide the Army with a consolidated capability to support a full end-to-end directed energy system, from software simulation, to subcomponent system testing, subsystem testing and full system verification and validation testing. The lab, dedicated Aug. 8, 2022, is located on Redstone Arsenal, Alabama. (U.S. Army photo by Carrie David Campbell)

Source: 2023 USASMDC Global Defender, 2023

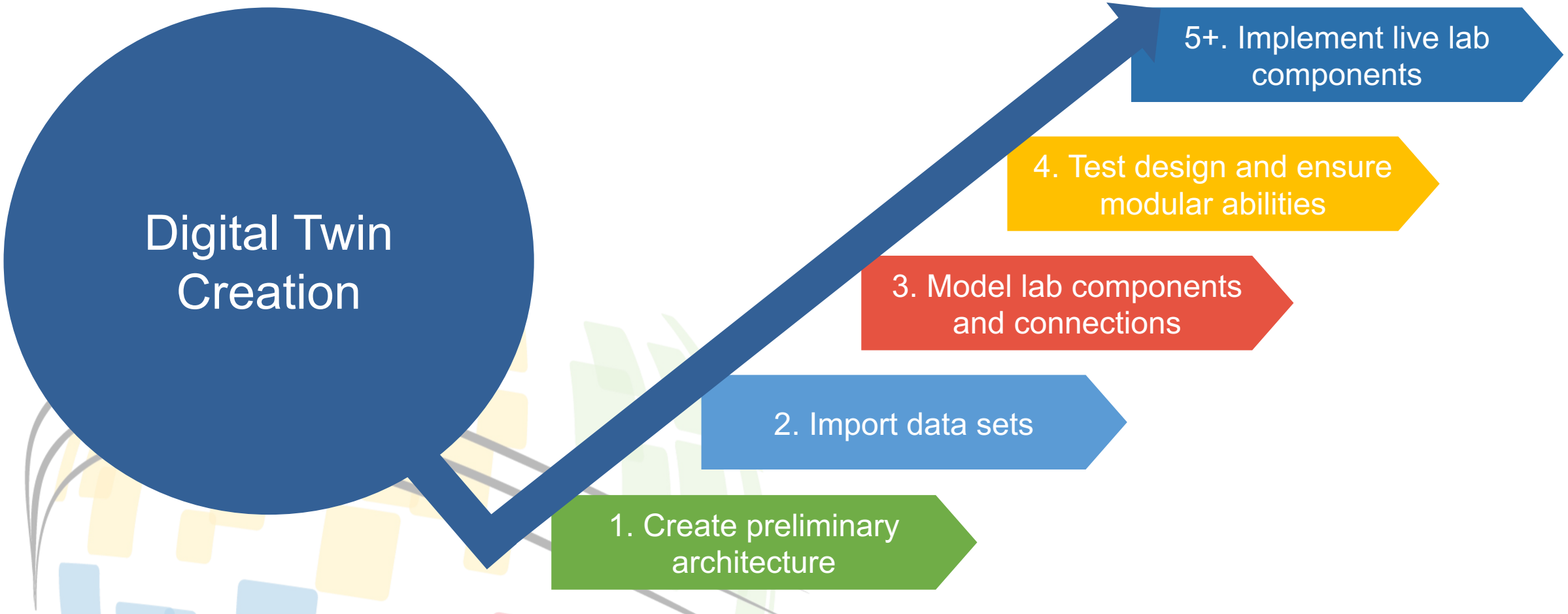
Digital Twins within SILs

DoD Definition

"A digital twin is a virtual representation of a product, system, or process that uses the best available models, sensor information, data collected from the physical system, and input data to mirror and predict system activities and performance over the life of its corresponding physical twin and inform system design changes over time."

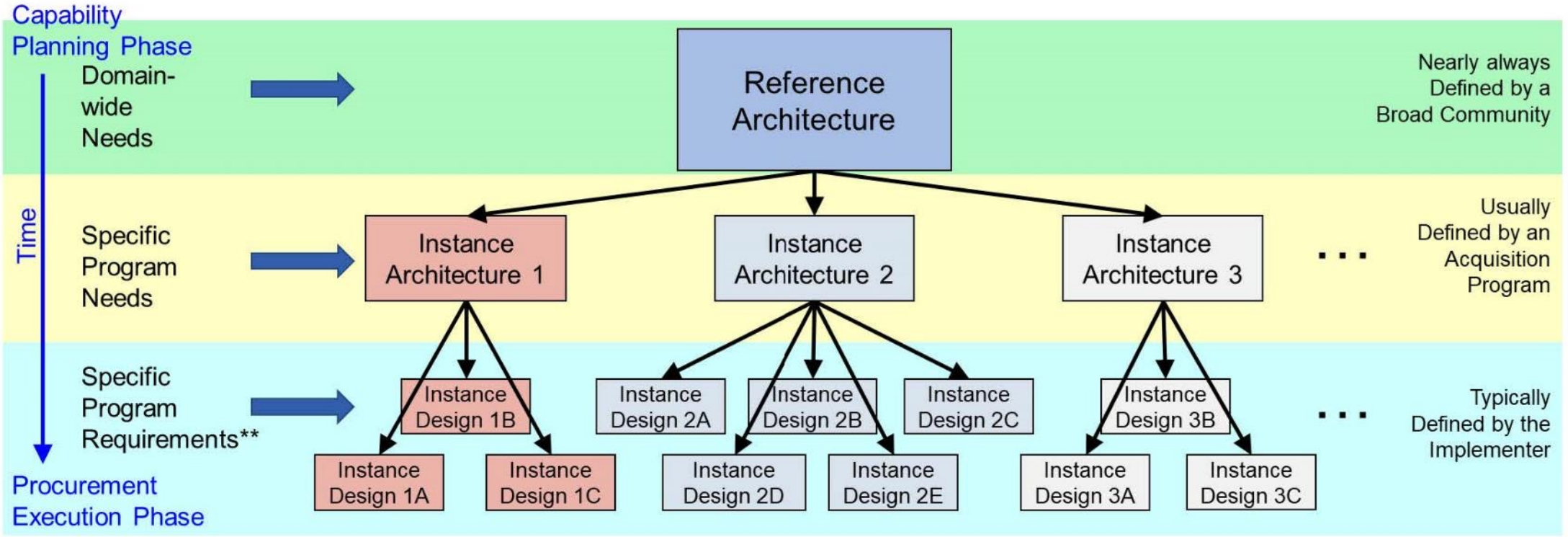
Source: DoD 5000.97, December 2023

Creating a Digital Twin



Source: DoD 5000.97, December 2023

Create Preliminary Architecture



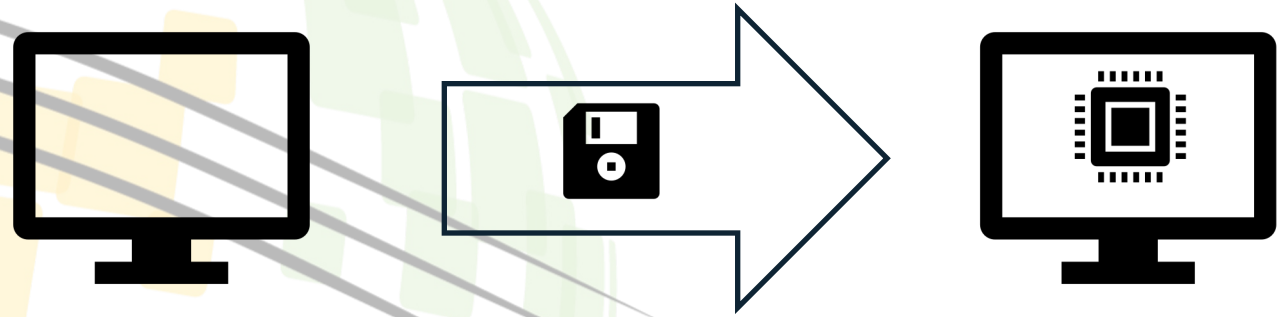
*The Reference Architecture will evolve over time as experience from its use is folded back into it
**Selection of the Implemented Design will be based on factors such as price/performance trades, SWaP, etc.

Source: Overview of the DEWS MOSA RA Powerpoint, DAU

Derived from SOSA 101

Import Data Sets

- Collecting data either from models and simulation, or through physical asset data
- Implementation of machine learning to train models

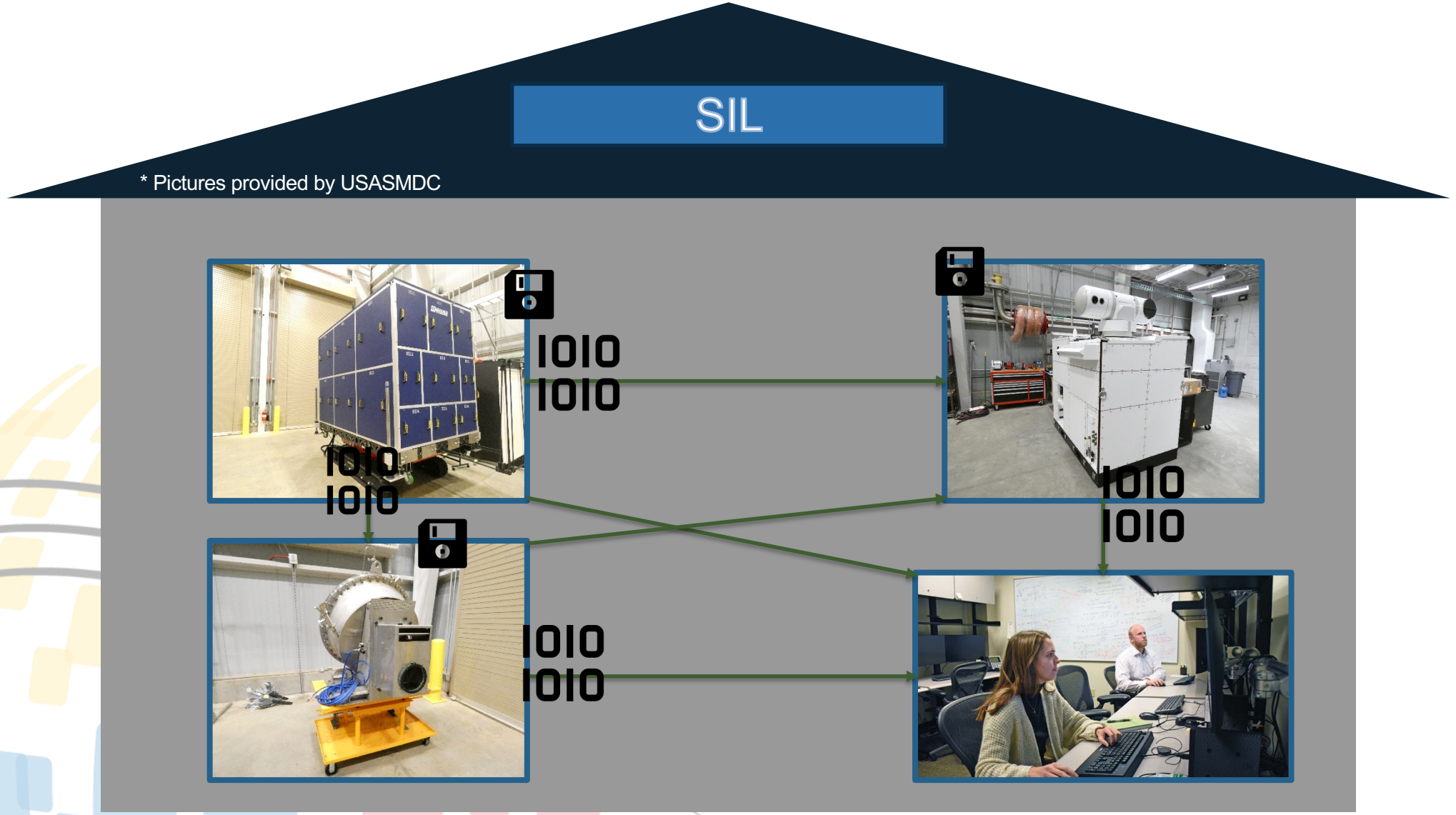


Model Lab Components

- Understand digital threads to create initial framework
- Taking real life sensors or components and mapping them into the virtual model
- Complete using SysML and modeling software
- Modeling includes the asset's materials, performance factors, and design geometry

Source: DoD Engineering of Defense Systems Guidebook, February 2022

Implement Lab Components



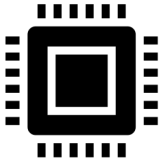
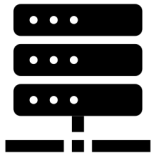
Testing Design

- Validation to see how both the digital twin and the physical asset are performing
- Sensitivity studies and impact analyses
  - Is the model allowing modular application?
  - Can the digital twin implement changes quickly?
  - Are efficiencies changing comparatively?

SILs and Industry

- In military industries, digital twins of SILs will push standards and architectures for industry to use
- For other industries, seeing how digital twins and reference architectures can be used in their spaces

SIL Digital Twin Examples

- Sub-Component 
- Component 
- System of Systems 
- Personnel/Resources 

INCOSE 2035

Source: INCOSE 2035, 2021

- Looking into the future, there are several areas that systems engineering is growing
- As technologies change, the modular approach in our development will allow for easy implementation

Next Research Steps

- Preliminary plans for our research and implementation of a lab wide digital twin
- Look into adding Artificial Intelligence and other DoD focuses
- Investigating social impacts and their processes

Source: 2024 USASMDC Global Defender, 2024

Summary

- Digital Engineering is a growing field, and the DoD is pushing for implementation across the branches
- The DoD uses SILs to ensure streamlined development and integration of systems
- In these environments, Digital Twins can optimize processes and provide a modular approach to integration
- Virtual labs ensure a fully modular customer experience

Questions?

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hybrid event

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www.incose.org/symp2024
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References

Defense Acquisition University Glossary

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