International Council on Systems Engineering
A better world through a systems approach

Foundations of MBSE and DE

Why DE is not a 101 class

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INCOSE International Symposium 2025 | Ottawa, Canada

Today's Agenda

- My Roadmap
- MBSE Foundations
- MBSE Pathway to DE
- A Perspective on Origins of DE: Concurrent Engineering
- Complexities of DE
- Considerations for the future for MBSE and DE

Stephanie Sharo Chiesi

Professional experience Roadmap

Senior Director of Engineering, ALRE Program

General Atomics – Electromagnetic Systems

BS, A/A

MIT

Co-Op

JPL

MIT

BS, Bio
MS, A/A

Draper

Applying Skills, Identifying Knowledge Gaps

Paragon

Leadership and Management Experience

State-of-the-Art, Advancing the Practice

INCOSE AIAA

Raytheon

Innovation and Development of Expertise

INCOSE TLI

Doctoral Research

SERC

SAIC

Subject Matter Expert

Blue Origin

Industry Leader, Growing People and Teams

General Atomics EMS

MBSE Foundations 101

The introductory topics that provide an overview of Model Based Systems Engineering concepts

- Definition
- Pillars: Methodology, Language, Tool
- Education and Training

What is MBSE?

Definitions

INCOSE SE Vision 2020: The formalized application of modeling to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases.

SEBoK v 2.12: Identical reference

IEEE Tech Committee on MBSE: Identical reference

DoD Instruction 5000.97: The formalized application of modeling to support system requirements, design, analysis, verification, and validation activities beginning in the conceptual design phase and continuing throughout development and later system life-cycle phases

The Three Pillars of MBSE

Key concepts that need definition, support, continuous learning/training, and governance in an organization for implementation success

Methodology

- The processes and approach for performing system engineering in your organization to support your customers and programs
- May include published methodologies such as OOSEM or SYSMOD
- May be tailored depending on other program or company characteristics, such as top-down, bottom-up, or middle-out engineering

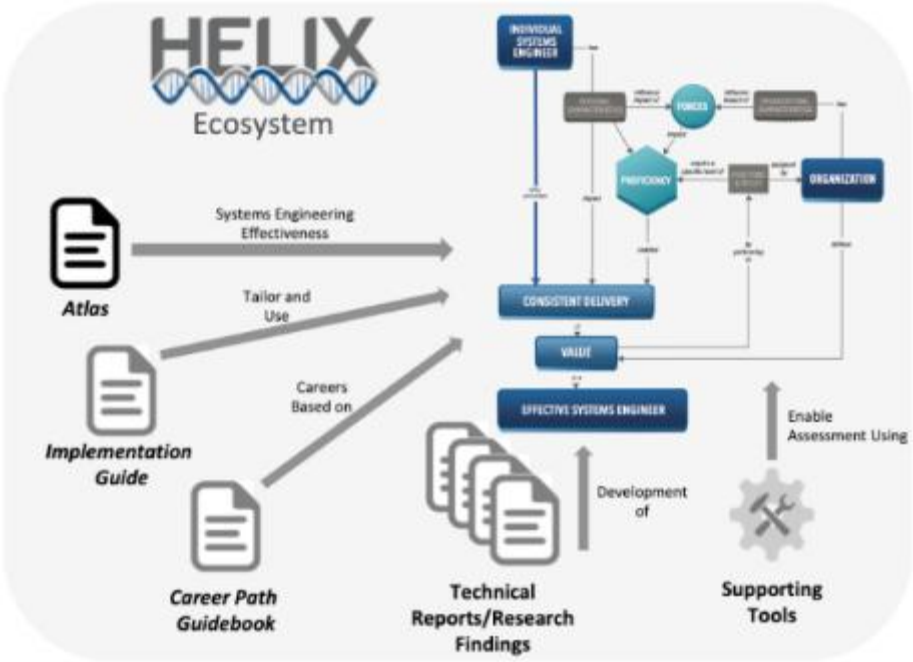
Language

- A formal language used to express information, knowledge, or data in a structured way
- Provides consistent set of rules for defining the elements and relationships according to the applied methodology
- Examples include SysML, OPM, LML, UML
- May have a style guide that outlines how the language should be used for programs as part of organizational processes

Tool

- Supports the creation, analysis, review, and management of system models throughout the product lifecycle
- Provides the user environment to implement a methodology using a modeling language
- Many available options depending on the needs of a given organization

Education and Training as part of MBSE



Helix Technical Report: https://sercuarc.org/documents/technical-reports/227/

01 Formal Education

Undergraduate or Graduate degree programs in Systems Engineering include MBSE coursework, including professional degree programs that may be co-sponsored by academia and industry

02 Certification and Skill Courses

Instruction that is focused towards achieving certifications (such as OCSMP) or on learning specific elements of MBSE to perform required job tasking including courses developed and taught internal to an organization

03 On the Job Training

Task driven training through mentoring, shadowing, and/or other formal or informal approaches focused on specific product delivery including contract deliverables and career advancement artifacts

04 Experiential Learning

Beyond tasking in the workspace, experiential learning is interactive with communities of practice, professional organizations, webinars, conferences, symposia, journals and more

Moving to the next level classes for MBSE

Framing the strategy for your organization's 201, 301, 401, etc. courses

- Evaluate the needs of your organization
  - Individual training and continuous learning
  - Technical support
  - Leadership support
- Ensure buy-in across the enterprise
  - Program leadership
  - Customers
  - Supply Chain

MBSE Pathway to Digital Engineering

As MBSE transforms the discipline of Systems Engineering, implementation of MBSE transforms multidisciplinary engineering.

MBSE captures relational data in describing physical, logical, and behavioral views of the system. Implementing MBSE draws on connecting the systems engineering discipline to other engineering disciplines that contribute to the system design and development.

Building dependencies and communications paths between disciplines in implementation moves the focus from systems engineering to digital engineering.

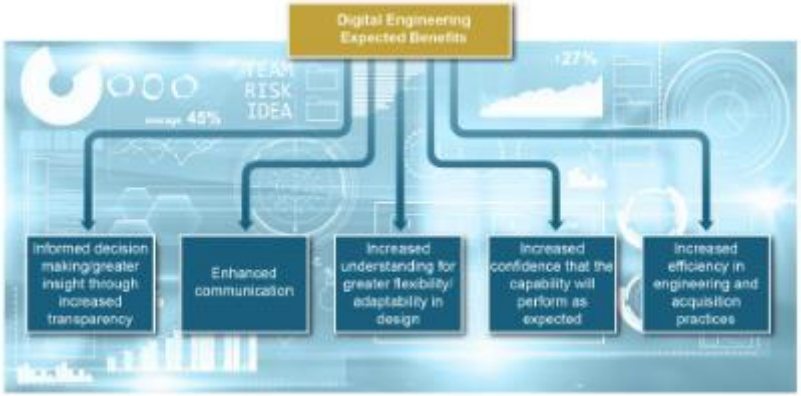


Image credit: DoD Digital Engineering Strategy, June 2018

What is Digital Engineering?

Definitions

SEBoK v 2.12: The creation of computer readable models to represent all aspects of the system and to support all the activities for the design, development, manufacture, and operation of the system throughout its lifecycle.

DEBoK v 3.1.0: 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.

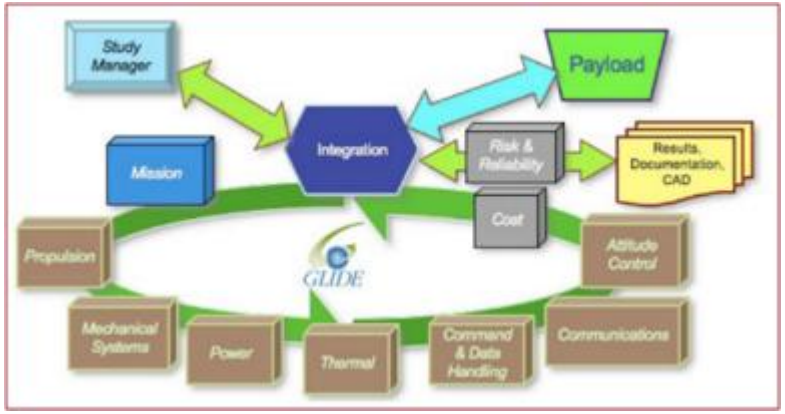
DoD Instruction 5000.97: A means of using and integrating digital models and the underlying data to support the development, test and evaluation, and sustainment of a system.

One Perspective on Origins of Digital Engineering

A brief look back at the principles of multidisciplinary and concurrent engineering that influenced current DE initiatives

DE Foundations in Concurrent Engineering

- Early Work in DE implementation grew from Concurrent Engineering
- Proven processes and environments
- Connected data environments for rapid solution development
- Subject matter experts for each discipline/domain
- Has not scaled to other lifecycle design phases after conceptual design

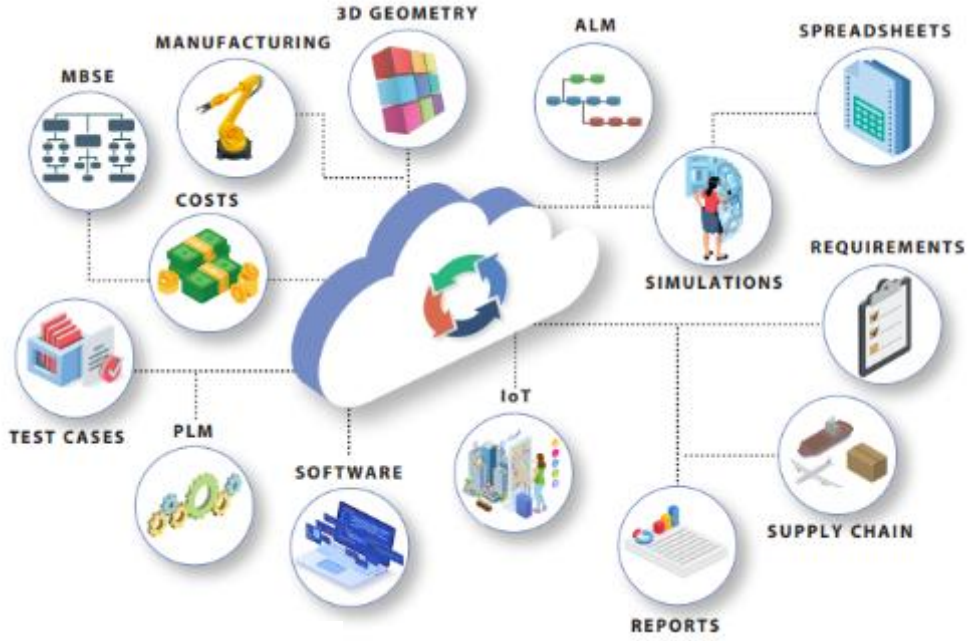


NASA Glenn: https://ntrs.nasa.gov/api/citations/20120008522/downloads/20120008522.pdf

JPL Team X: https://twitter.com/b_jour/status/1052400479156633600

Current DE industry approach builds on CE principles for success

- Automated tasks and data exchange
- Reduce human touch time and human entry errors
- Does not replace human decision-making
- Does change how humans use the data to make decisions



INCOSE Systems Engineering Vision 2035, page 34
https://www.incose.org/docs/default-source/se-vision/incose-se-vision-2035.pdf?sfvrsn=e32063c7_10

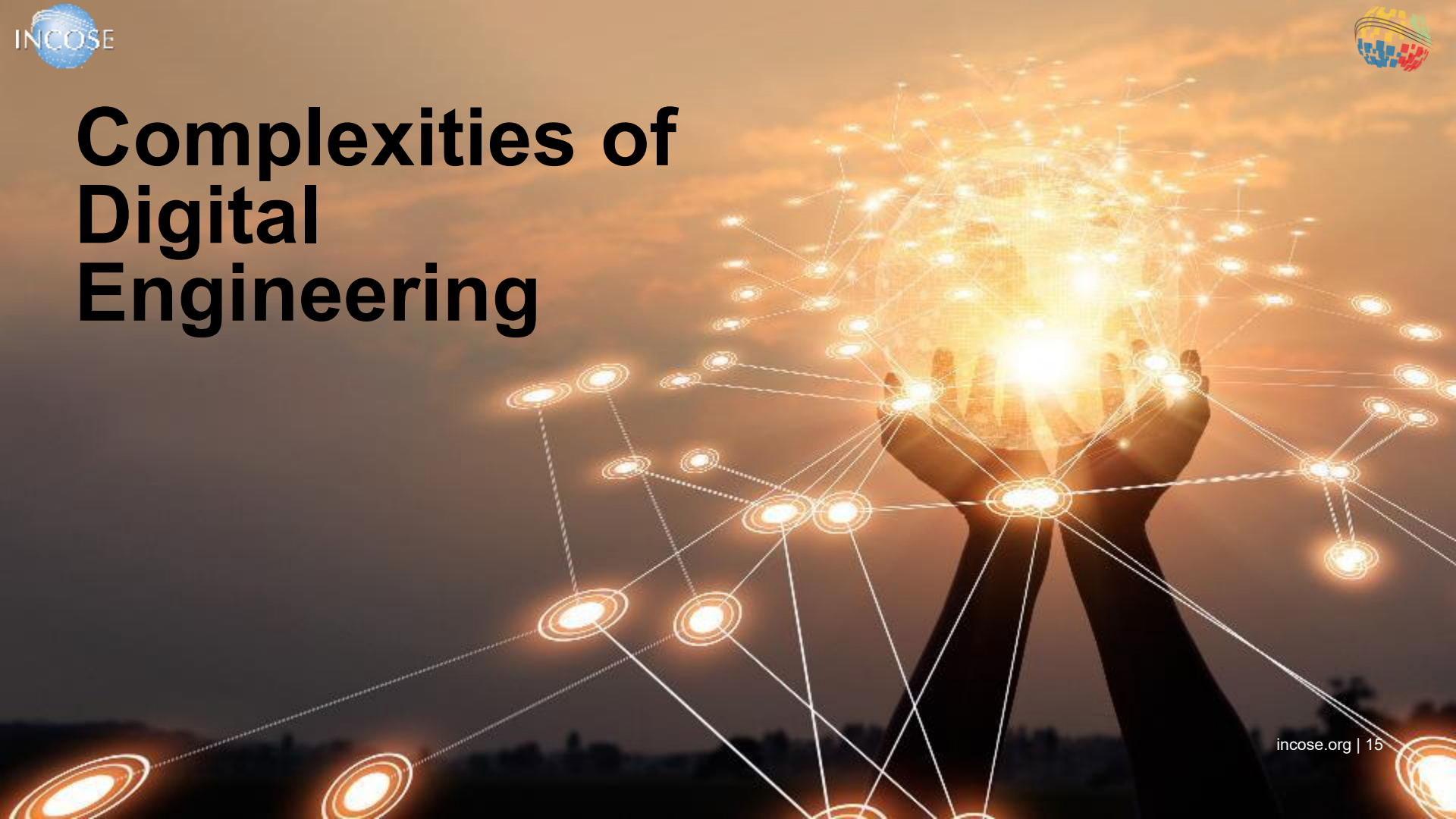
But is that the only approach to DE?

- Design and development centric
- Engineering centric
- Single discipline crossing silos

What if DE starts from production? From operation?

INCOSE Systems Engineering Vision 2035, page 23
https://www.incose.org/docs/default-source/se-vision/incose-se-vision-2035.pdf?sfvrsn=e32063c7_10

Complexities of Digital Engineering



Connections

Relating data across domains and throughout the lifecycle

Discovering lack of governance to resolve

Hard but Known Challenges

Interoperability

Intellectual Property

Culture

Emergent Unknown Barriers

Traversing Boundaries

Non-Functional Requirement influences on DE

Complexity Stack-Up

DE is a capstone to implementation

Difficult to determine an introductory topic when it is dependent on where you are starting

- Starting point may vary depending on your organization, product, infrastructure
  - Evaluate your starting infrastructure and company goals
  - More implementation may be needed from support functions initially than from technical disciplines
- Create, Evaluate, and Re-Evaluate a DE Roadmap
  - Know your starting point and where you are headed
  - Include those executing and supporting the DE journey

In closing…

SE, MBSE, DE *are* different *but* related *and* not equal

Systems Engineering is foundational

- Model Based Systems Engineering is an approach to performing SE in a digital, model-based context
- Building on that foundation is driven by the industry, application, etc.

Digital Engineering is applicational

- Foundations may be in SE, but could also be from other disciplines and different parts of the lifecycle
- Building on the breadth that contributes to the application is key for success

35th Annual INCOSE international symposium

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Ottawa, Canada
July 26 - 31, 2025

What keeps me up at night with MBSE and DE?

As an industry professional and a doctoral candidate

Balancing the state-of-the-art

- A 1-year plan for tactical implementation
- A 5-year plan for strategic industry growth
- A 20-year outlook for research impact

Innovate as we Implement

- Developing and applying at the speed of relevance
- Solving low-hanging fruit
- Keep the roots healthy: be aware of dependencies on future changes or obsolescence as you go

Impacts on People, Processes, Execution

- We lack a way of studying the impacts of DE on decision-making and process execution in a timeframe that is meaningful to both industry and research
- Do we have a way to measure success of what we implement?
- Will we recognize success?
- Are we willing to accept a dip in performance on the path to improvement?