



33rd Annual **INCOSE**
international symposium

hybrid event

Honolulu, HI, USA
July 15 - 20, 2023



Lessons from Research

Enterprise Adoption of DE and MBSE

Four SERC Research Projects 2017-2023

- Digital Thread Enabled Acquisition
 - Conceptualized a future DoD digital engineering & acquisition enterprise
- Measuring the Maturity and Benefits of DE/MBSE
 - Benchmarked DE/MBSE maturity (2019)
 - Categorized 28 benefits and 36 adoption factors for enterprise DE/MBSE
- Digital Engineering Metrics
 - Benefits/adoption causal model informed the DE Measurement Framework release V1.1
- Systems Engineering Modernization
 - Pain points and lessons learned for SE, DE, and MBSE adoption

Problem Statement

- Organizations launching their digital and model-based SE initiatives are repeating the same lessons learned
- Transformation requires significant investment in methods, tools, training, and workforce
- A “cookbook” to assist in primary activities/value, change management, and enablers would be helpful

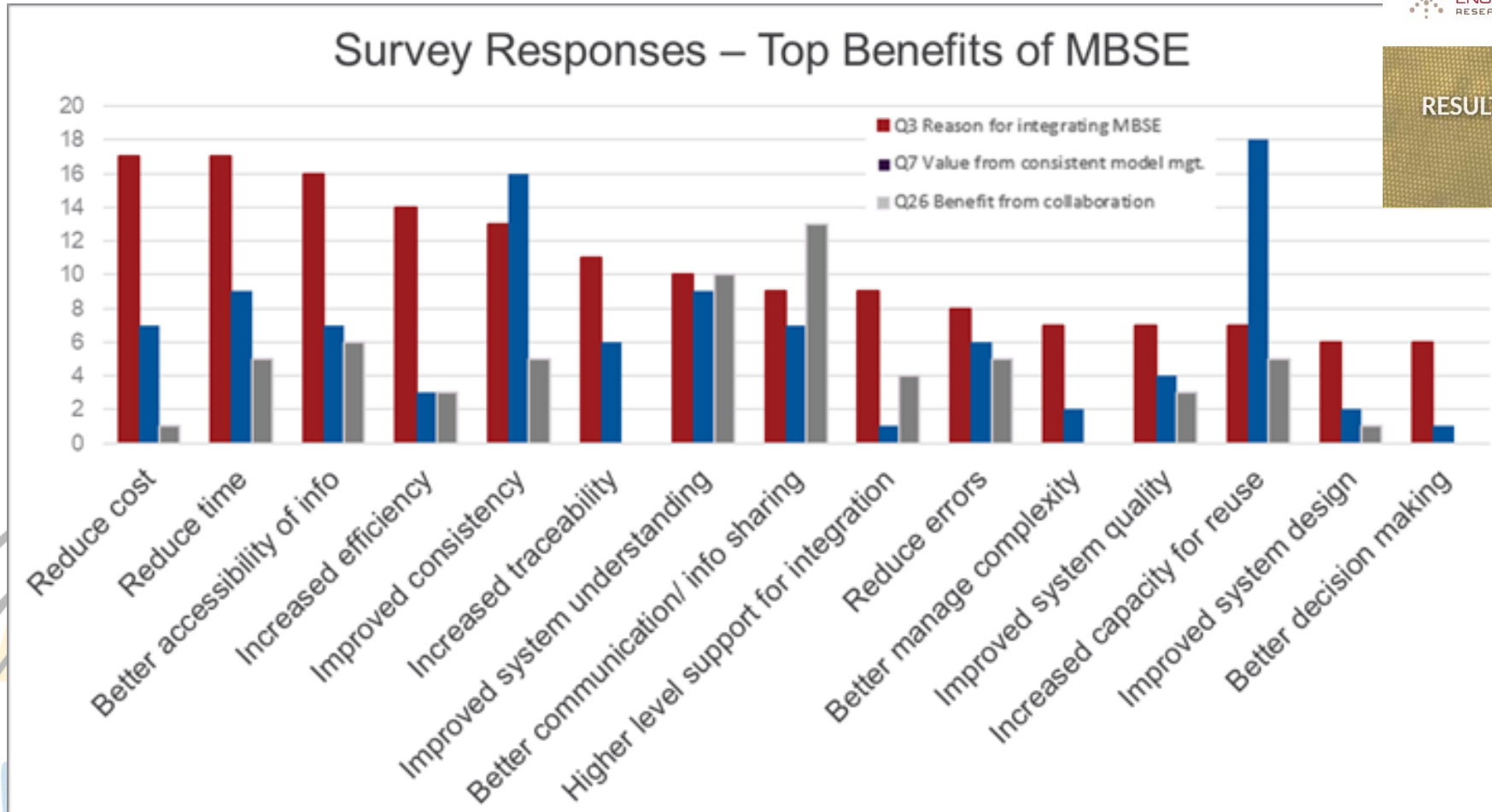
Research-Derived Organizational Adoption Factors

Organizational design	Organizational Enablers/Barriers	Organizational Change Management
Workforce knowledge/skills (1. SE domain, 2. MBSE tools & digital strategies)	Leadership support/commitment	DE/MBSE methods/processes (maturity)
Integration to support the digital implementation (tool infrastructure)	Training & categories of training	MBSE terminology and libraries
Demonstrated benefits/results	Resources for implementation (cost to use tools, willingness to invest)	Change management process design (lessons learned, communicating success)
Programs/projects using methods & processes	Tool Infrastructure: user experience and stakeholder buy-in	Greater use of DE/MBSE tools (overcoming resistance)
People in model building roles		People willing to use the DE/MBSE tools (a primary adoption measure)

Organizational Design for Modeling

- Start with SE: Good SE will enable success with MBSE, MBSE itself will not create value.
- Multidisciplinary value: Systems Engineers work across disciplines, DE and MBSE must create added value across disciplines.
- Digital literacy: Experienced SE's may not be comfortable with DE, younger engineers may bring a digital culture with them. Create knowledge transfer between them.
- Systems knowledge: is a unique value of DE/MBSE. A good system model can create/maintain systems knowledge to improve awareness of other disciplinary engineers.
- Model quality: models must demonstrably improve system understanding and decisions.
- Model abstractions: commensurate to the roles and uses of DE/MBSE. Models must communicate decisions at all levels.

Top-cited Benefits from the Survey



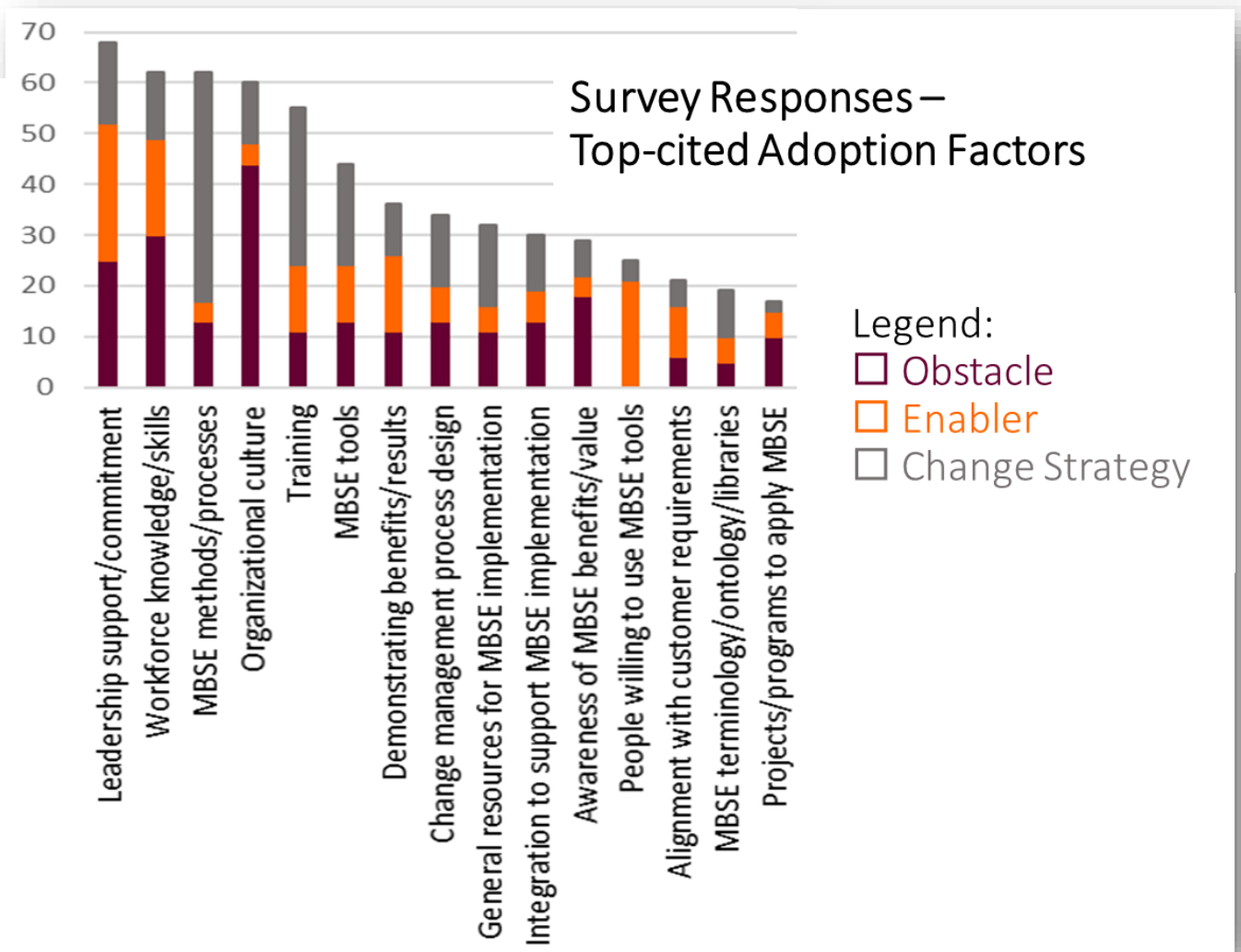
RESULTS OF THE SERC | INCOSE | NDIA MBSE MATURITY SURVEY ARE IN

June 10, 2020

<https://sercuarc.org/results-of-the-serc-incose-ndia-mbse-maturity-survey-are-in/>

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Top cited adoption factors from the survey



Green:
Primary benefits

Blue: Adoption factors

Black:
secondary
factors leading
to measurement

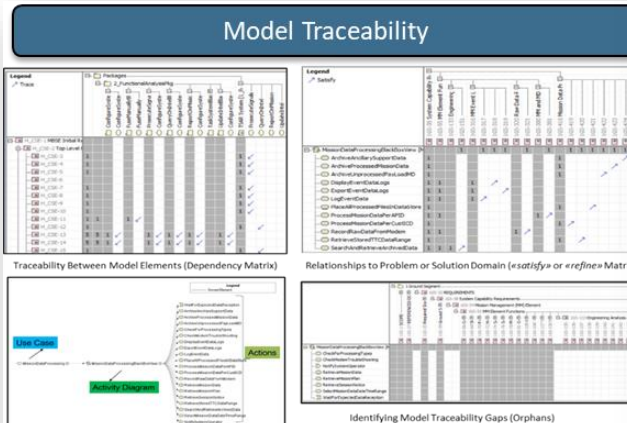
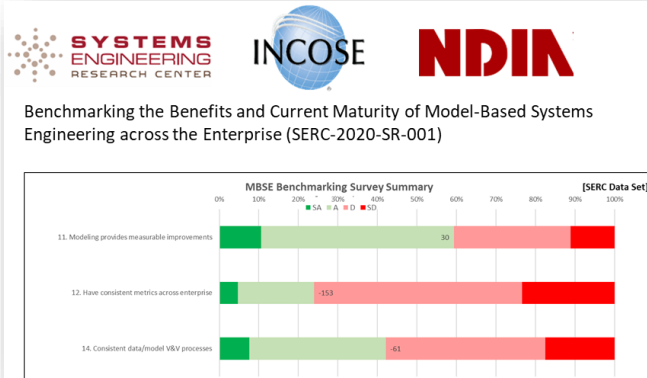


Activities to Gain Benefit from DE/MBSE

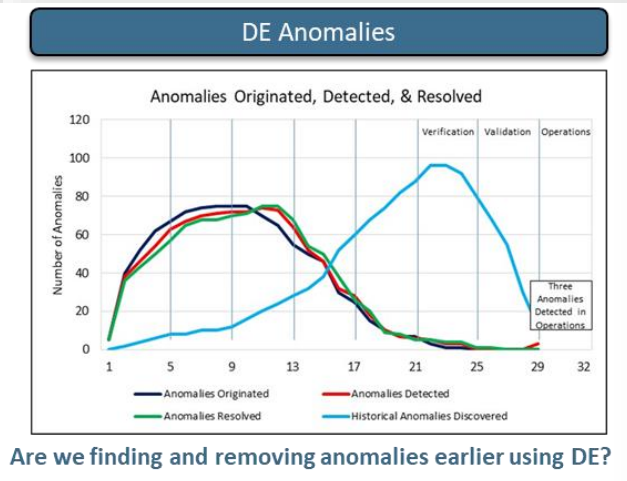
- These benefits come directly from the improved capability or additional features of DE/ MBSE
- Require organizational design, enabling environment, and change management strategy
- Require an organizational measurement approach

Direct Benefits	Definition
Higher level support for automation	Use of tools and methods that automate previously manual tasks and decisions
Early V&V	Moving tasks into earlier development phases that would have required effort in later phases
Reusability	Reusing existing data, models, and knowledge in new development
Increased traceability	Formally linking requirements, design, test, and so forth through models
Strengthened testing	Using data and models to increase test coverage in any phase
Better accessibility of information	Increasing access to digital data and models to more people involved in program decisions
Higher level support for integration	Using data/models to support both the integration of information and system integration tasks
Multiple viewpoints of model	Presentation of data and models in the language and context of those that need access

DE Measurement



What is the traceability and coverage of model elements?



Practical Software and Systems Measurement (PSM) Digital Engineering Measurement Framework

Version 1.1
June 21, 2022

Developed and Published by Members of:

Practical Software & Systems Measurement

Systems Engineering Research Center

Aerospace Industries Association



National Defense Industrial Association

International Council on Systems Engineering

Department of Defense Research & Engineering



The Aerospace Corporation
AEROSPACE

<http://www.psmcsc.com/DEMeasurement.asp> and the INCOSE Store

www.incose.org/symp2023

Putting the Research into Practice

- Focus on the two primary measurable values of DE and MBSE:
 - models that provide holistic insight on the end product behavior and performance
 - the digital connectivity to data and analysis models that improve the efficiency of the development, management, and support teams
- Really talented systems modelers are needed to create models that involve and lead the team to make faster and better decisions
- Really good software/information technology people are needed who transparently improve the team's efficiency through the digital connectivity
- Must measure the data/model lifecycle
- Must have understanding of the factors that need to be addressed for successful adoption of the digital and MBSE methods and tools
- Must have the organizational leadership and change management support.

- **Thanks to Kaitlin Henderson, PhD, who collected all this data and built the models!**

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Lessons learned on the progress of adoption of digital and model-based systems engineering into engineering enterprises

The SERC research on DE/MBSE adoption found many factors that must be addressed for organizations to achieve this transformation. Table 1 organizes the 12 most prominent factors in our research, organized across three categories: Organizational design, Organizational enablers/barriers, and Organizational change management. This research collected a set of detailed lessons learned around each from existing literature.

Organizational design	Organizational Enablers/Barriers	Organizational Management	Change
Workforce knowledge / skills (SE domain, MBSE tools, digital strategies)	Leadership support / commitment	DE/MBSE methods / processes (maturity): MBSE terminology and libraries	
Integration to support the digital implementation (tool infrastructure)	Training & categories of training	Change management process design (lessons learned, communicating success)	
Demonstrated benefits/ results Programs/projects using methods & processes	Resources for implementation (cost to use tools, willingness to invest)	People willing to use the DE/MBSE tools (a primary adoption measure)	
People in model building roles	Tool Infrastructure: user experience with them and stakeholder buy-in	Greater use of DE/MBSE tools (overcoming resistance)	

Organizational Enablers/Barriers

Leadership Support/Commitment:

1. "Successful implementation and adoption of MBSE is not a single, discrete event. Successful implementation requires a time-phased transformation in a complex System-of-Systems enterprise environment. As such, a coordinated vision across the entire enterprise is essential." [35](#)
2. "Leadership sets direction, supports staff development, organizes for project management, development, support and sustainment (ask for artifacts, implement milestones, track progress and reward milestones, measure progress)." [42](#)
3. "Unity of Leadership is Essential. In the first infusion of leadership, the message must be clear and consistent. Management must be visible and active. The effort to pay dividends. In addition,



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