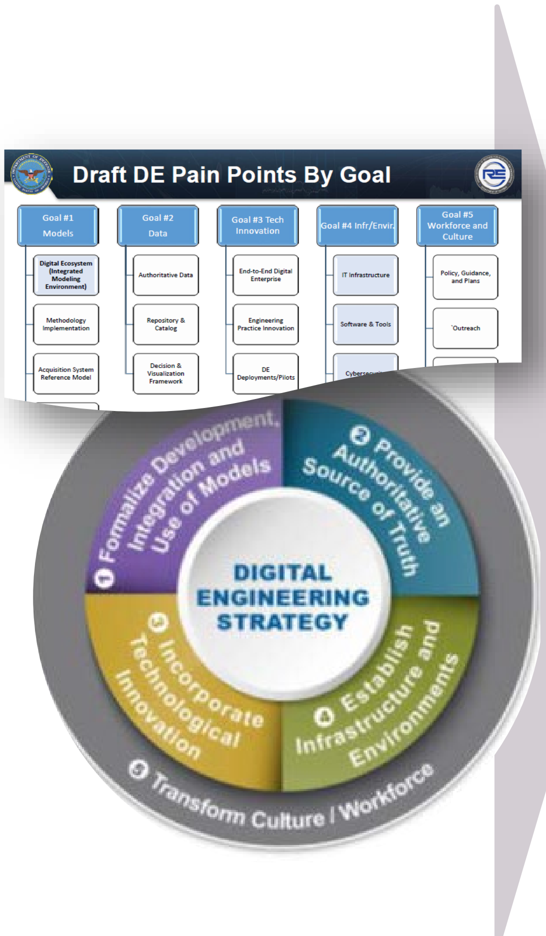
DE Metrics: Categorizing the Benefits and Value of Digital Engineering

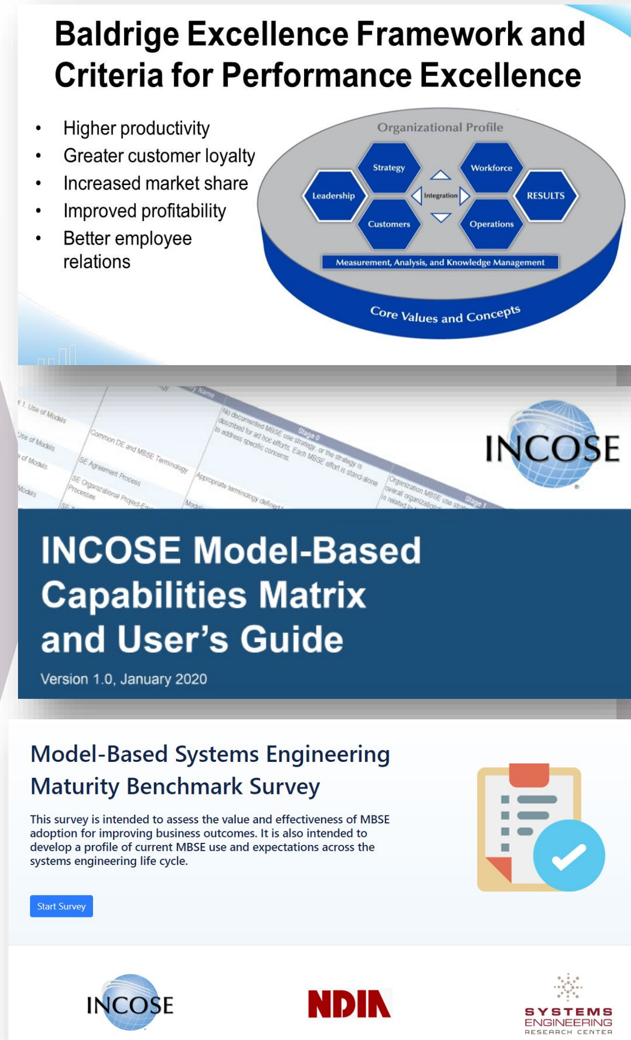
Tom McDermott, Deputy Director and CTO, SERC
Stevens Institute of Technology

Dr. Eileen Van Aken, Dr. Alejandro Salado, Kaitlin Henderson (Va Tech)
Dr. Nicole Hutchison, Dr. Annie Yu, Megan Clifford, Neal Chen (Stevens)

This material is based upon work supported, in whole or in part, by the U.S. Department of Defense through the Systems Engineering Research Center (SERC) under Contract H98230-08-D-0171. The SERC is a federally funded University Affiliated Research Center (UARC) managed by Stevens Institute of Technology consisting of a collaborative network of over 20 universities. More information is available at www.SERCuarc.org

SERC Research Program on DE Metrics





Metrics Framework:
Digital Engineering Value, Benefits, and Adoption

Metrics Implementation

SYSTEMS ENGINEERING RESEARCH CENTER

Summary DE Success Measures Framework

Models are used to inform enterprise and program decision making	An enduring, authoritative source of truth is used over the lifecycle	Use technological innovation to improve engineering practices	Infrastructure and environments support improved communication and collaboration	Transform culture and workforce engineering across the lifecycle

Quality:
- Reduce Errors/Defects
- Improve System Quality
- Increase Traceability
- Reduce Cost

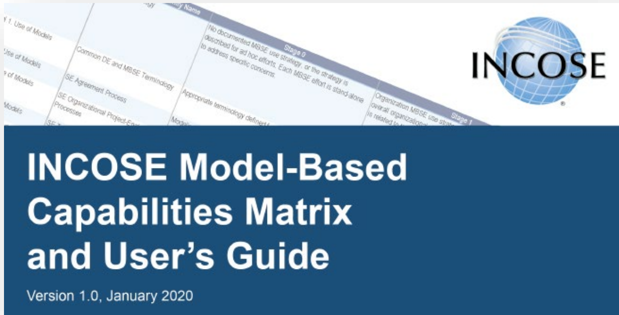
Knowledge Transfer:
- Better knowledge capture
- Better accessibility of information
- Increased communication
- Improved collaboration

Velocity/Agility:
- Reusability
- Increase Consistency
- Increase Efficiency
- Support Integration
- Reduce Effort/Time

User Experience:
- Manage Complexity
- Improved System Understanding
- Automation
- Multiple viewpoints
- Early V&V

Adoption:
- Tool Infrastructure
- Methods/Processes
- Roles/Skills
- Training/Tools
- Leadership support
- Resources

INCOSE Model-Based Capabilities Matrix



- Released January 2020 by INCOSE
- Framework for assessing organizational maturity

Model-Based Capability Stages	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4
Tools & IT Infrastructure					
Collaboration	E-mail, telecom.	System Model File Exchange.	Various organizations working on different parts of model. Full model integrated by a single organizations.	Partial On-line, real-time collaboration amongst distributed teams	On-line, real-time collaboration amongst distributed teams
Disparate Database/Tool interoperability	None	Tool-to-Tool, ad hoc interoperability	Partial Federated Database Management System (FDBMS)	Main tools interoperable. Supporting tools interact through file transfer.	Fully Federated w/ standard "plug-and-play" interfaces. Data is interchanged among tools
Inter-Database/Tool Data Item Associations	Databases/tools are independent	Inter-Database/Tool Data Item associations defined	Inter-Database/Tool Data Item associations defined, captured, managed	Inter-Database/Tool Data Item associations among all data items defined, captured, managed, and traceable	Inter-Database/Tool Data Item associations among all data items defined, captured, managed, and traceable where changes in one data source alerts owners of other data sources of intended updates
User IF, Viewpoint/Views	N/A	Doc Gen	UI draws from Model app	UI draws from multiple models/DBs	UI supports Interrogation; multiple configs

SYSTEMS ENGINEERING RESEARCH CENTER

ABOUT SERC PEOPLE RESEARCH EDUCATION LIBRARY NEWS AND EVENTS

Download Results

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

June 8, 2020 – Summary Report Task Order WRT-1001: Digital Engineering Metrics Supporting Technical Report SERC-2020-SR-003

View the DE Metrics Summary Report (June 8, 2020)

March 19, 2020 — Benchmarking the Benefits and Current Maturity of Model-Based Systems Engineering across the Enterprise Results of the MBSE Maturity Survey / Part 1: Executive Summary

View the SERC-2020-SR-001 report on the results of the MBSE Maturity Survey

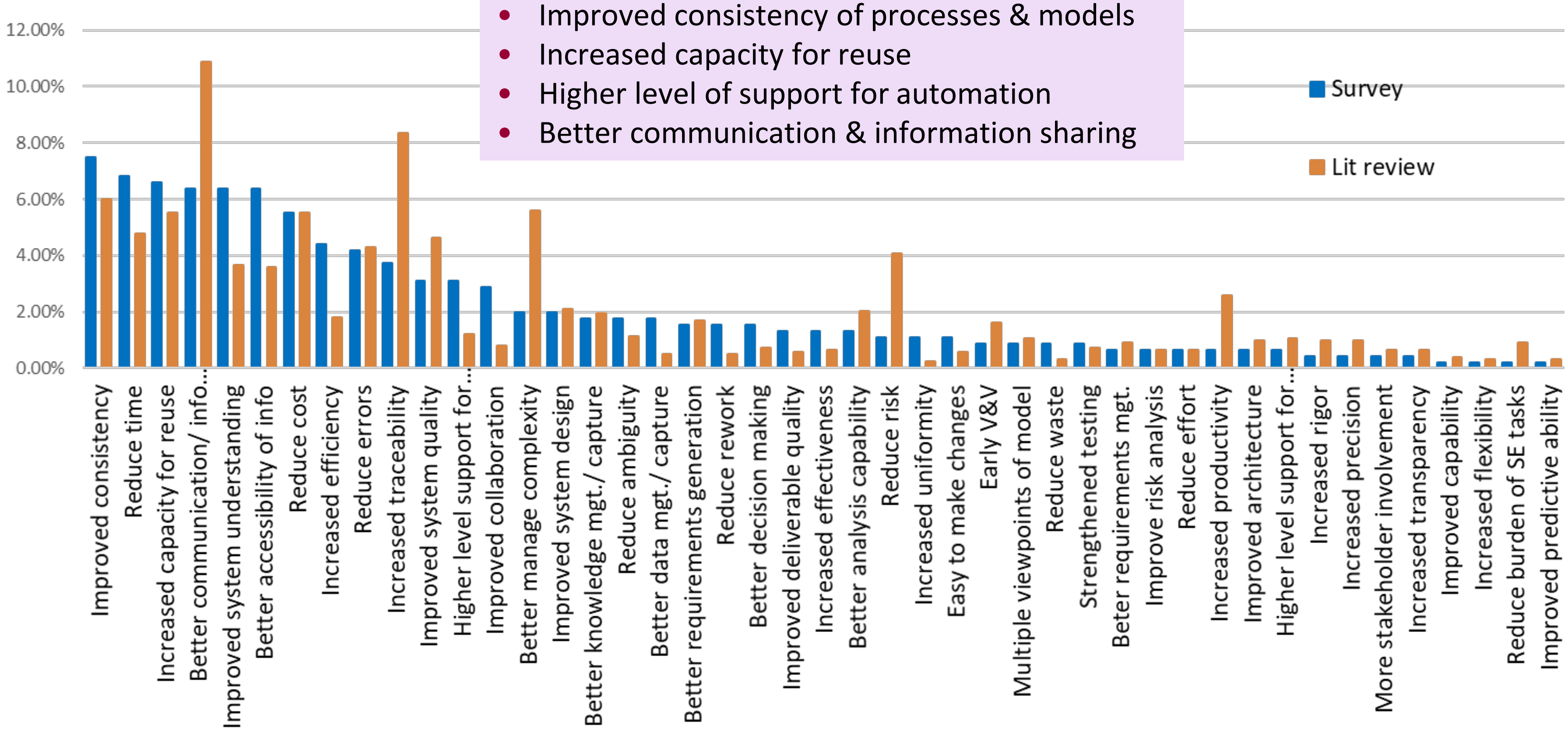
June 8, 2020 – Task Order WRT-1001: Digital Engineering Metrics Technical Report SERC-2020-TR-002

View the Digital Engineering Metrics Full Technical Report

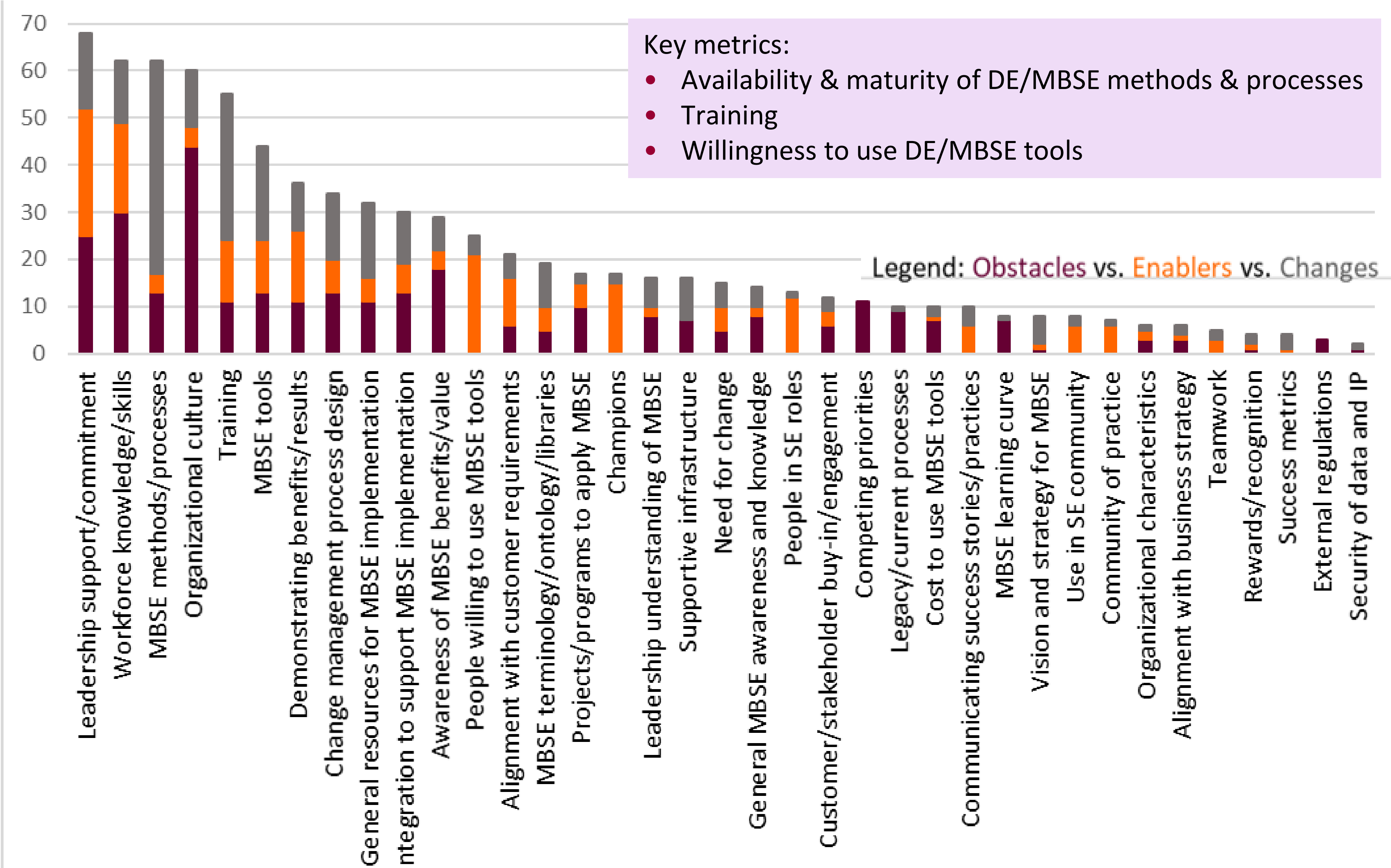
Top Cited DE Benefits Areas from Literature and Survey Results

Key metrics:

- Increased traceability
- Reduced defects/errors
- Reduced time
- Improved consistency of processes & models
- Increased capacity for reuse
- Higher level of support for automation
- Better communication & information sharing



Top-cited Adoption
Obstacles vs. Enablers vs. Changes



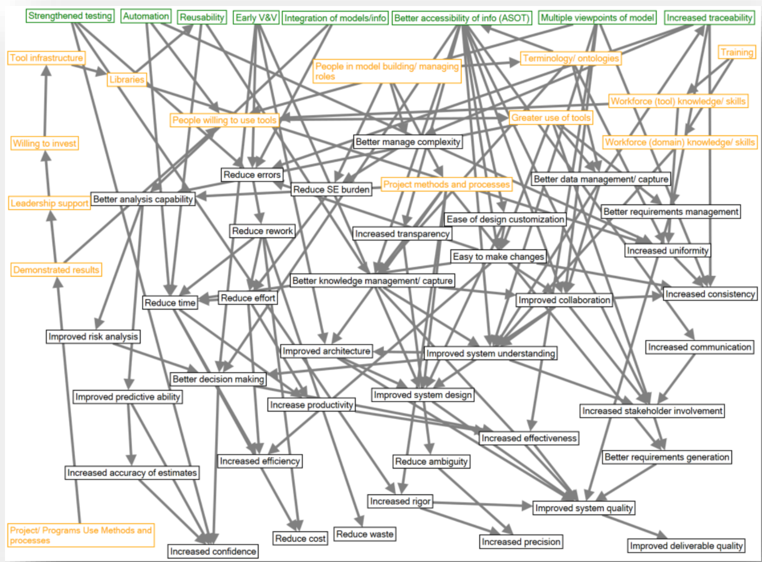
Key metrics:
- Availability & maturity of DE/MBSE methods & processes
- Training
- Willingness to use DE/MBSE tools

Causal Analysis for Measurement Model

Primary Benefits

Secondary Benefit Metrics

Secondary Adoption Metrics



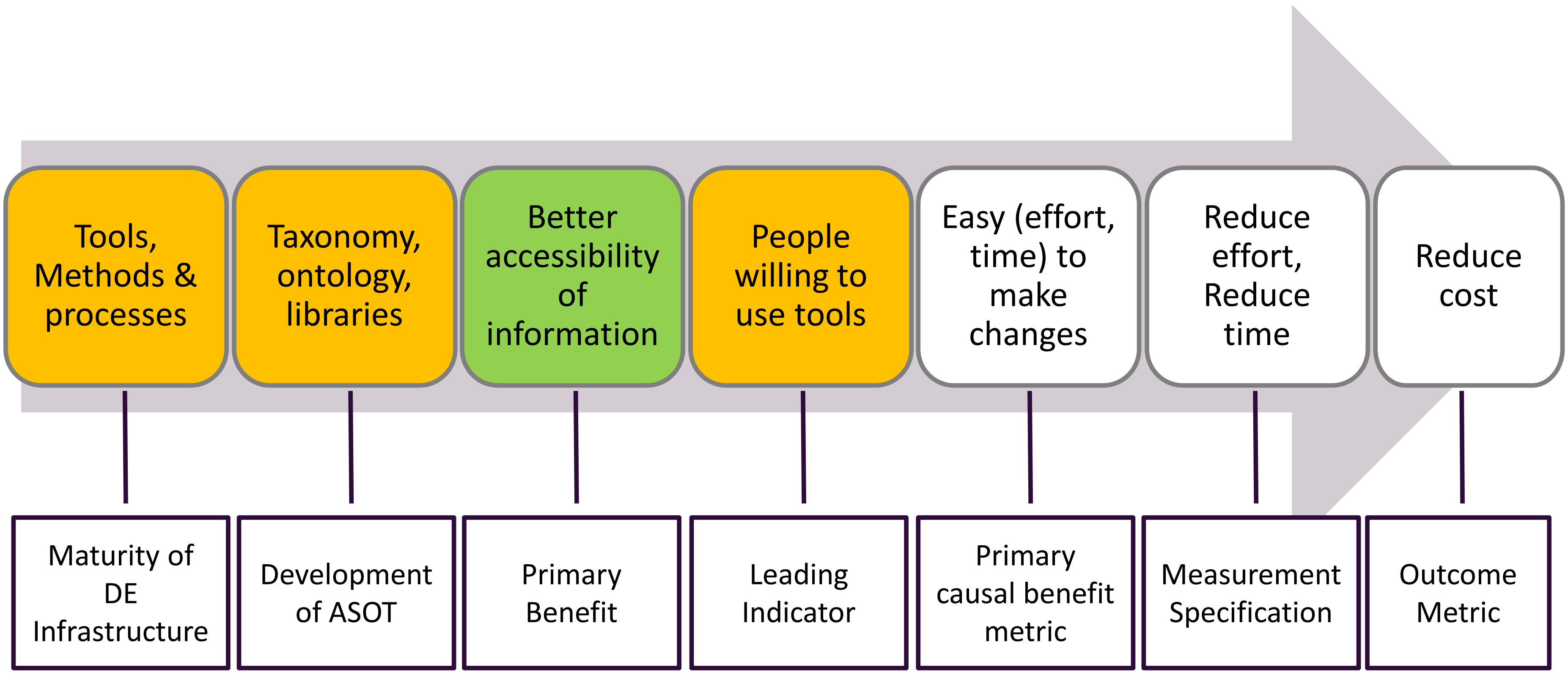
- Causal Analysis of benefits and adoption data
- Link primary benefits to measures
- Used to scope detailed measurement specifications

SYSTEMS ENGINEERING RESEARCH CENTER

Primary Benefits of Digital Engineering

— Higher level support for automation – use of tools and methods that automate previously manual tasks and decisions
— Early V&V – moving tasks into earlier developmental phases that would have required effort in later phases
— Strengthened testing – using data & models to increase test coverage in any phase
— Higher level support for integration – using data and models to both support integration of information and to support system integration tasks
— Better accessibility of info (ASOT) – increasing access to digital data & models to more people involved in program decisions
— Reusability – reusing existing data, models, and knowledge in new development
— Increased traceability – formally linking requirements, design, test, etc. via models
— Multiple viewpoints of model – presentation of data and models in the language and context of those that need access

Example Causal Pathway



DE Metrics Working Group

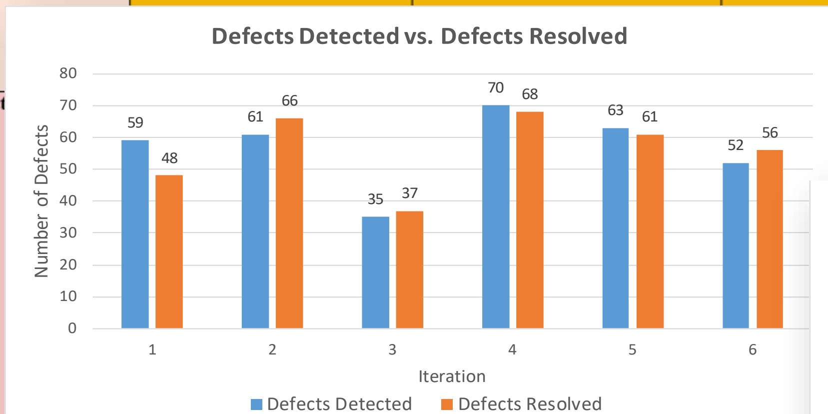
Chair: Joe Bradley
joseph.bradley@mainsailgroup.com

- Chartered to standardize DE metrics specification
- Based on the Practical Software Measurement (PSM) methodology
- Government/ Industry consensus-based

SYSTEMS ENGINEERING RESEARCH CENTER

DE Metrics WG Sample

Information Categories	Measurable Concept	Project Information Need	Enterprise Information Need	Potential Measures
Size and Stability	Functional Size and Stability ***	What % of system elements have been modeled vs. plan?	Is architectural integrity and traceability improved using digital engineering methods relative to traditional approaches?	Architectural completeness: System element coverage and traceability (% of functions allocated to system model elements)
Product		errors across the project lifecycle compared to traditional approaches? Are post-review actions closing faster?	and removing defects earlier using digital ethods (models, simulations) relative to thods? lity improved using digital engineering discrepanc	Defect detection and removal profiles Defect containment vs. escape ratios across life cycle activities Defect saves - defects found that would have impacted a later design phase (particularly saves in requirements or architecture phases that
Process Performance	Process Efficiency - Automation	How much of the digital engineering design and development process can be automated to reduce effort and shorten cycle times? (e.g., system artifacts automatically generated using digital models) How much task time can be saved through the automation of digital engineering tasks?	How muc develop effort and artifacts models) What percentage of system artifacts are automatically generated from digital models? What is the savings in labor costs for automatically generating model-driven digital artifacts vs. traditional methods? Will automation encourage greater tool use?	e Labor cost for generating model-driven artifacts $ savings in labor costs for generating model-driven artifacts vs. traditional methods (recommend effort not cost)



Questions?