Systems of Systems: Why Model Based Approaches to System of Systems Engineering?

Dr. Judith Dahmann
The MITRE Corporation

SoSE 2018

Approved for public release. Distribution unlimited 17-3712-46

© 2018 The MITRE Corporation. All rights reserved.

System of Systems

Set of systems that interact to provide a unique capability that none of the constituent systems can accomplish on its own. Each constituent system is a useful system by itself, having its own management, goals, and resources, but interacts within the SoS to provide the unique capability of the SoS.

Systems of Systems Engineering

The process of planning, analyzing, organizing, and integrating the capabilities of a mix of existing and new systems into a system-of-systems capability that is greater than the sum of the capabilities of the constituent parts

Approved for public release. Distribution unlimited 17-3712-46

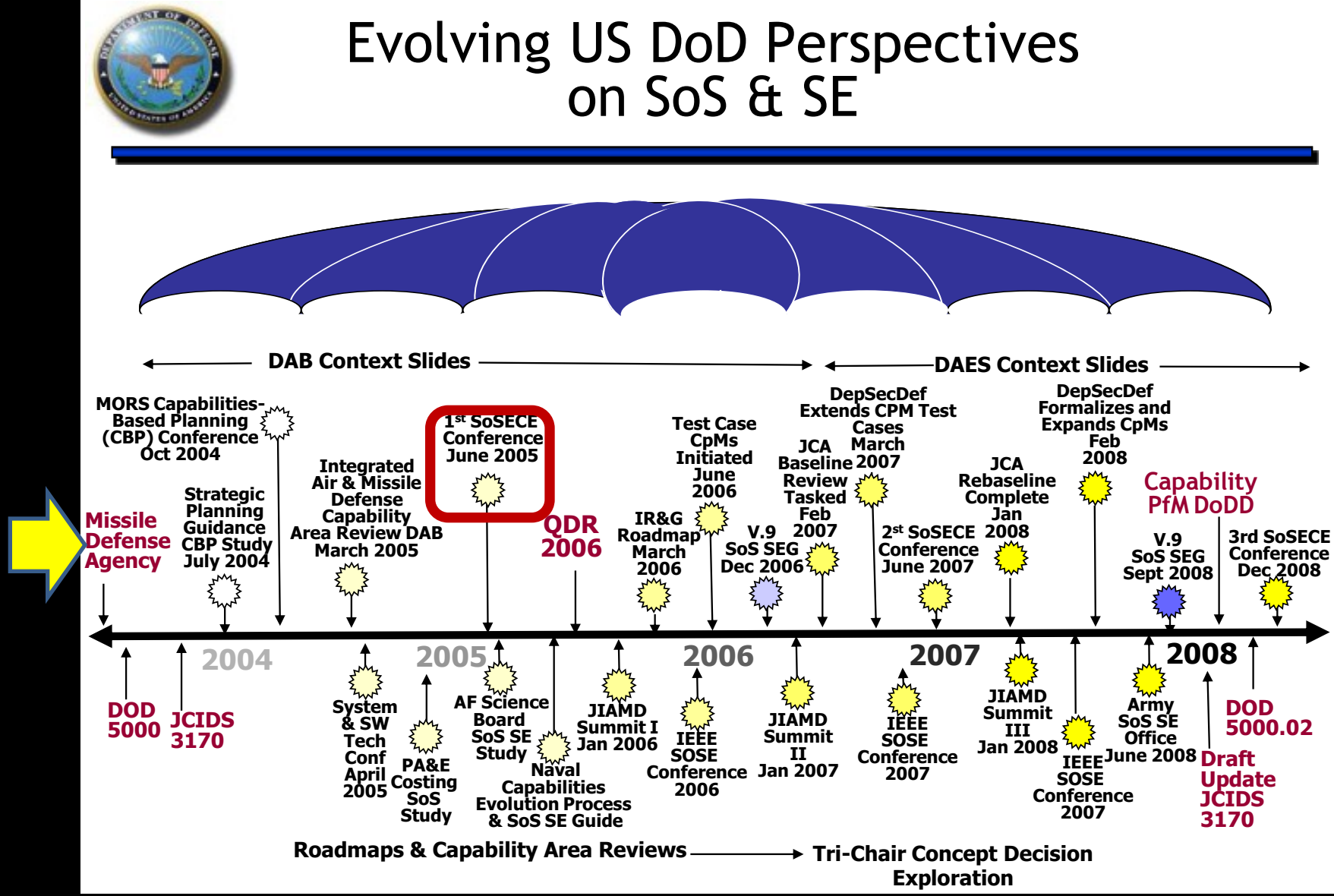
© 2018 The MITRE Corporation. All rights reserved.

Approved for public release. Distribution unlimited 17-3712-46

© 2018 The MITRE Corporation. All rights reserved.

2008 US DoD Perspective

Evolving US DoD Perspectives on SoS & SE

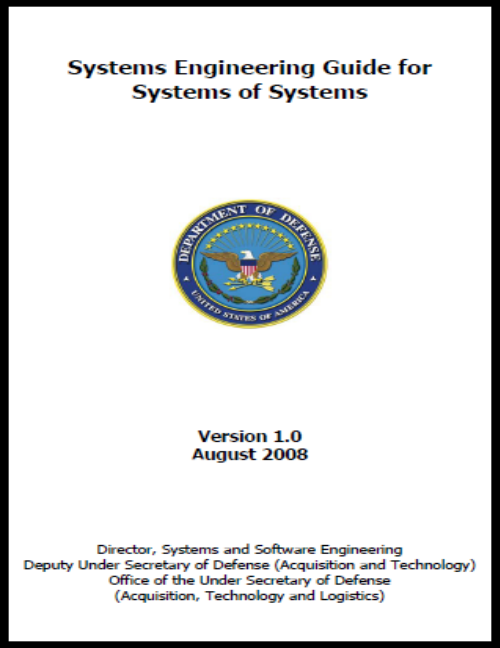


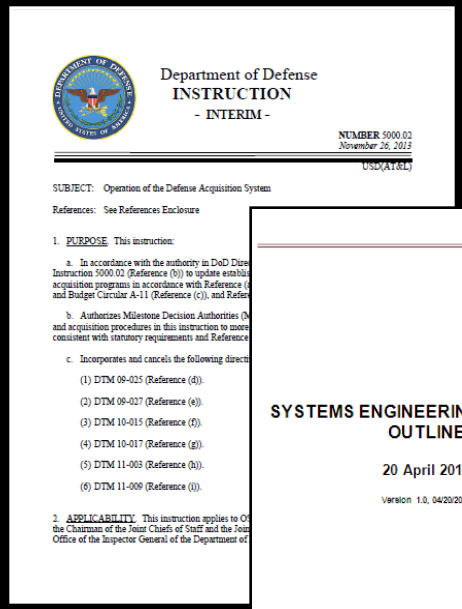
From SoSE 2014

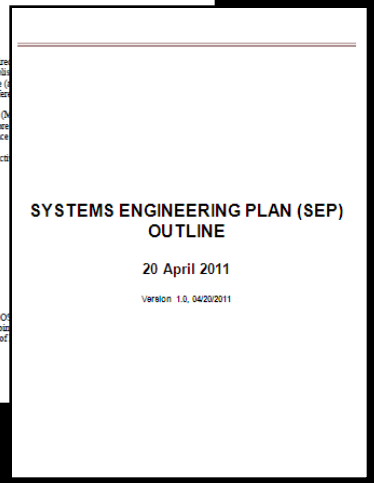
Approved for public release. Distribution unlimited 17-3712-46

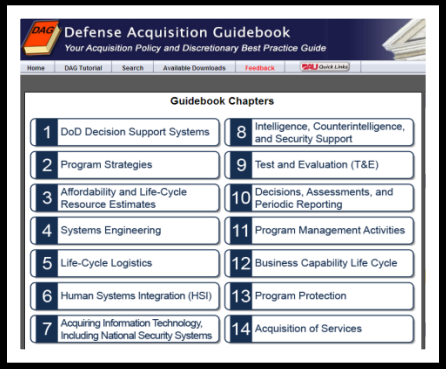
© 2018 The MITRE Corporation. All rights reserved.

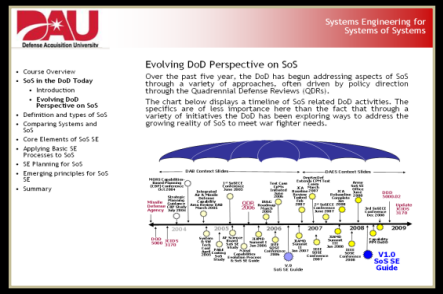
SoS SE in US DoD

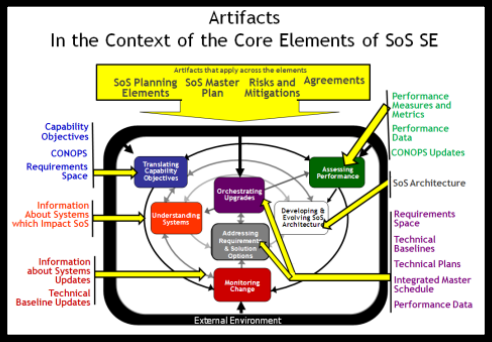


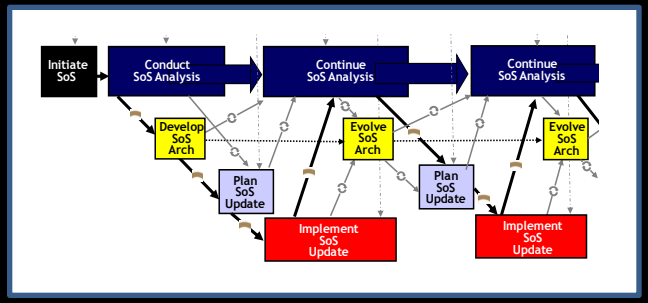


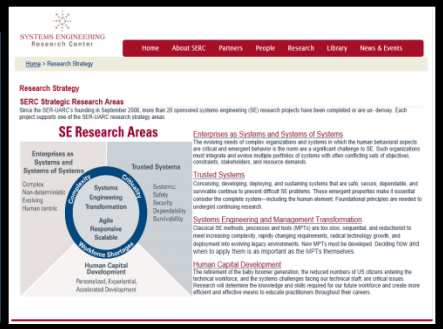










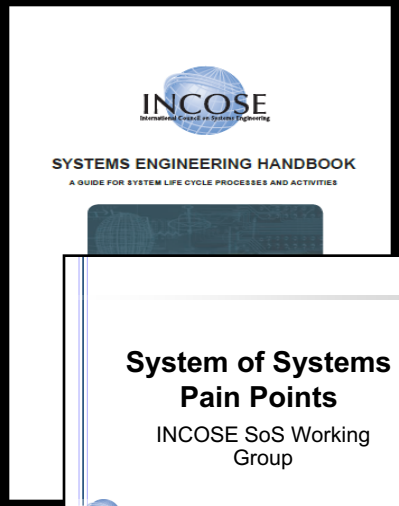


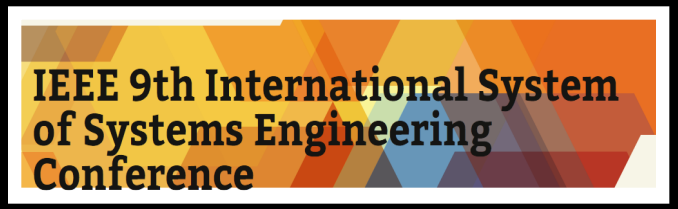
From SoSE 2014

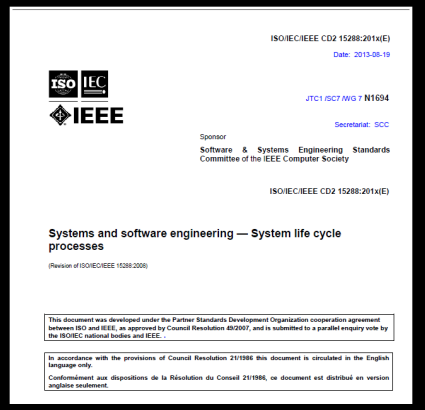
Approved for public release. Distribution unlimited 17-3712-46

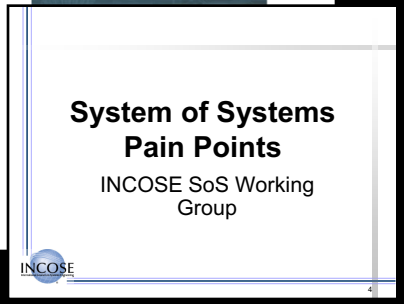
© 2018 The MITRE Corporation. All rights reserved.

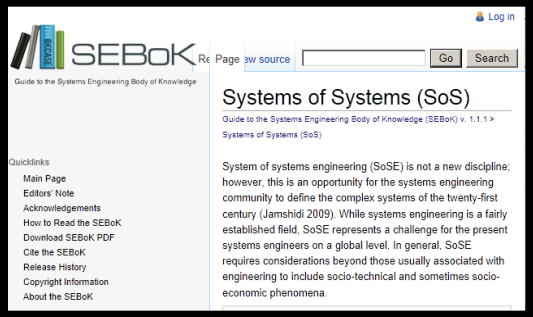
…. And Beyond

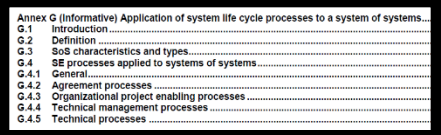


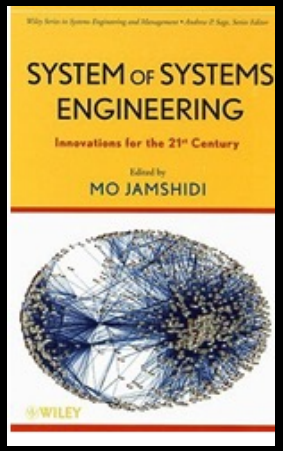


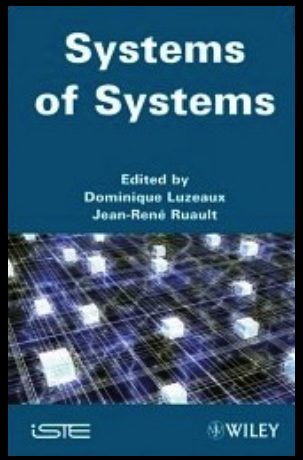


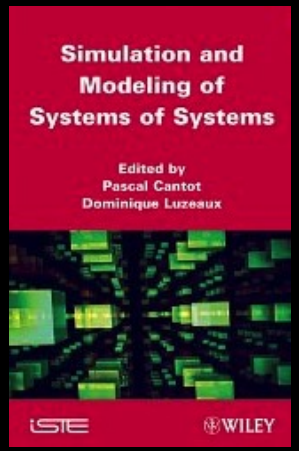


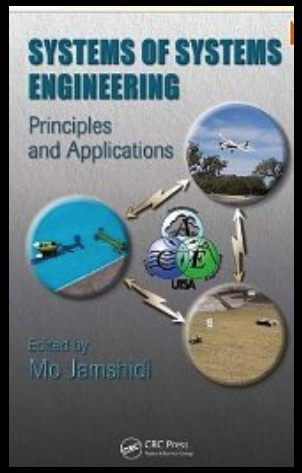


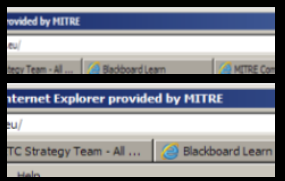










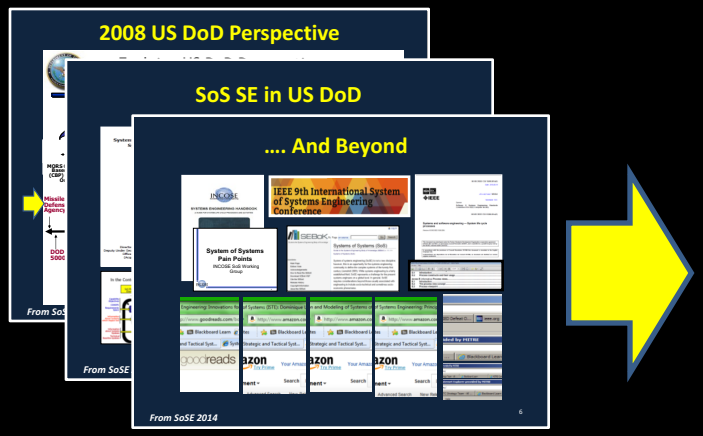


From SoSE 2014

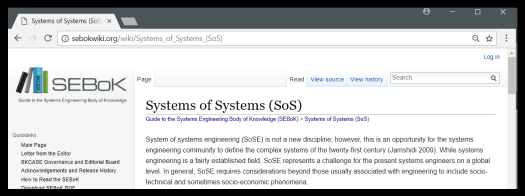
Approved for public release. Distribution unlimited 17-3712-46

© 2018 The MITRE Corporation. All rights reserved.

And Today?



IEEE – 13th System of Systems Engineering Conference
SoSE 2018



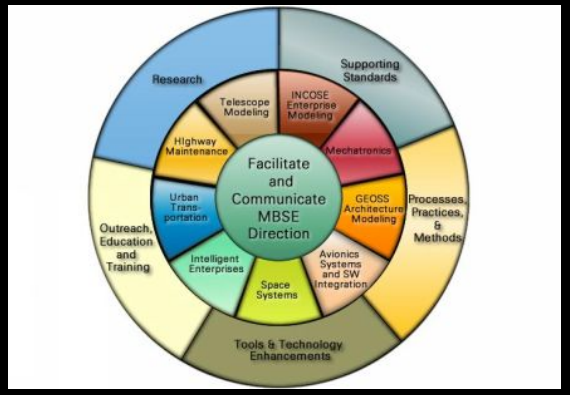
Approved for public release. Distribution unlimited 17-3712-46

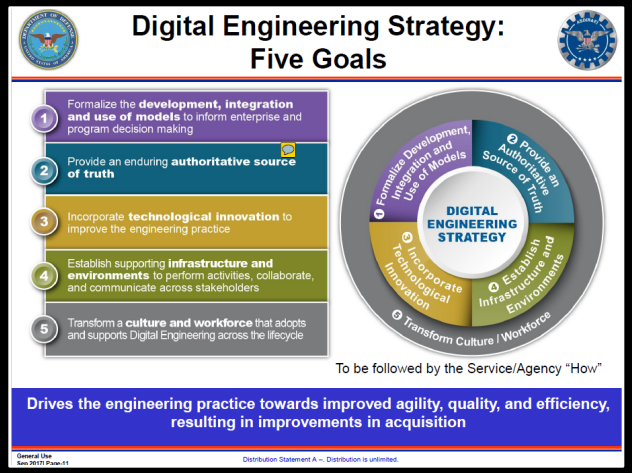
© 2018 The MITRE Corporation. All rights reserved.

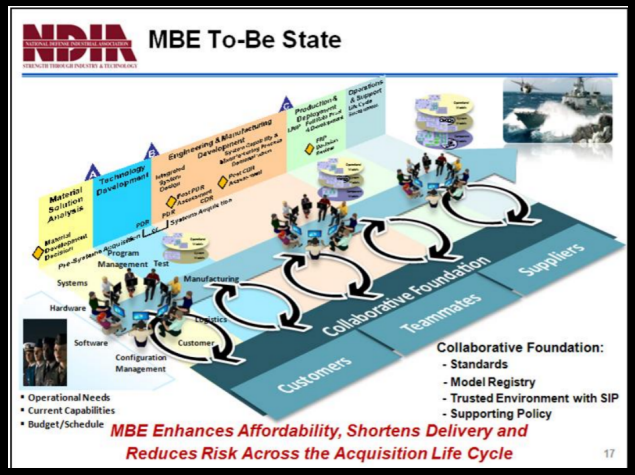
Also Today …..

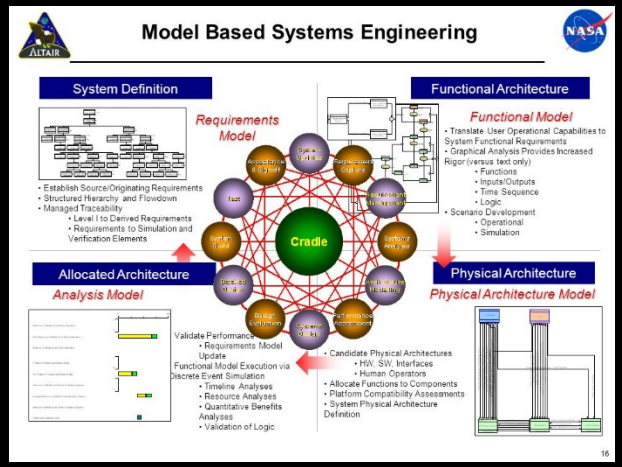
Model-Based Systems Engineering:

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. (INCOSE 2007)









Approved for public release. Distribution unlimited 17-3712-46

© 2018 The MITRE Corporation. All rights reserved.

Why Model Based Approaches to SoSE?

Approved for public release. Distribution unlimited 17-3712-46

© 2018 The MITRE Corporation. All rights reserved.

Time to Stop Admiring the Problem?

Pain Points

INCOSE International Symposium
Las Vegas, NV
June 30 - July 3, 2014

SoS Authority
What are effective collaboration patterns in SoS?

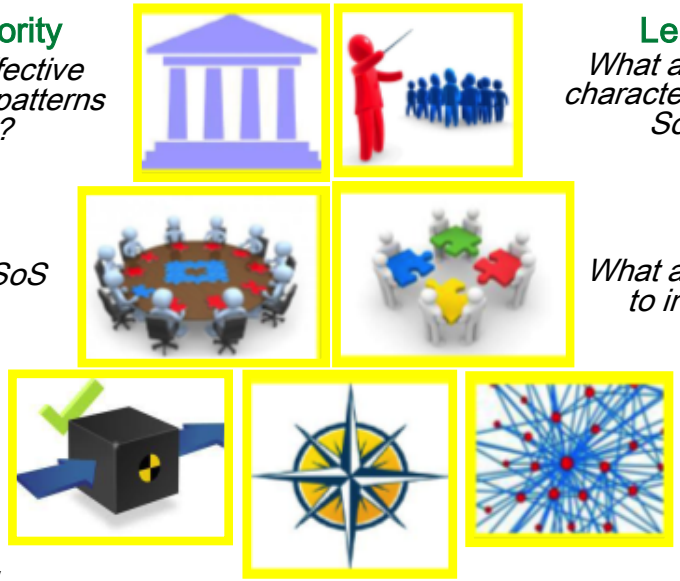
Leadership
What are the roles and characteristics of effective SoS leaders?

Capabilities & Requirements
How can SE address SoS capabilities and requirements?

Constituent Systems
What are effective approaches to integrating constituent systems?

Testing, Validation & Learning
How can SE approach SoS validation, testing, and continuous learning in SoS?

Autonomy, Interdependencies & Emergence
How can SE address the complexities of interdependencies and emergent behaviors?



SoS Principles
What are the key SoS thinking principles?

7

Approved for public release. Distribution unlimited 17-3712-46

© 2018 The MITRE Corporation. All rights reserved.

Each constituent system brings its own perspective to the SoS

Constituent Systems

What are effective approaches to integrating constituent systems?

https://medium.com/gnostic-studies-living-gnosis-now/elephant-and-the-blind-men-625101030e60

Approved for public release. Distribution unlimited 17-3712-46

© 2018 The MITRE Corporation. All rights reserved.

Constituent Systems Have Their Own Constraints

Constituent Systems

What are effective approaches to integrating constituent systems?

https://inhabitat.com/inhabitots/twisty-critters-blocks-let-kids-create-fun-wacky-animals/

Approved for public release. Distribution unlimited 17-3712-46

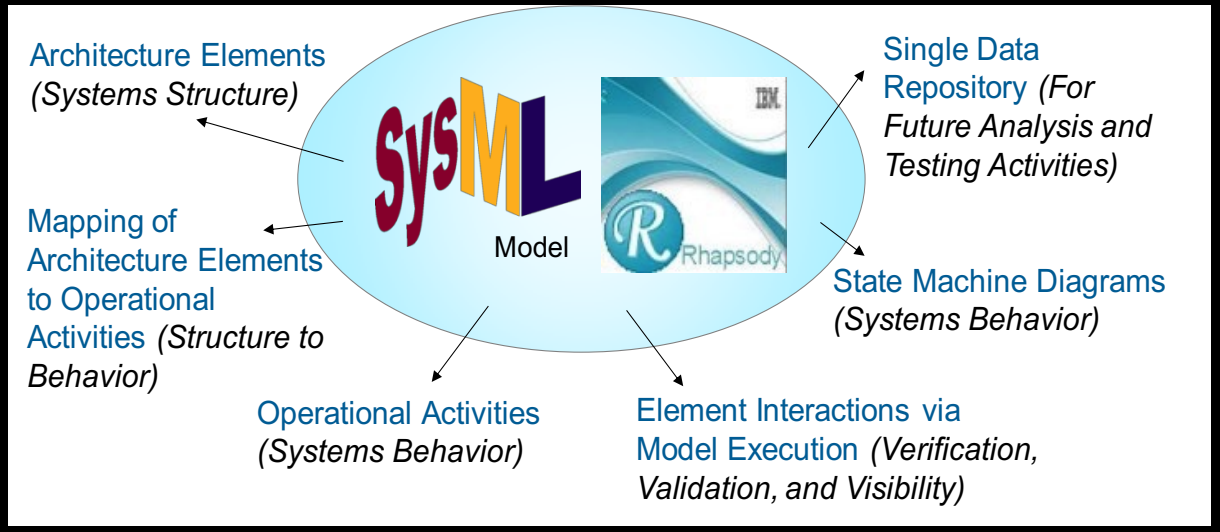
© 2018 The MITRE Corporation. All rights reserved.

Shared Venue for Understanding the SoS and Its Constituents

Constituent Systems

What are effective approaches to integrating constituent systems?

A standards-based SoSE model provides a common, unambiguous, structured, executable, digital representation of the SoS architecture



"SysML Executable Systems of Systems Architecture Definition: A Working Example"

Approved for public release. Distribution unlimited 17-3712-46

© 2018 The MITRE Corporation. All rights reserved.

Lack of Top-Level Authority Calls for Effective Collaboration

SoS Authority

What are effective collaboration patterns in SoS?

http://rrppmaster.uab.es/comunicacion-interna-la-columna-vertebral-una-organizacion/

Approved for public release. Distribution unlimited 17-3712-46

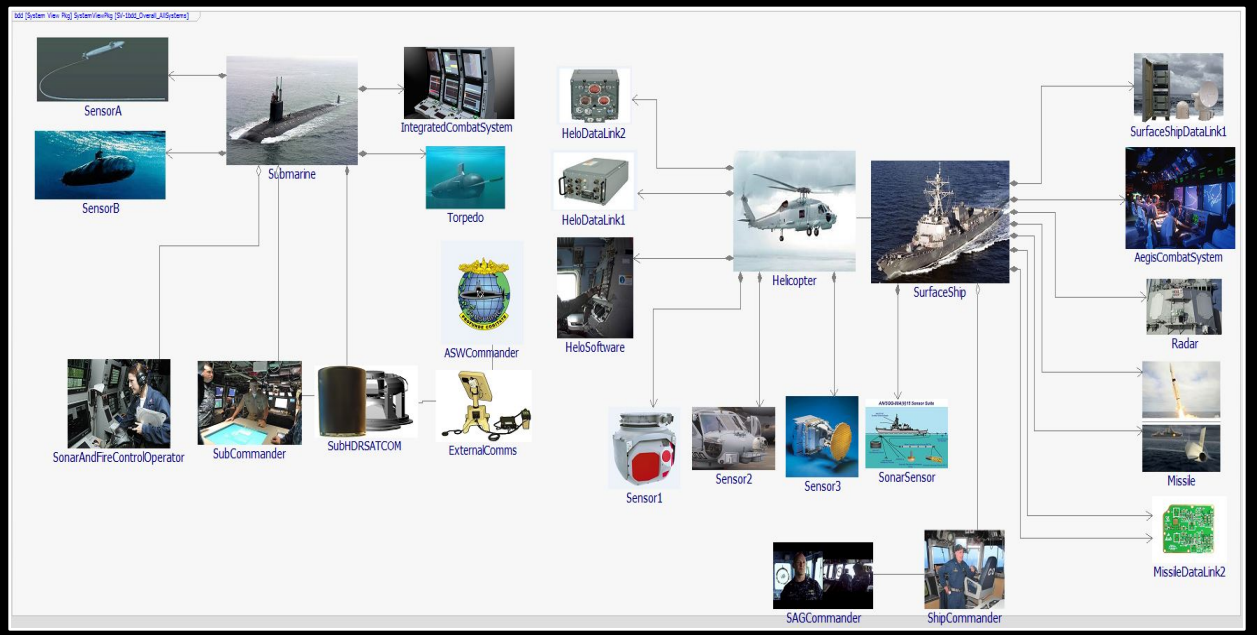
© 2018 The MITRE Corporation. All rights reserved.

Collaboration Begins With Communication

SoS Authority

What are effective collaboration patterns in SoS?

Models provide a common basis for consistent and coherent views of the SoSE to communicate across stakeholders



http://2017.ieeesyscon.org/

Approved for public release. Distribution unlimited 17-3712-46

© 2018 The MITRE Corporation. All rights reserved.

Effective SoSE Requires Trades Across Multiple Interdependent Considerations

Capabilities & Requirements

How can SE address SoS capabilities and requirements?

https://www.economist.com/buttonwoods-notebook/2016/03/02/a-trade-off-between-sovereignty-and-economics

Approved for public release. Distribution unlimited 17-3712-46

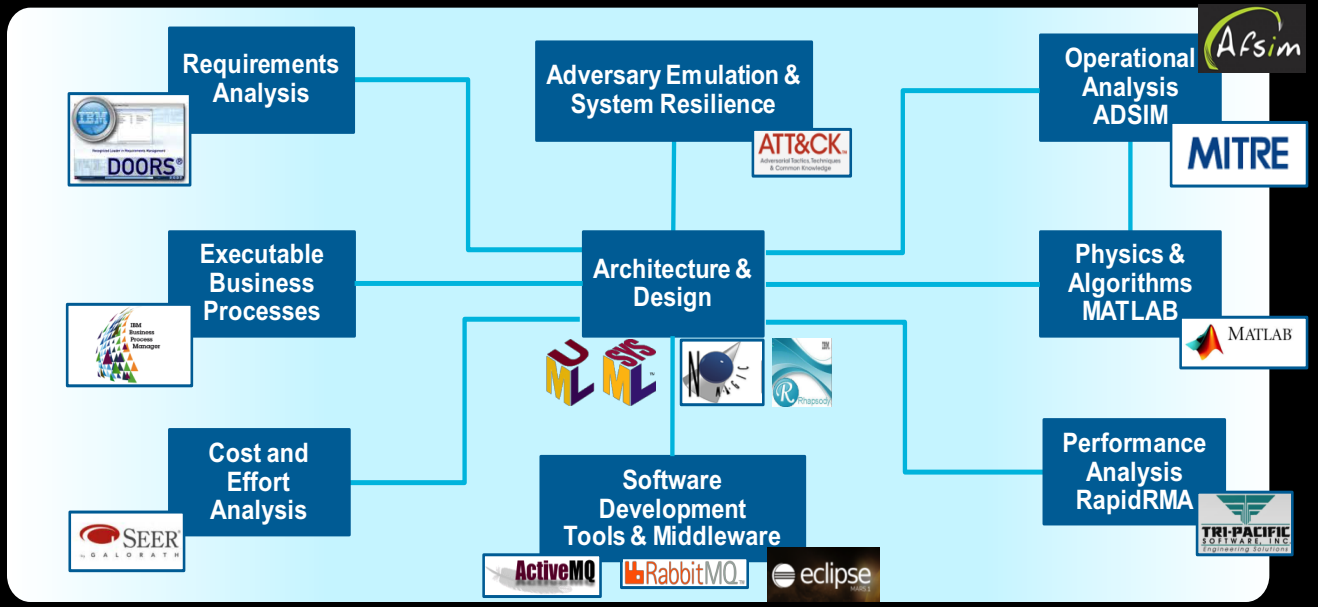
© 2018 The MITRE Corporation. All rights reserved.

Effective SoSE Requires Trades Across Multiple Interdependent Considerations

Capabilities & Requirements

How can SE address SoS capabilities and requirements?

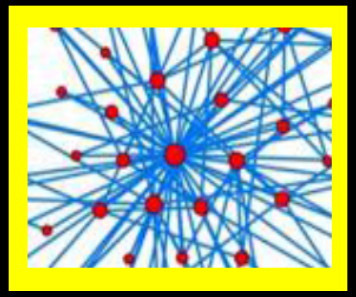
Linked models addressing different aspects of the SoS through a common set of core data supports concurrent analysis across competing dimensions



Approved for public release. Distribution unlimited 17-3712-46

© 2018 The MITRE Corporation. All rights reserved.

SoSE Needs Mechanisms to Express and Address Complexity



Autonomy, Interdependencies & Emergence

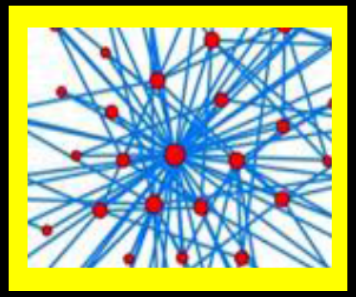
How can SE address the complexities of interdependencies and emergent behaviors?

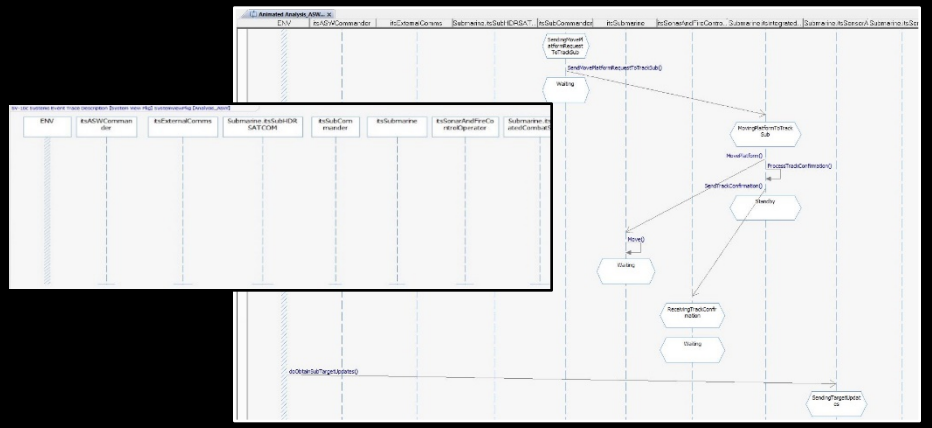
https://cmns.umd.edu/news-events/features/3491

Approved for public release. Distribution unlimited 17-3712-46

© 2018 The MITRE Corporation. All rights reserved.

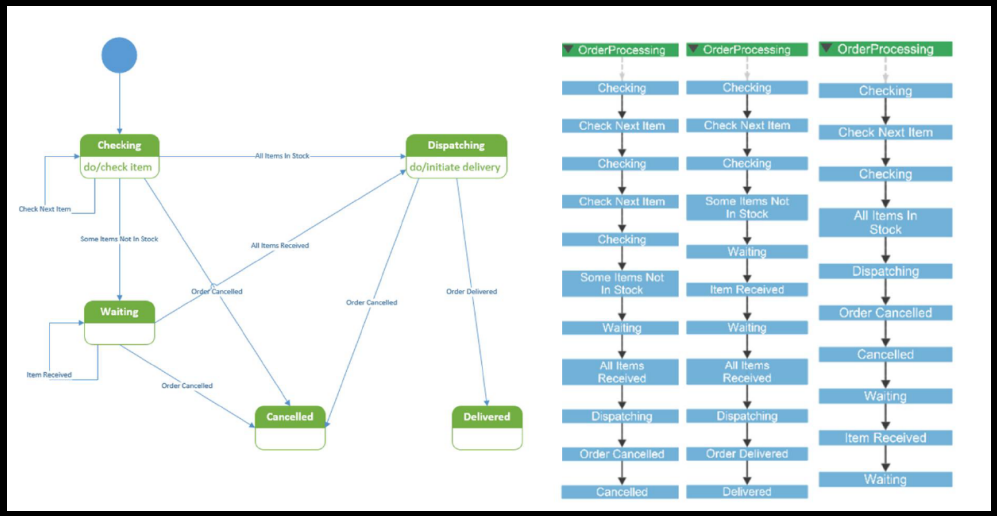
Effective SoSE Needs Mechanisms to Express and Address Complexity





Autonomy, Interdependencies & Emergence

How can SE address the complexities of interdependencies and emergent behaviors?

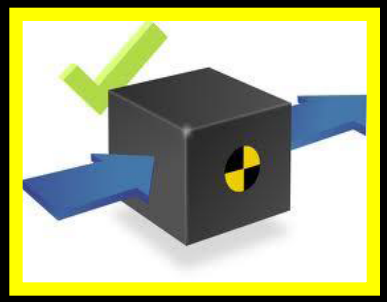


Giammarco et al. 2017

Approved for public release. Distribution unlimited 17-3712-46

© 2018 The MITRE Corporation. All rights reserved.

Testing, Validation and Learning



Testing, Validation & Learning

How can SE approach SoS validation, testing, and continuous learning in SoS?

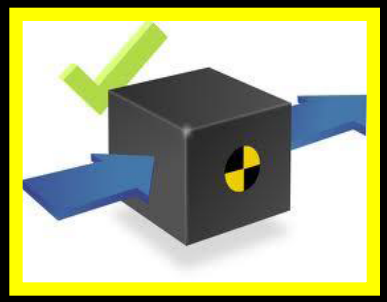
https://www.ped30.com/2017/10/29/apple-december-guidance/

"Wack-a-Mole"

Approved for public release. Distribution unlimited 17-3712-46

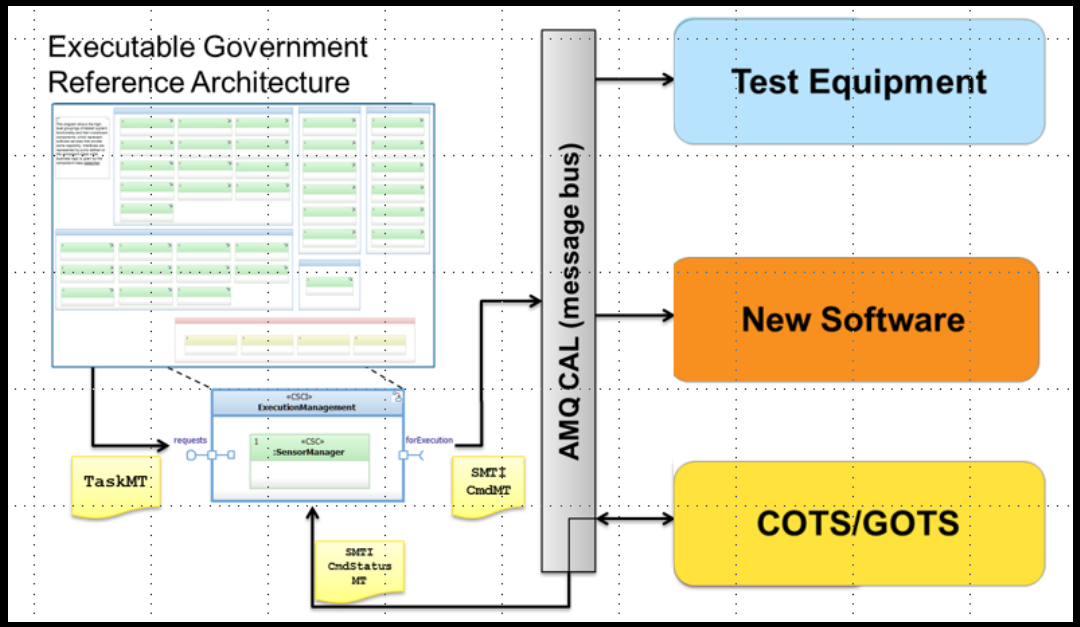
© 2018 The MITRE Corporation. All rights reserved.

Testing, Validation and Learning



Testing, Validation & Learning

How can SE approach SoS validation, testing, and continuous learning in SoS?



Wheeler, 2016

Approved for public release. Distribution unlimited 17-3712-46

© 2018 The MITRE Corporation. All rights reserved.

So … why Model-Based Approaches to SoSE?

SoS Principles

What are the key SoS thinking principles?

Leadership

What are the roles and characteristics of effective SoS leaders?

Approved for public release. Distribution unlimited 17-3712-46

© 2018 The MITRE Corporation. All rights reserved.

Questions?

Dr. Judith Dahmann
MITRE Corporation
jdahmann@mitre.org

Approved for public release. Distribution unlimited 17-3712-46

© 2018 The MITRE Corporation. All rights reserved.