31st Annual INCOSE international symposium
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Is CAD a Good Paradigm for MBSE?

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Motivation

- CAD transition is used to explain MBSE
  - MBSE is relatively new and inconsistently understood
  - Both represent shift from document-based to model-based
- But is this actually a good comparison…

Framework

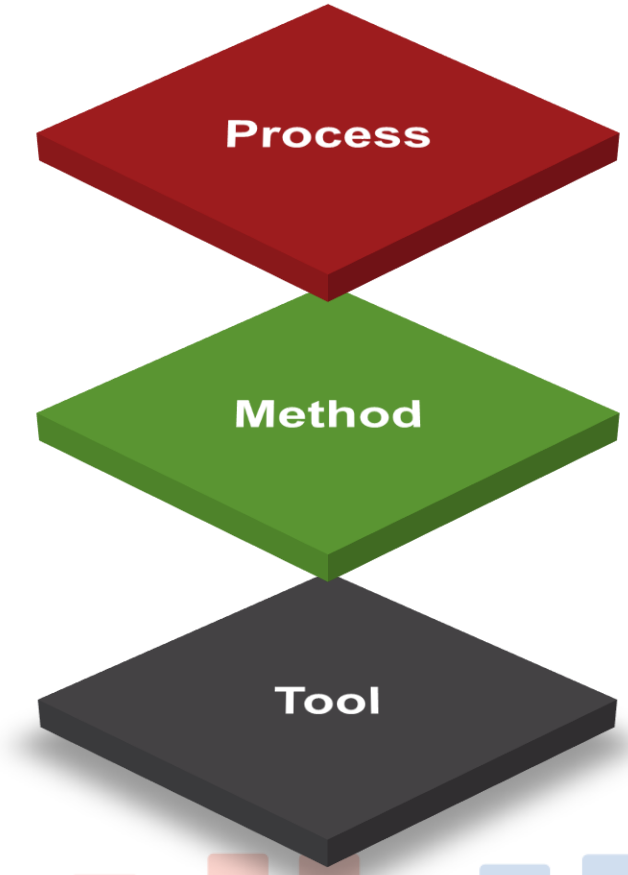
Compare CAD and MBSE on three criteria:

1. Definition
2. Adoption process/ barriers
3. Expected benefits

Definition Criterion

Definitions characterized using a framework utilized by Estefan (2007) to evaluate appropriate terminology for MBSE

- ***Process***: a logical sequence of tasks performed to achieve a particular object (what is to be done)
- ***Method:*** techniques for performing a process (how each task should be accomplished)
- ***Tool***: an instrument that when applied to a method can enhance the efficiency of a task



Adoption & Benefit Criteria

Adoption

- Process of adoption
- Difficulties/ barriers to adoption

Rationale: comparison used to convince others to adopt MBSE

Benefit

- Commonly expressed benefits

Rationale: comparison used to show what benefit MBSE will provide

CAD Definition

Process: defines what is to be done without specifying how
Method: how each task should be accomplished
Tool: instrument applied to method

"Computer-aided design (CAD) can be defined as the use of computer systems to assist in the creation, modification, analysis, or optimization of a design." (Groover & Zimmers, 1983)

- The space where the design is created is the CAD model, which also manages physical design information and its interrelationships (Reil, 2015).
- A CAD model provides "a natural way of sharing design information among participants in the design process" (Jezernik & Hren, 2003).

MBSE Definition

Process: defines what is to be done without specifying how
Method: how each task should be accomplished
Tool: instrument applied to method

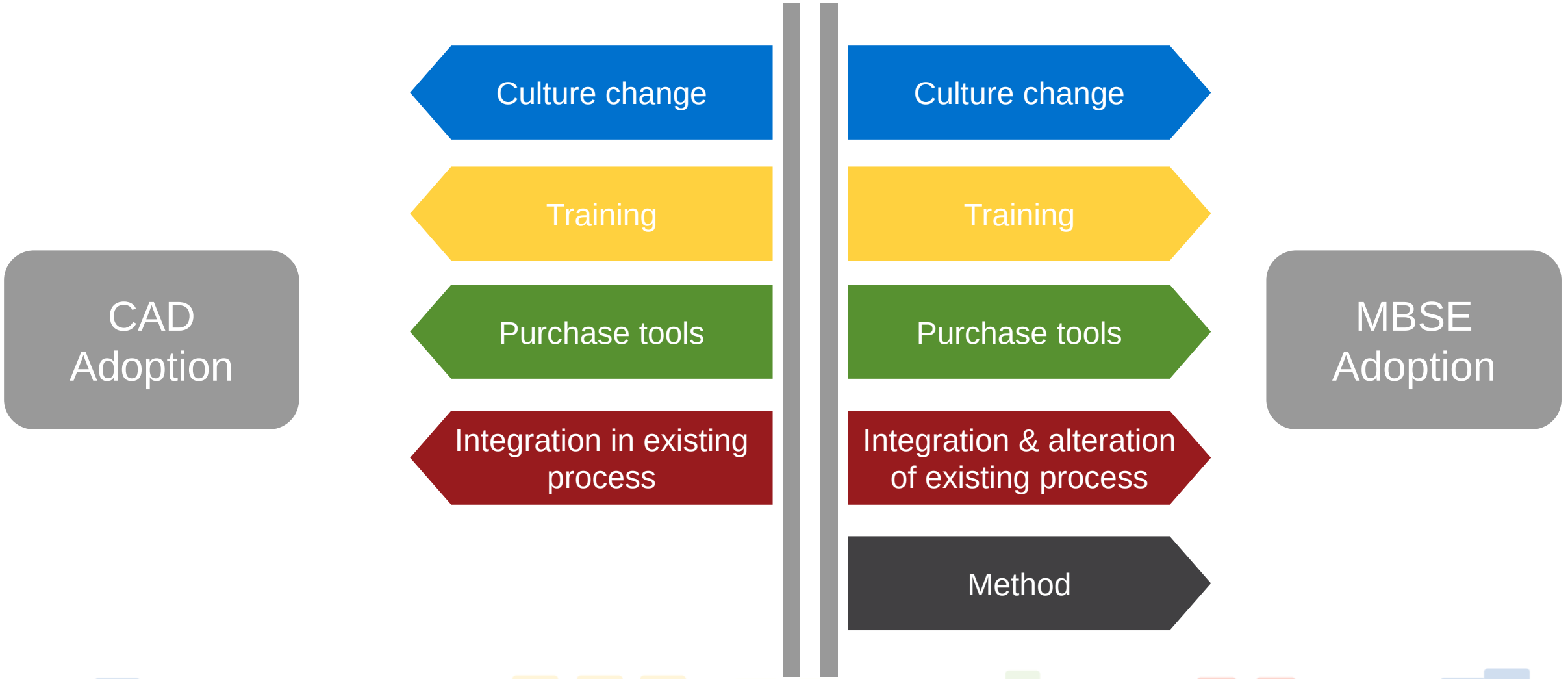
"MBSE is the formalized application of modeling to support system requirements, design, analysis, verification and validation, beginning in the conceptual design phase and continuing throughout development and later life cycle phases." (Friedenthal, Griego, & Sampson, 2007)

- The term MBSE includes multiple concepts: modeling language, method, and tool (Chami & Bruel, 2018)
- The 'method' determines what modeling activities are performed and in what order, as well as the artifacts produced
- Various tools required to carry out the modeling activities (software, computers, and modeling languages)

Definition Comparison

Characteristic	MBSE Context	CAD Context
Process	MBSE is a process with various methods to carry out the necessary tasks.	CAD cannot be conceptualized at the process level
Method	MBSE is a method of executing systems engineering. There are also methods for executing MBSE as a process	CAD is a method to create manufacturing drawings and designs
Tool	There are tools used to implement MBSE (i.e. modeling languages, software, etc.)	There are tools used to implement CAD (i.e. computer systems)

Adoption Process Comparison



Adoption Barriers Comparison

MBSE Barriers	Original CAD Barriers
-Upfront Investment	-Cost
-Failure to perceive true benefits	-Failure to perceive true benefits
-Leadership support	-Leadership support
-Availability of MBSE methods/tools	-Technological limitations
-Resistance to change	-Resistance to change
-Workforce knowledge/skills	-Workforce knowledge/skills
-Organizational culture	-Lack of coordination and cooperation within an organization
-Adoption strategy	
-Method definition	

Benefit Comparison

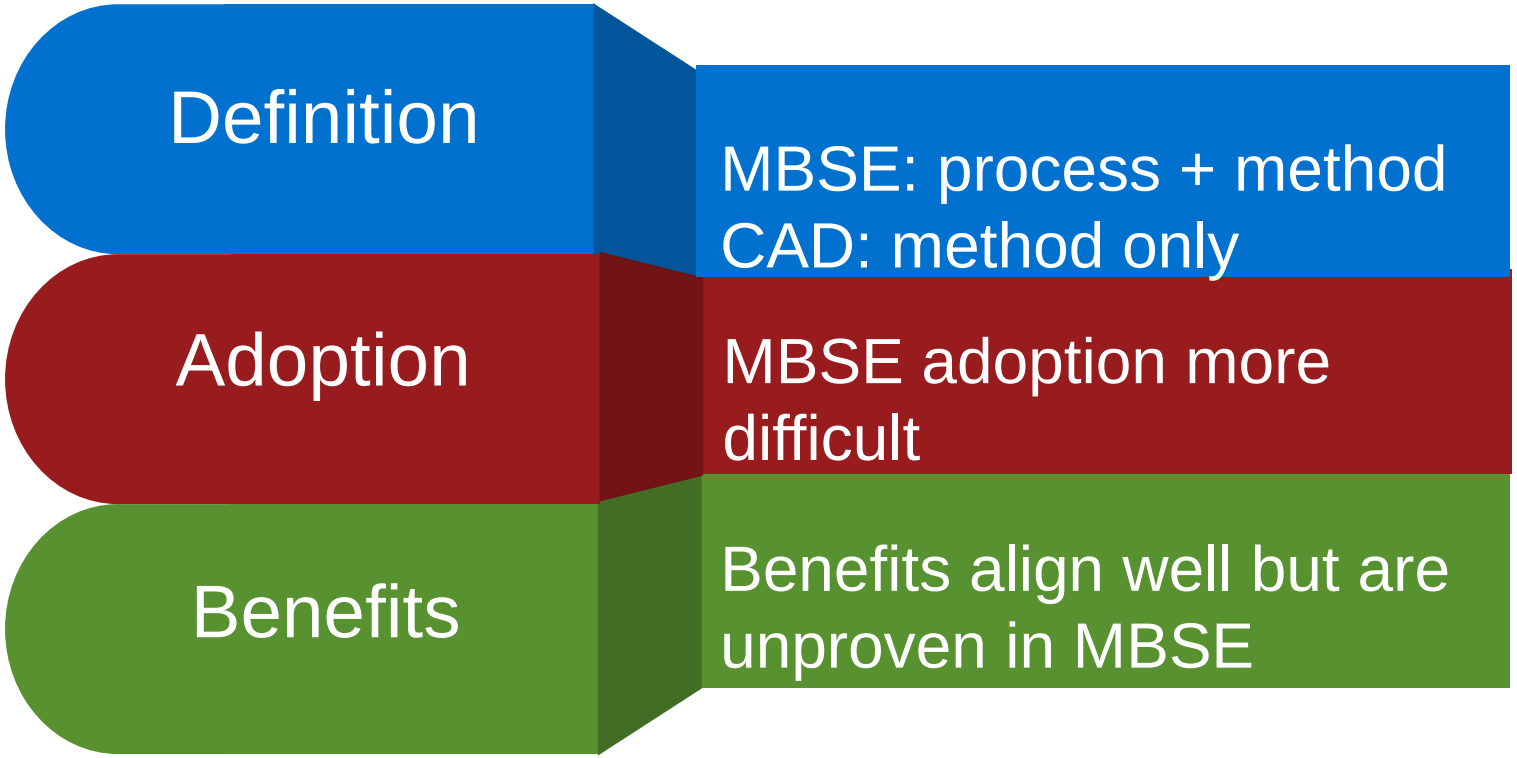
Shared Benefits
Increased quality
Increased productivity
Reduce errors
Increased info mgt.
Reduce cost
Better manage complexity
Increased flexibility
Reduce time
Automation & simulation
Knowledge transfer
Reduce rework

MBSE Specific
Early V&V
Better requirements generation
Better requirements management
Increased traceability
Increased capacity for reuse

CAD Specific
Domain specific benefits (i.e. safety)

Where does this leave us?

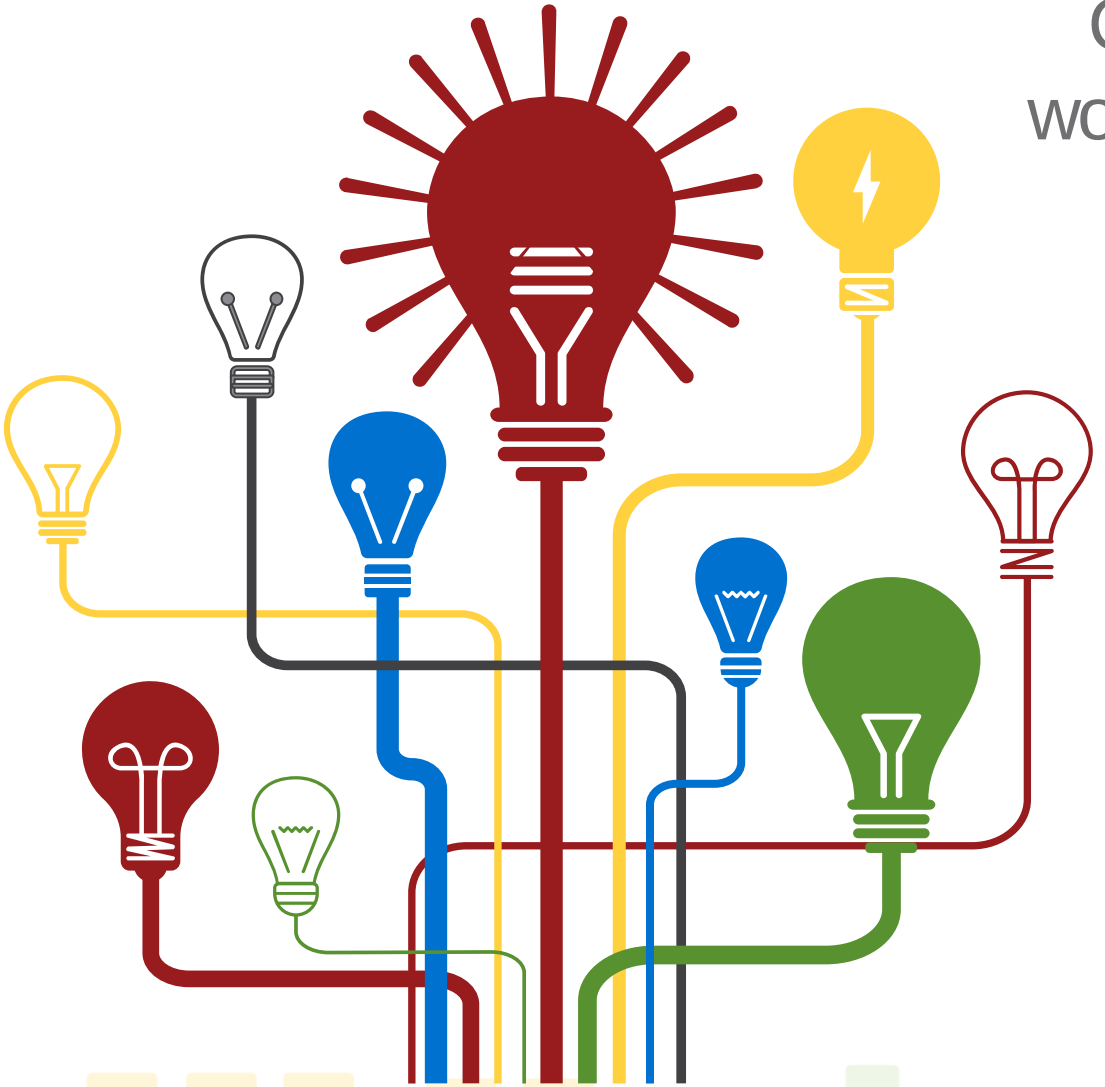
Conceptually, both are a transition to model-based approach



Conclusions

We believe the SE community should cease to refer to CAD as the paradigm-shift that MBSE should mirror

Instead, identify MBSE as part of the larger ***Digital Transformation***



CAD comparison works at surface level only

Need to recognize difficulty associated with adopting & implementing MBSE

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See paper for complete list of references.

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