Understanding the impact of changing role of simulation

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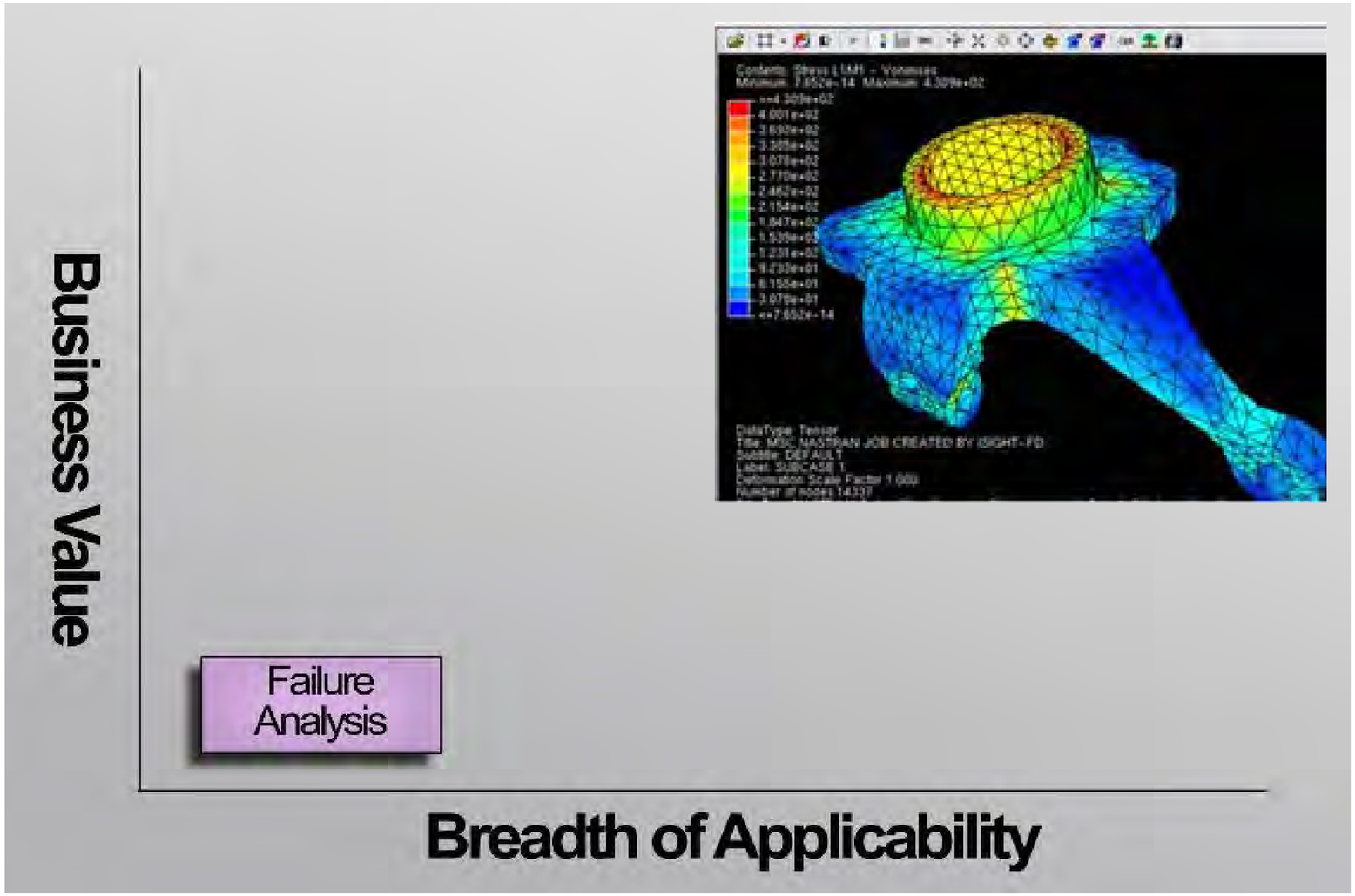
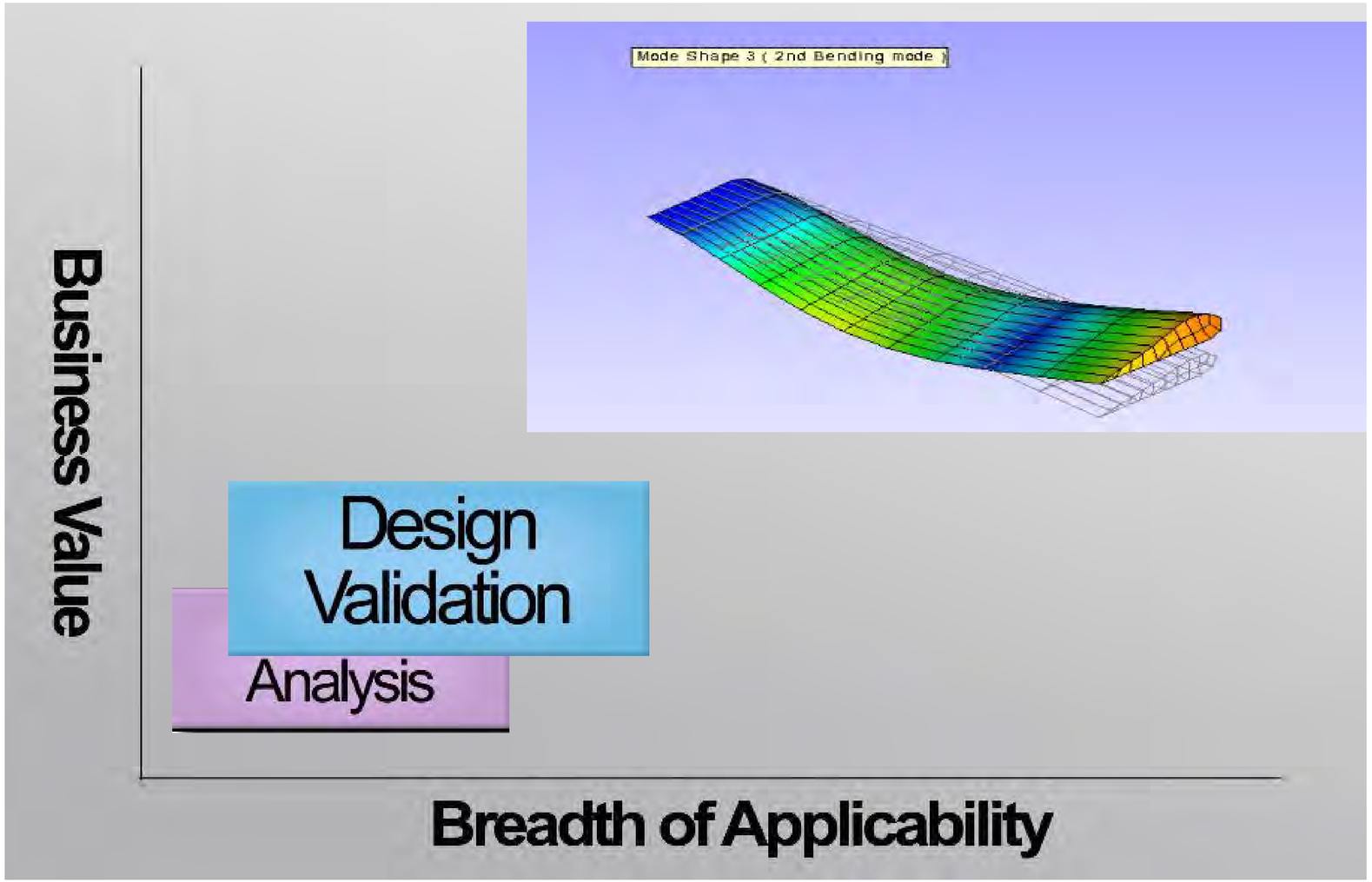
The Changing Role of Simulation

The Changing Role of Simulation



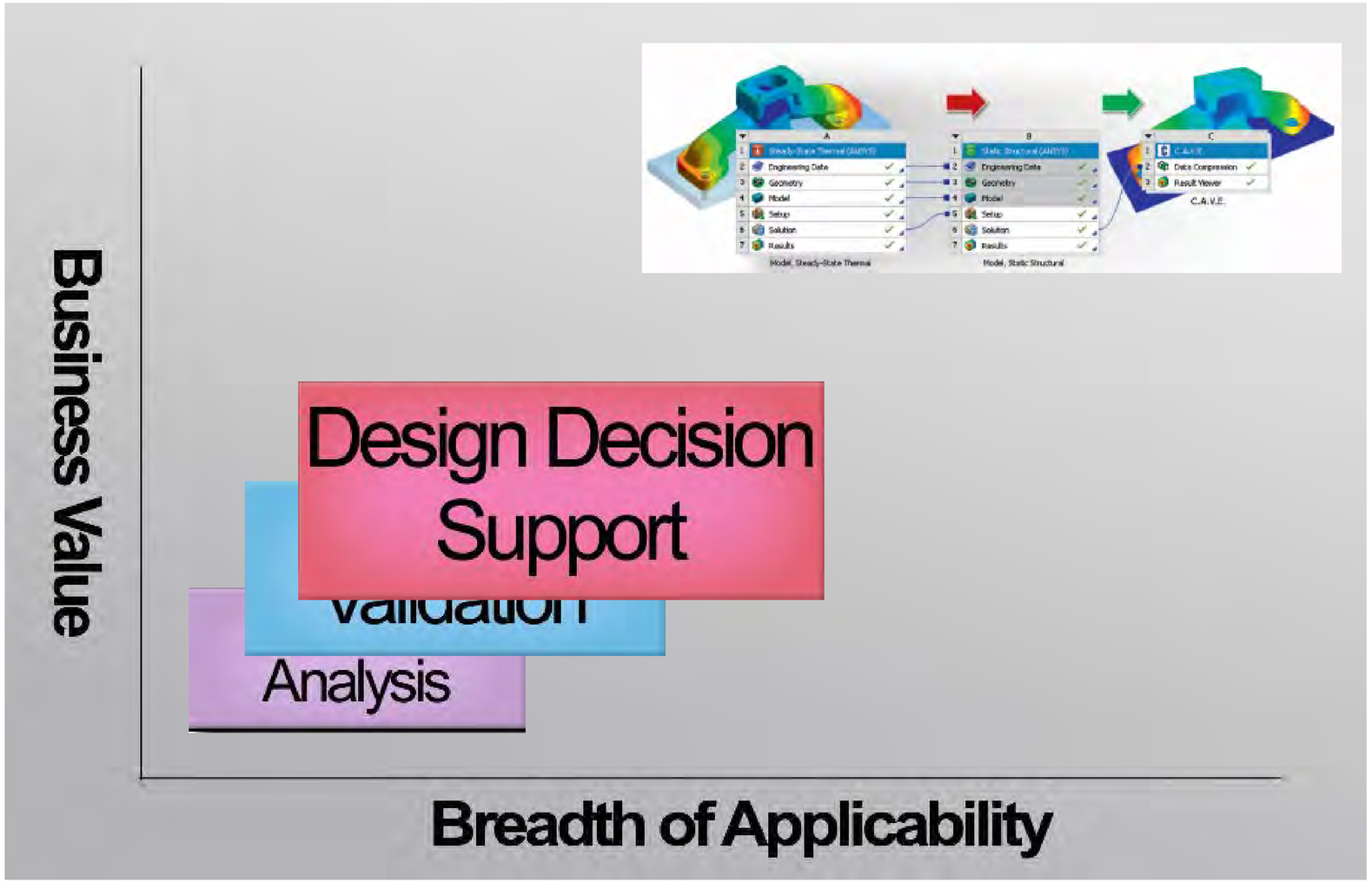
- **Failure Analysis**
  - This is where simulation begins
  - Understanding “why it failed”
  - Run by a few “experts”
  - Dominated by test vs analysis comparisons

The Changing Role of Simulation



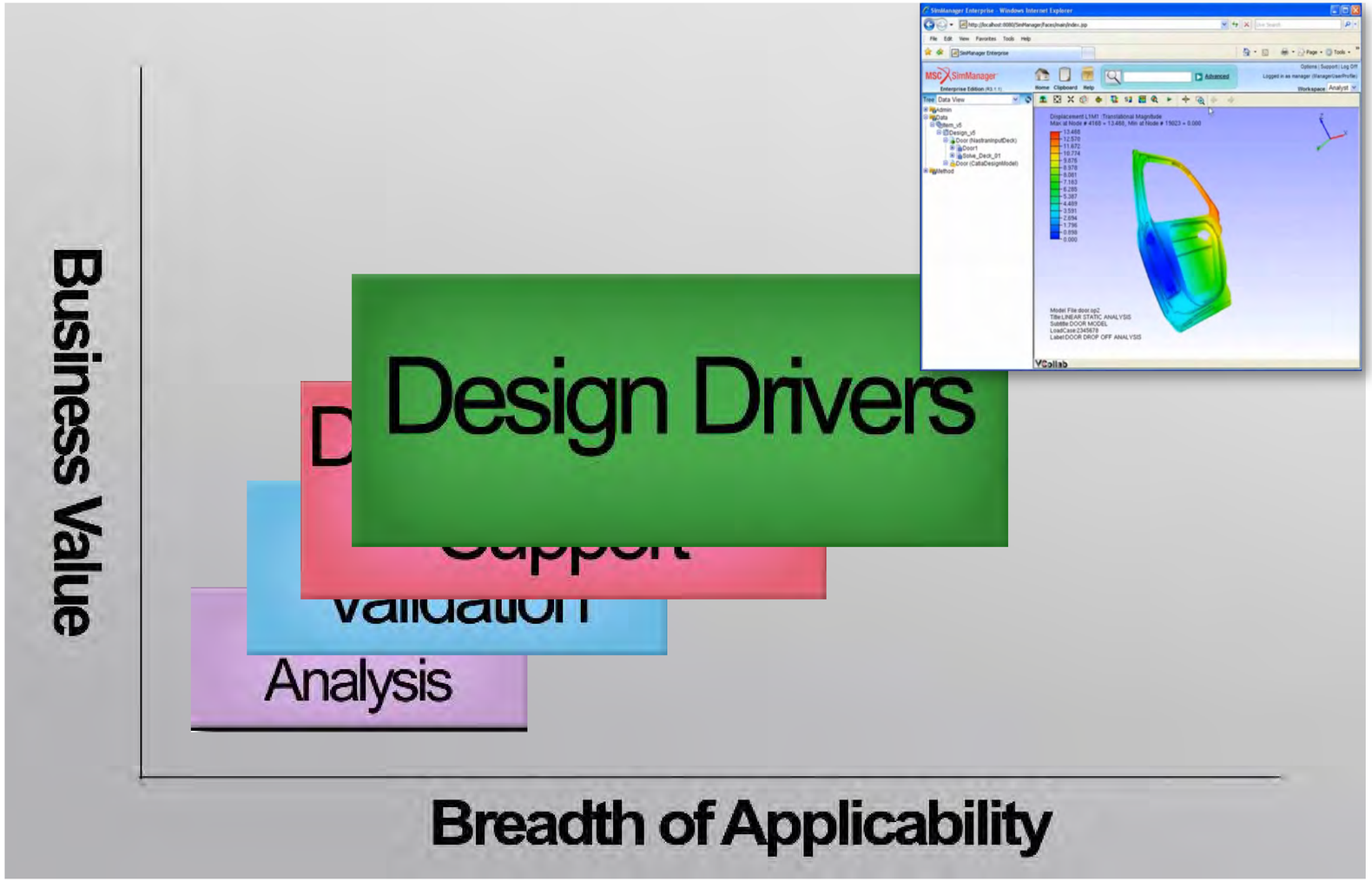
- **Design Validation**
  - Checking before it fails
  - The dawn of Virtual Prototyping
  - Broader use of simulation

The Changing Role of Simulation



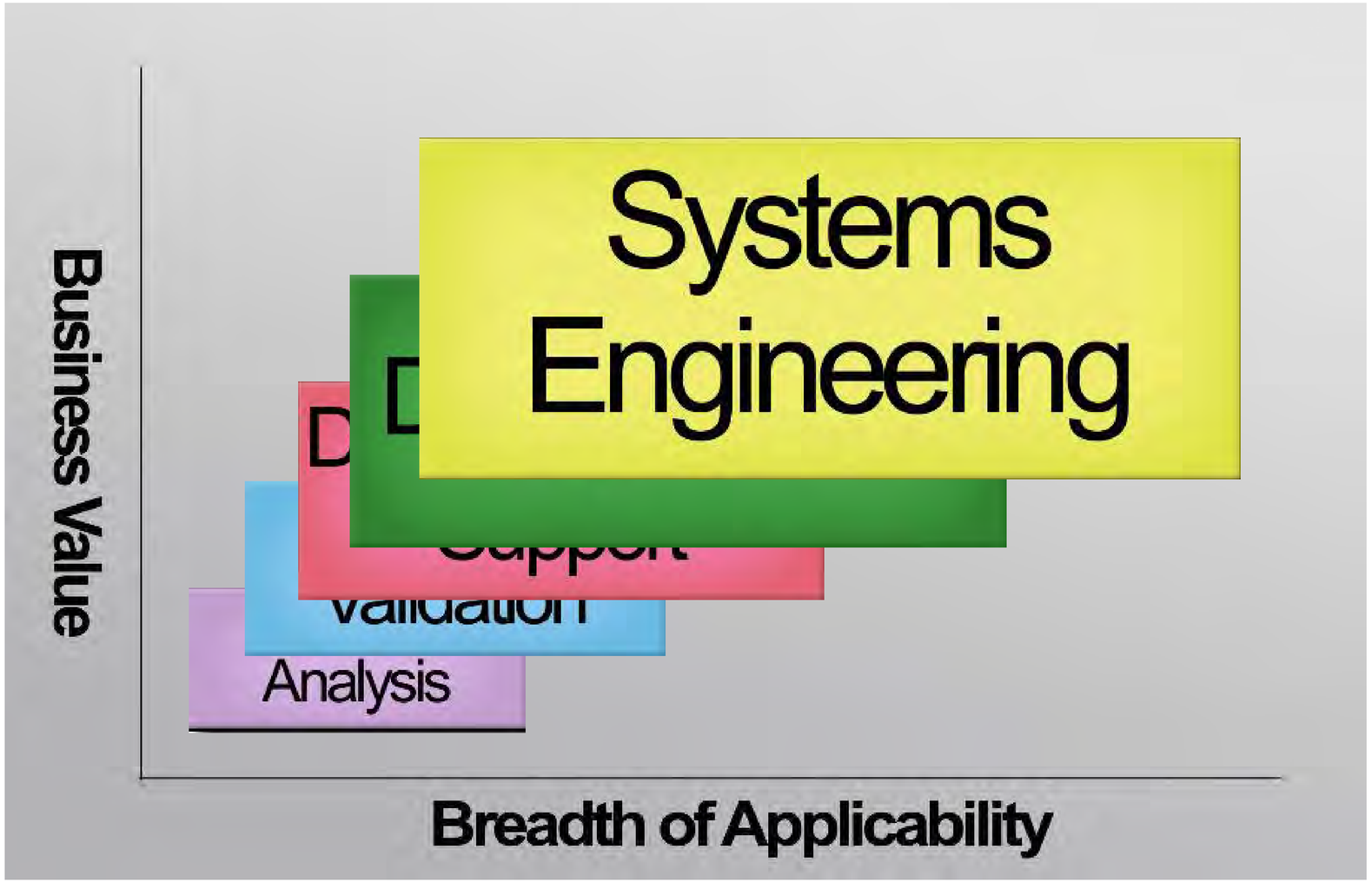
- **Design Decision Support**
  - Why not use simulation to make better design decisions
  - Why not ask designers to run simulations

The Changing Role of Simulation



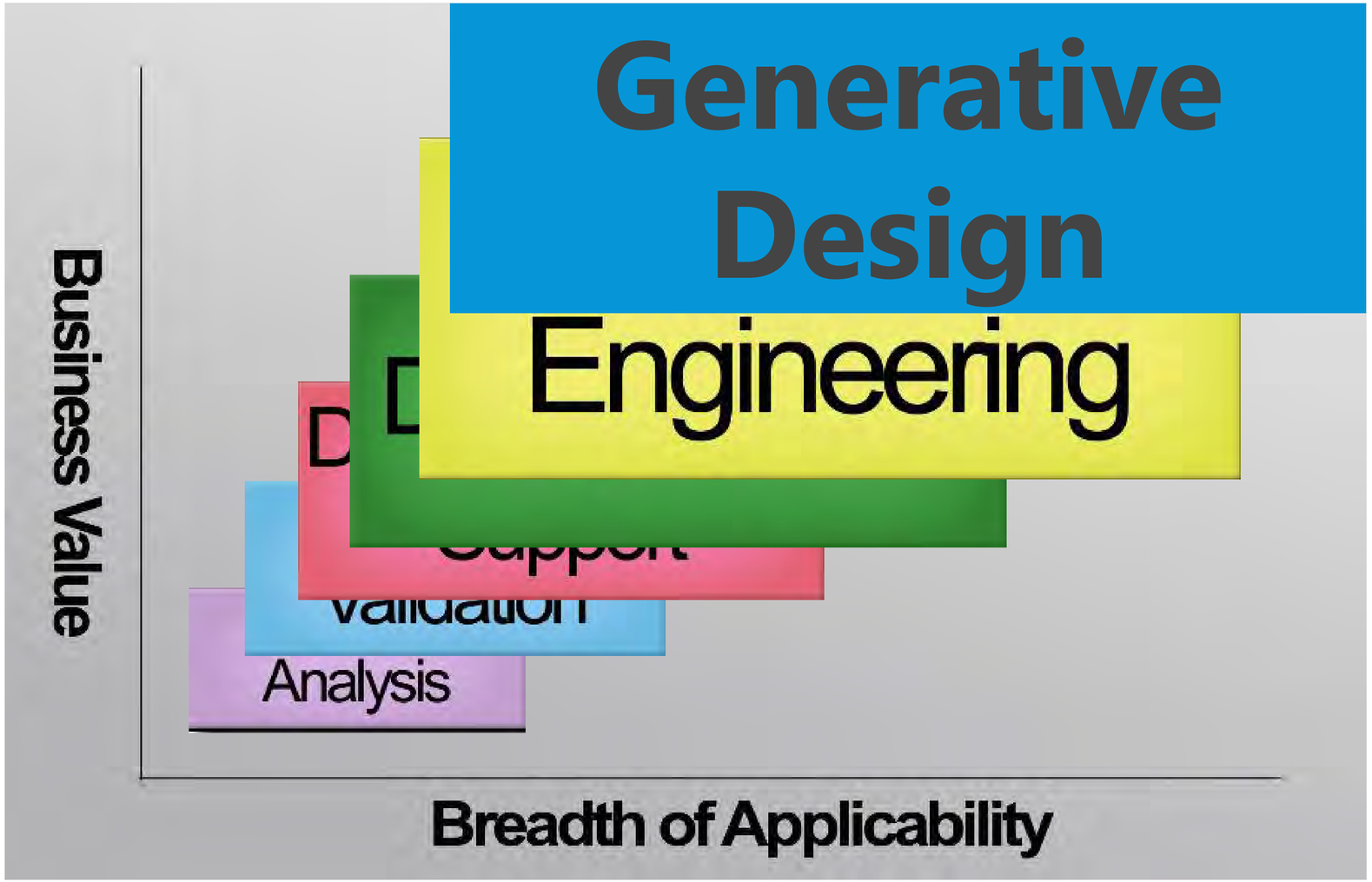
- **Design Drivers**
  - Simulation Driven Design
  - Simulation making design decisions

The Changing Role of Simulation



- **Systems Engineering**
  - Driven by growth of embedded software
  - Heavily used in EDA world
  - Design drivers extended to systems
  - System rather than sub-system optimization

The Changing Role of Simulation

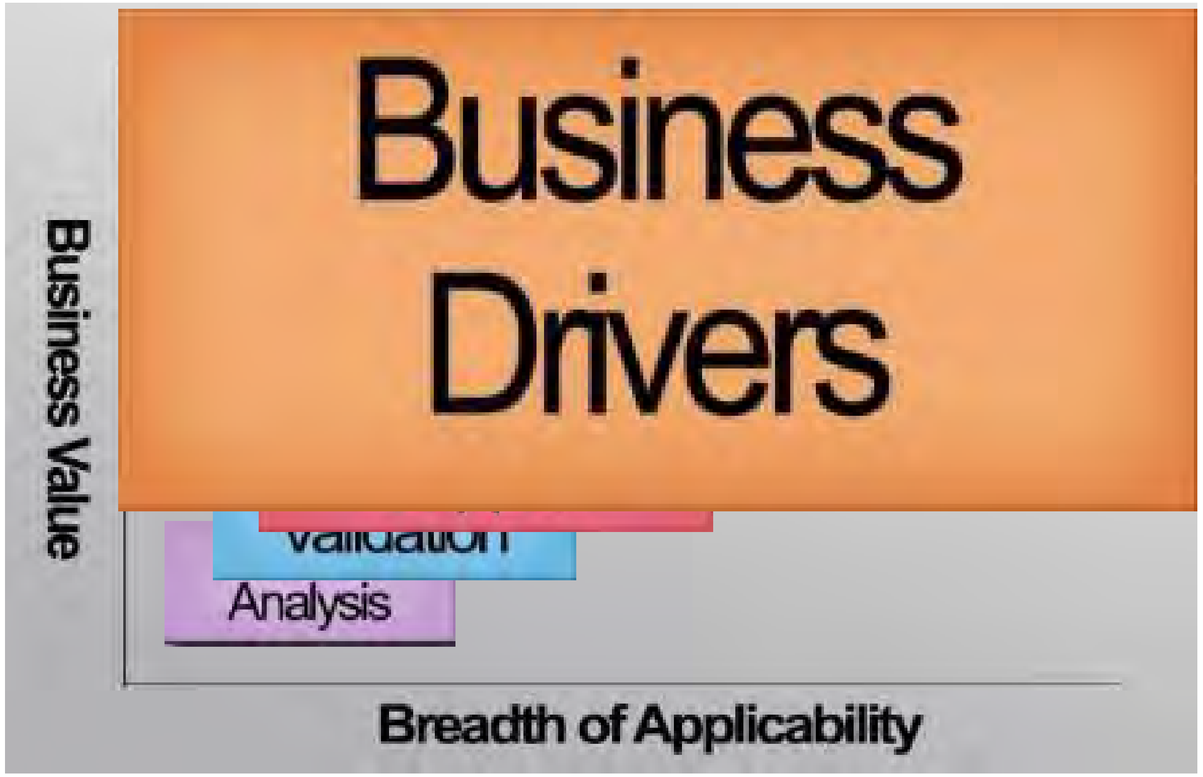


- **Generative Design**
  - Software developing design options accounting for:
    - Objectives
    - Constraints
    - Manufacturing
    - Cost
    - Design space

The Changing Role of Simulation

The Changing Role of Engineering Simulation is about becoming a major key to strategic goals for improving competitiveness

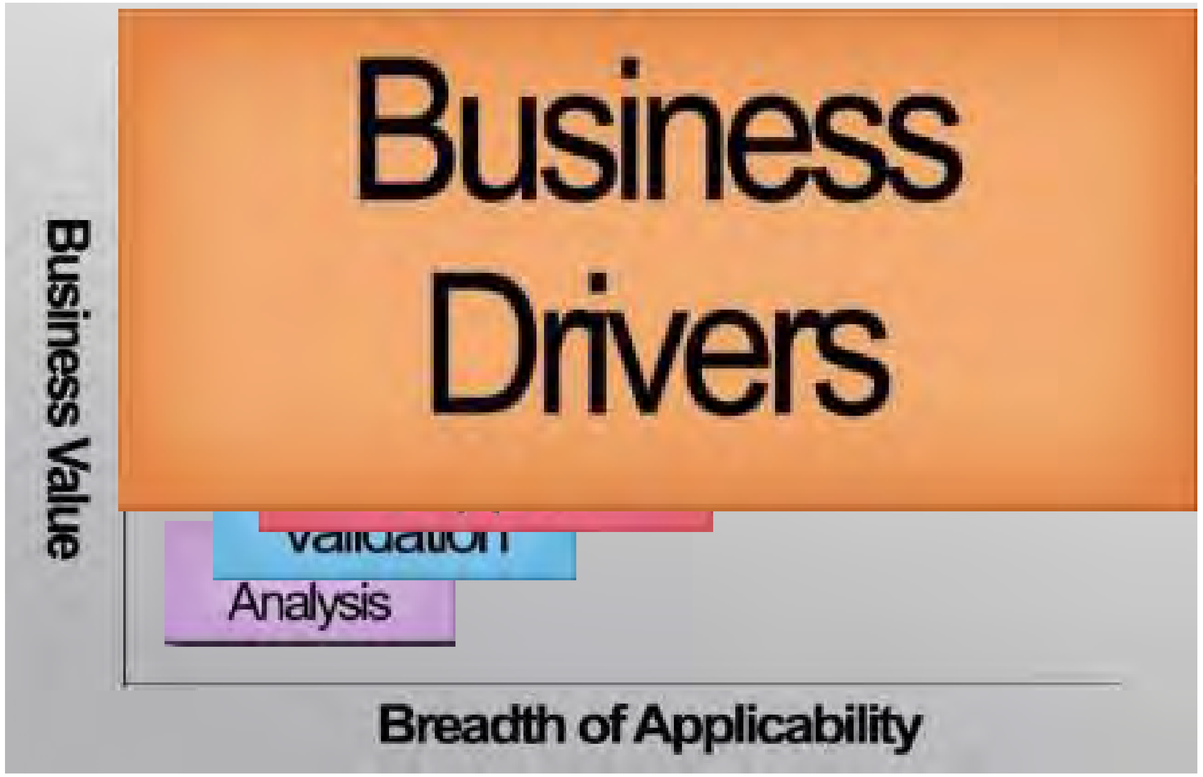
- Increase Innovation
- Increase Quality
- Reduce Risk
- Reduce Time
- Reduce Cost



The Changing Role of Simulation

Business Drivers are forcing a “Simulation Revolution” to overcome an expertise-based limitation

Engineering Simulation will be forced to find a way



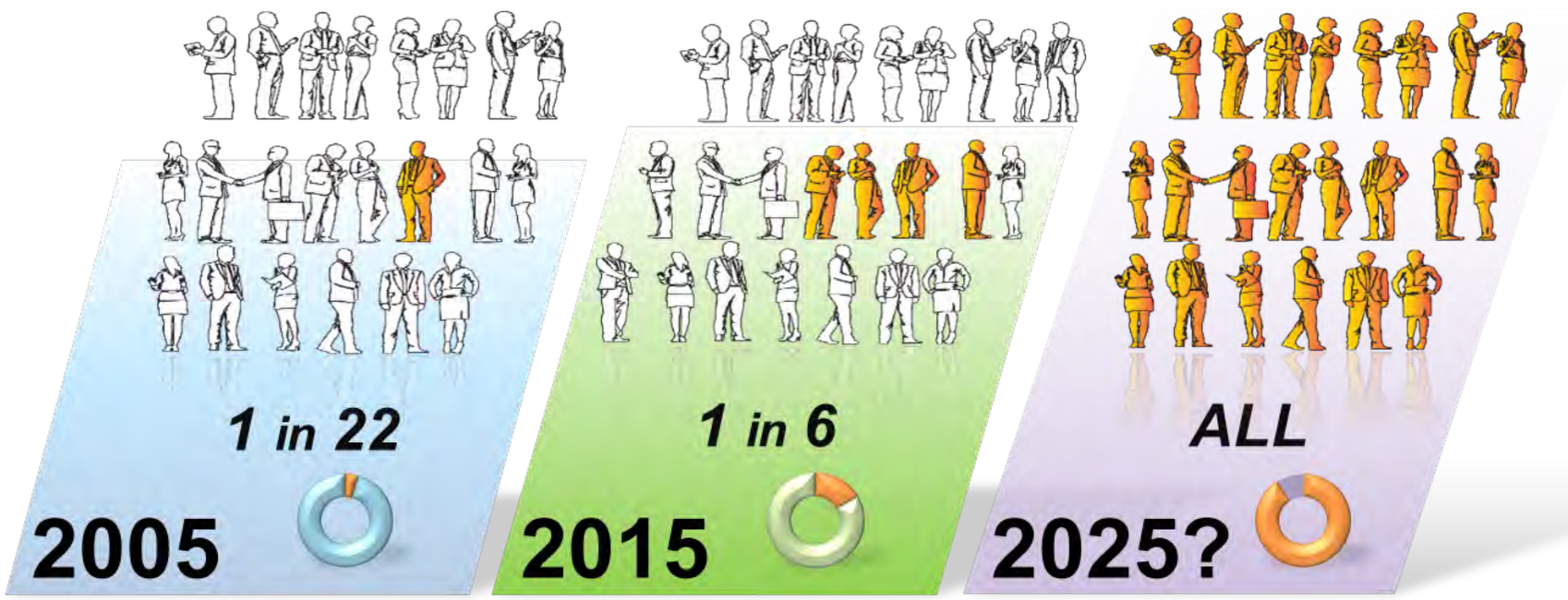
The Changing Role of Simulation

- Engineering Simulation is rapidly being recognized as a key enabler to Increased Innovation & Increased Competitiveness

- The Simulation Revolution is about making Engineering Simulation widely available & appropriate to support improved decision making throughout the entire life-cycle of engineered products and processes

The Changing Role of Simulation

Potential for Growth in Engineering Simulation Use



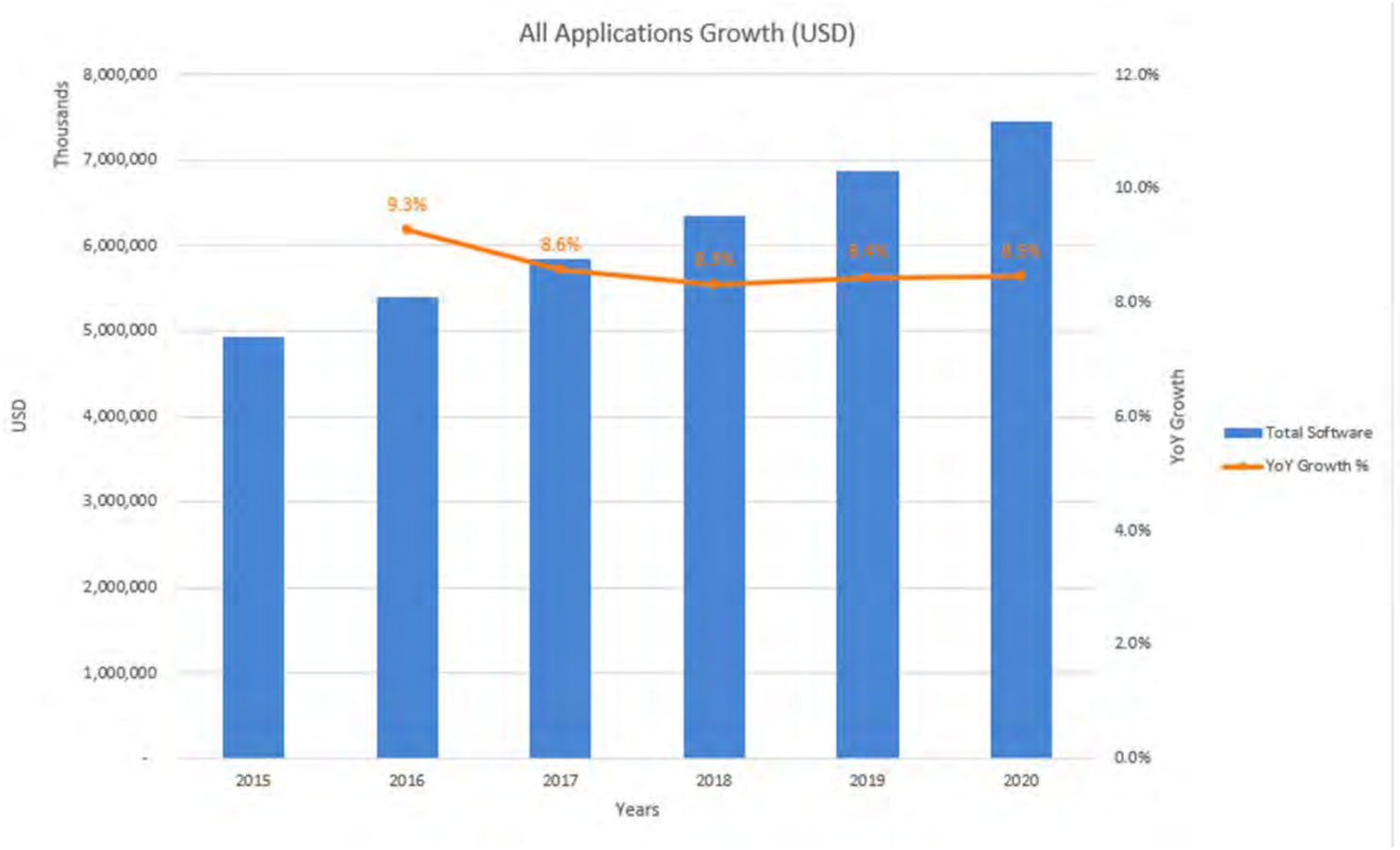
The Simulation Revolution is Real

The Simulation Revolution is Real

2D-3D CAE Market

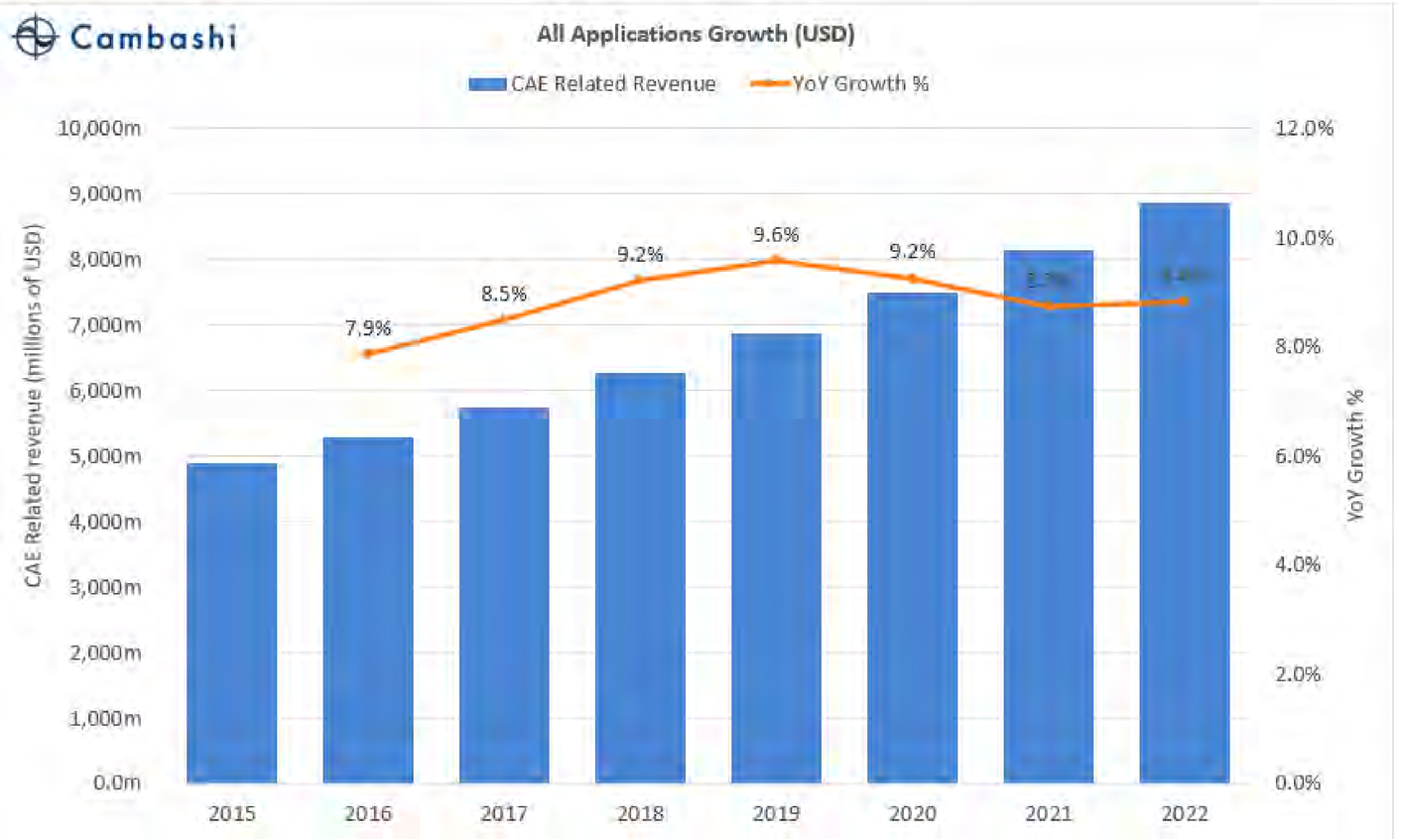
data courtesy of Cambashi CAE Market Observatory

- 2017 CAE Observatory
  - Market of almost $ 7.5Bn in 2020
  - Growth rate through 2020 of ~ 8.5%



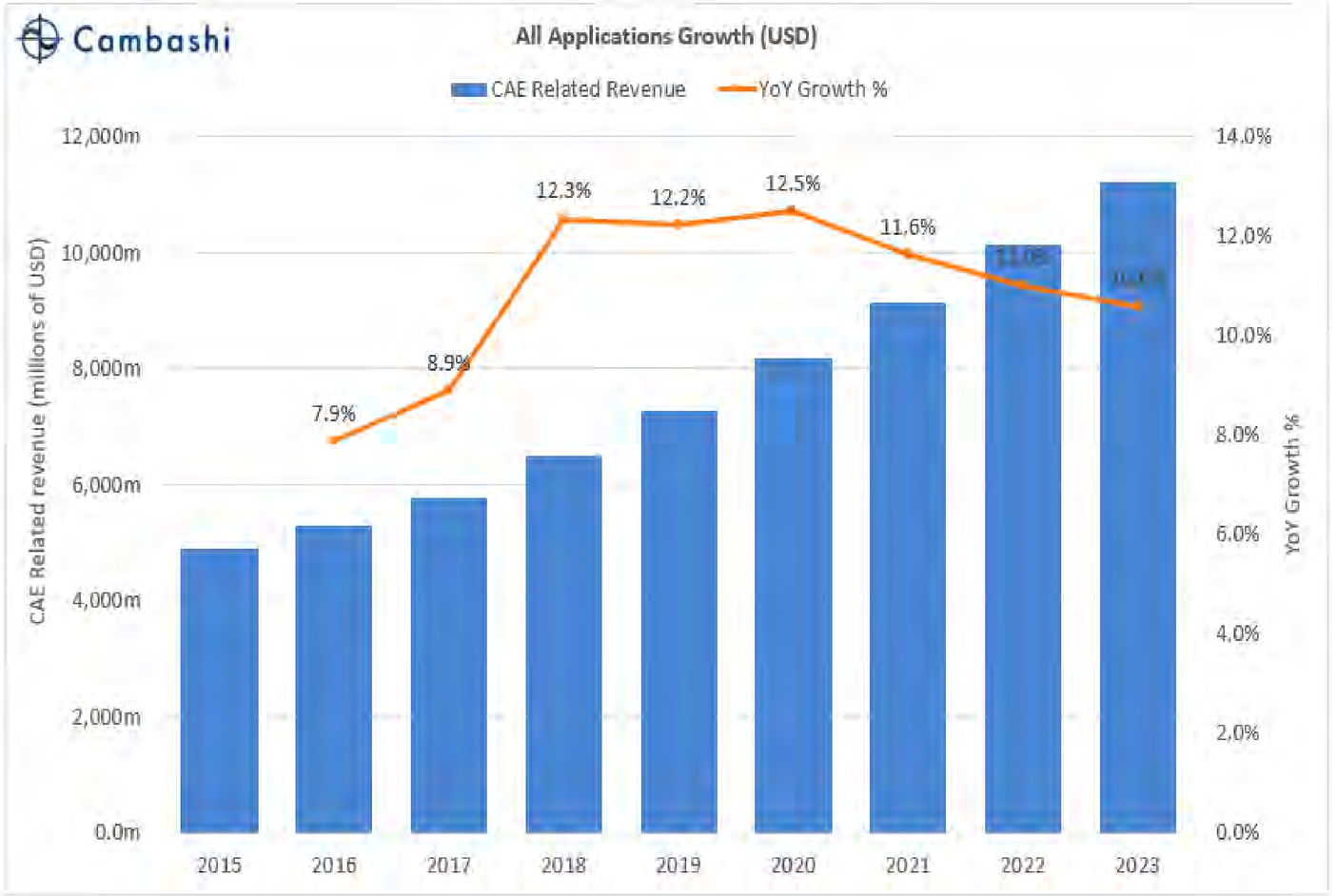
The Simulation Revolution is Real

- 2018 CAE Observatory
  - Market of $ 7.5Bn in 2020
  - Growth rate through 2020 of ~ 9.2% - 9.6%
  - CAE Market of $ 8.9Bn in 2022

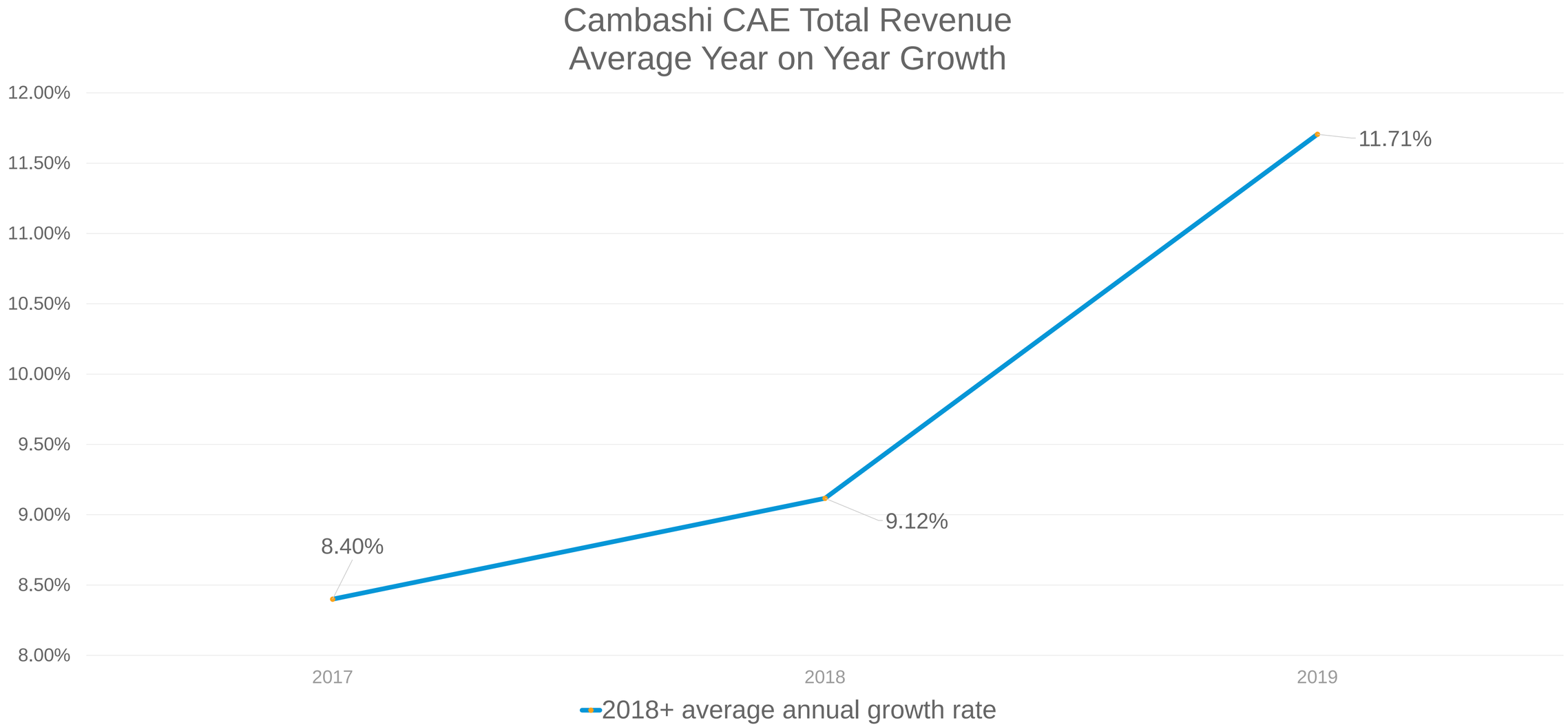


The Simulation Revolution is Real

- 2019 CAE Observatory
  - Market of almost $ 8.2Bn in 2020
  - Growth rate through 2020 of ~ 12.2% - 12.5%
  - CAE Market of over $ 10.1Bn in 2022 and over $ 11.2Bn in 2023

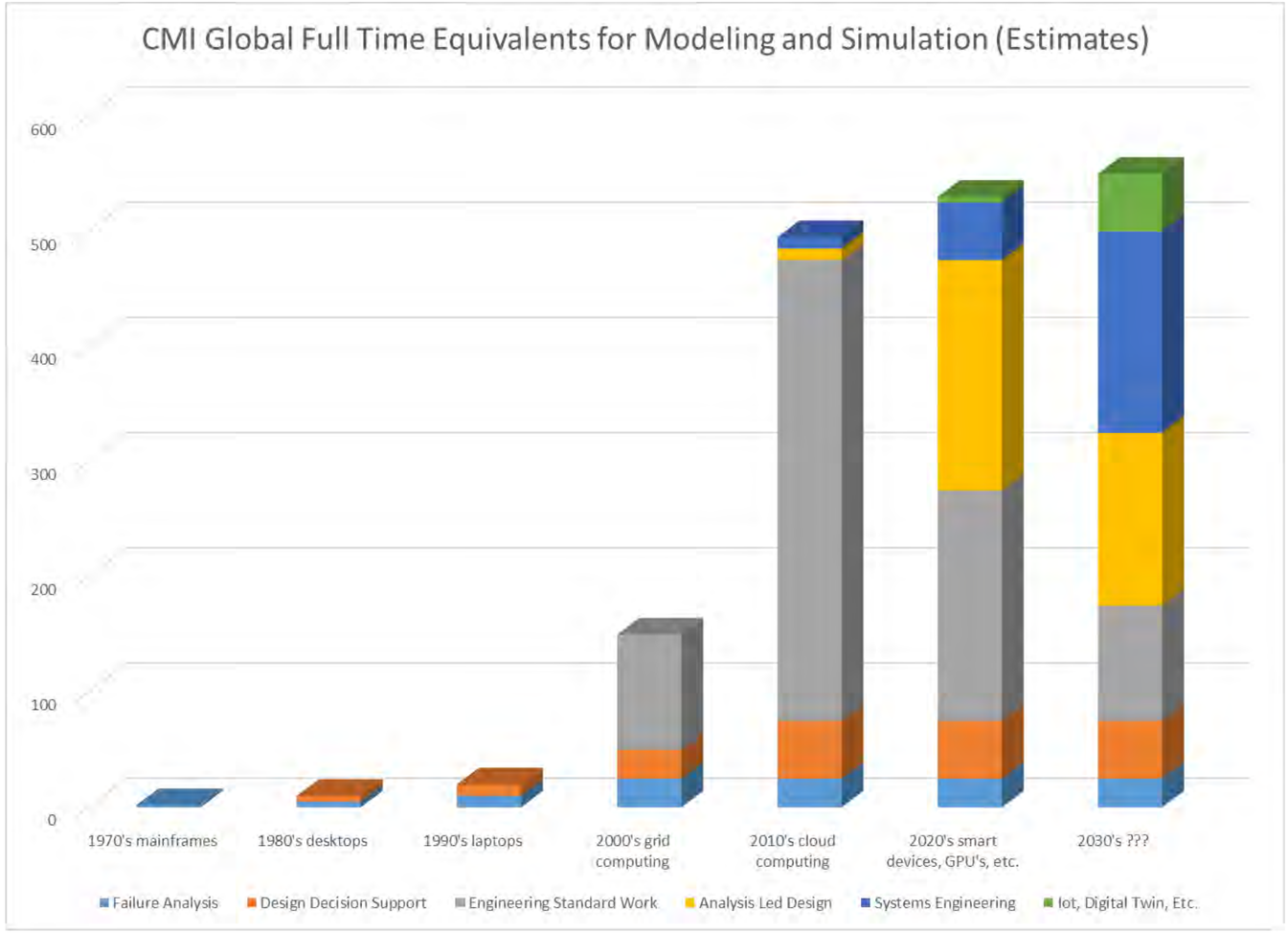


The Simulation Revolution is Real



The Simulation Revolution is Real

- Bob Tickel's ASSESS 2017 Congress Keynote illustrates estimated usage of Engineering Simulation at Cummins



Advancing The Simulation Revolution

Advancing The Simulation Revolution

The ASSESS Initiative was formed to bring together key players to guide and influence strategies for software tools for model-based analysis, simulation, and systems engineering.

> “To significantly expand the use and benefit of software tools for model-based analysis, simulation, and systems engineering in the engineering applications domain.”

Advancing The Simulation Revolution

Key drivers behind the ASSESS Initiative

1. Growing demand on “How to be more competitive”
2. Exponentially growing complexity of products & processes
3. Available computing power is rapidly removing the computing bottlenecks
4. New world of 3D printed objects and light weighting
5. Entirely new applications are creating a rapidly growing demand for simulation to enable breakthroughs
6. Simulation is used almost exclusively by a limited number of expert analysts
7. Simulation efforts have three key but disjointed vectors – Commercial / Government / Research

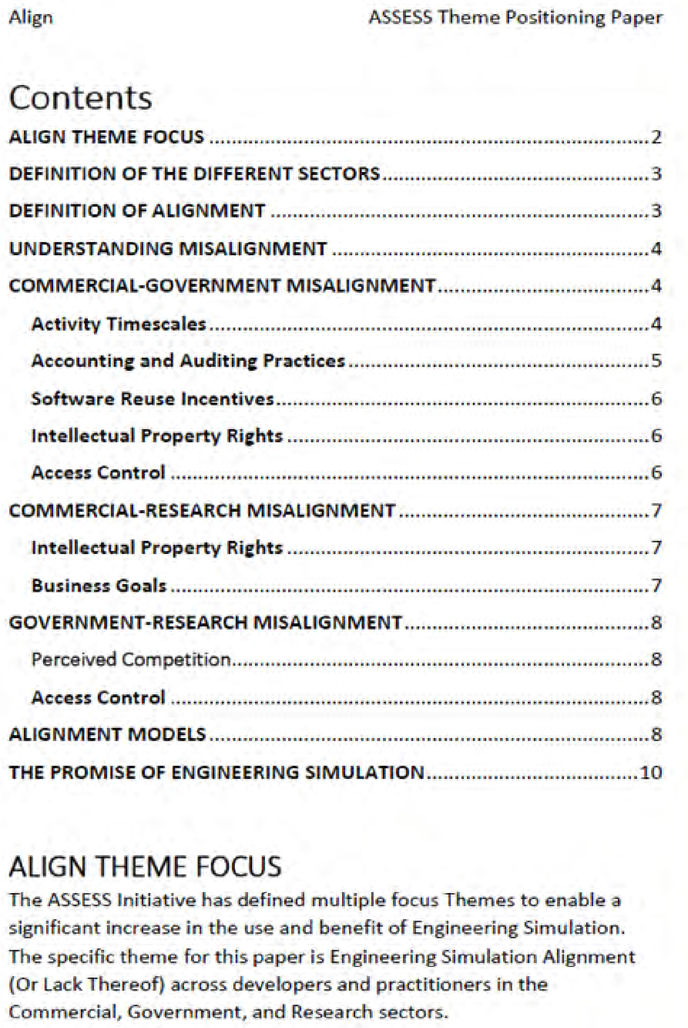
ASSESS Initiative Themes

ASSESS Initiative Themes

- Seven key themes with associated working groups to advance the Simulation Revolution
  - **Align**ment of Government/Research/Commercial Activities
  - **Business** Challenges
  - Engineering Simulation **Credibility**
  - Democratization of Engineering Simulation (**DoES**)
  - **Generative** Design
  - **Integration** of Systems and detailed Sub-System Simulations
  - Engineering Simulation Digital **Twin(s)**

ASSESS Initiative Activities

- **Align**ment of Government/Research/Commercial Activities
  - Provide guidance and foster improved alignment
  - Align Theme Positioning Paper
    - What is alignment?
    - Why are we misaligned?
    - What are some alignment models?



Align ASSESS Theme Positioning Paper

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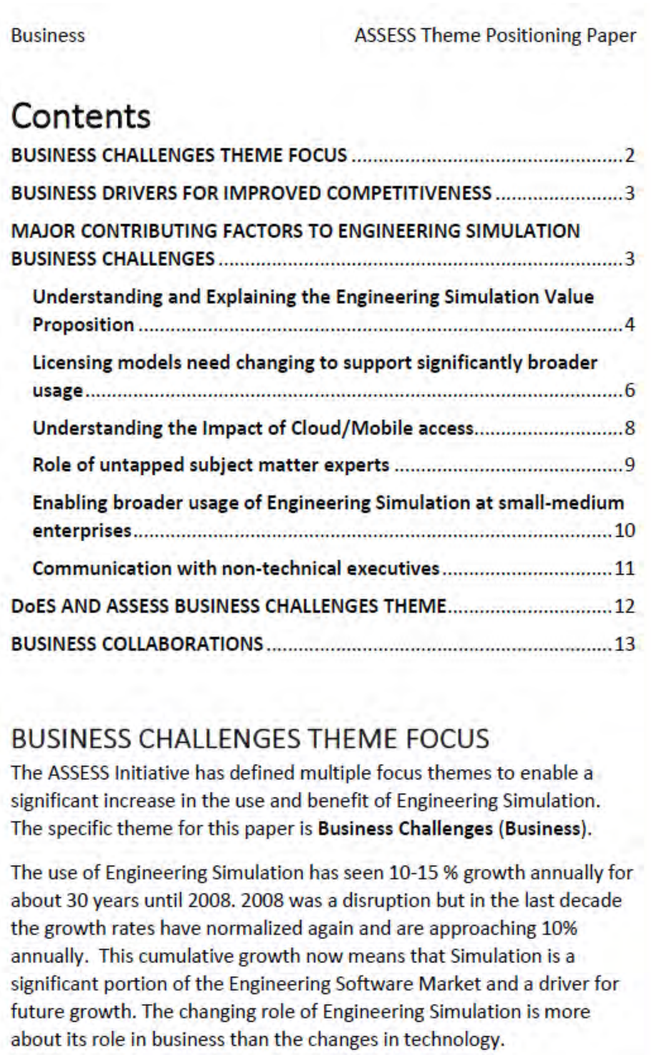
ALIGN THEME FOCUS

The ASSESS Initiative has defined multiple focus Themes to enable a significant increase in the use and benefit of Engineering Simulation. The specific theme for this paper is Engineering Simulation Alignment (Or Lack Thereof) across developers and practitioners in the Commercial, Government, and Research sectors.

The objective of the ASSESS Initiative Align theme is to provide guidance and foster improved alignment of commercial, government and research Engineering Simulation efforts.

ASSESS Initiative Activities

- **Business** Challenges
  - Investigate Issues and develop approaches to enable a transformation of business models
  - Business Theme Positioning Paper
    - Exploring the business drivers
    - Engineering Simulation Value Proposition
    - Communication with non-technical executives



Business ASSESS Theme Positioning Paper

Contents

BUSINESS CHALLENGES THEME FOCUS

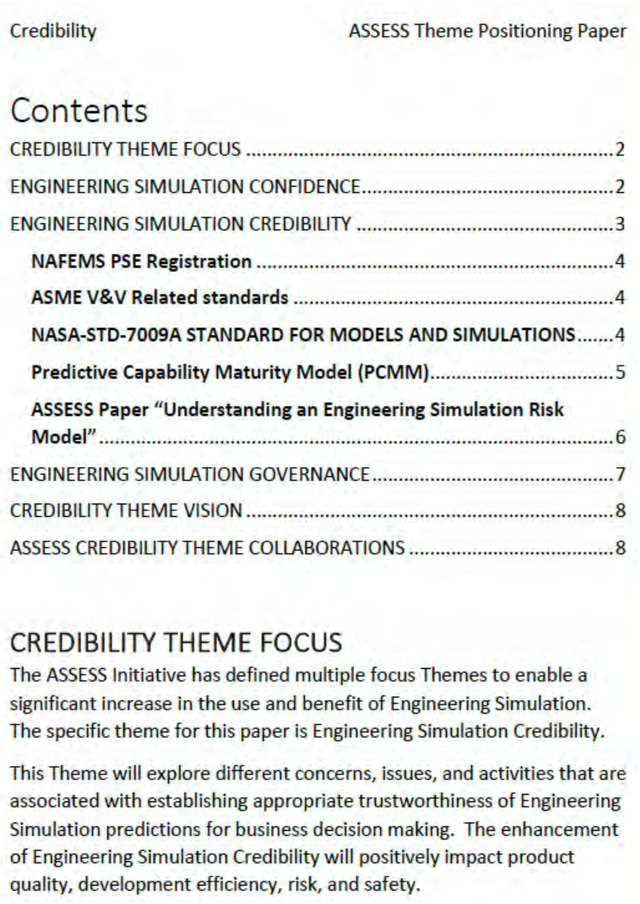
The ASSESS Initiative has defined multiple focus themes to enable a significant increase in the use and benefit of Engineering Simulation. The specific theme for this paper is **Business Challenges (Business).**

The use of Engineering Simulation has seen 10-15 % growth annually for about 30 years until 2008. 2008 was a disruption but in the last decade the growth rates have normalized again and are approaching 10% annually. This cumulative growth now means that Simulation is a significant portion of the Engineering Software Market and a driver for future growth. The changing role of Engineering Simulation is more about its role in business than the changes in technology.

The focus of this ASSESS Initiative theme is to investigate issues and to develop approaches to enable a transformation of business models to enable a significant increase in usage and benefit of Engineering Simulation software tools.

ASSESS Initiative Activities

- Engineering Simulation **Credibility**
  - Establishing appropriate trustworthiness of Engineering Simulation predictions
  - Credibility Theme Positioning Paper
    - What is the difference between “confidence” and “credibility”
    - Review of industry efforts to manage “credibility”
    - The role of Simulation Governance



Credibility ASSESS Theme Positioning Paper

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CREDIBILITY THEME FOCUS

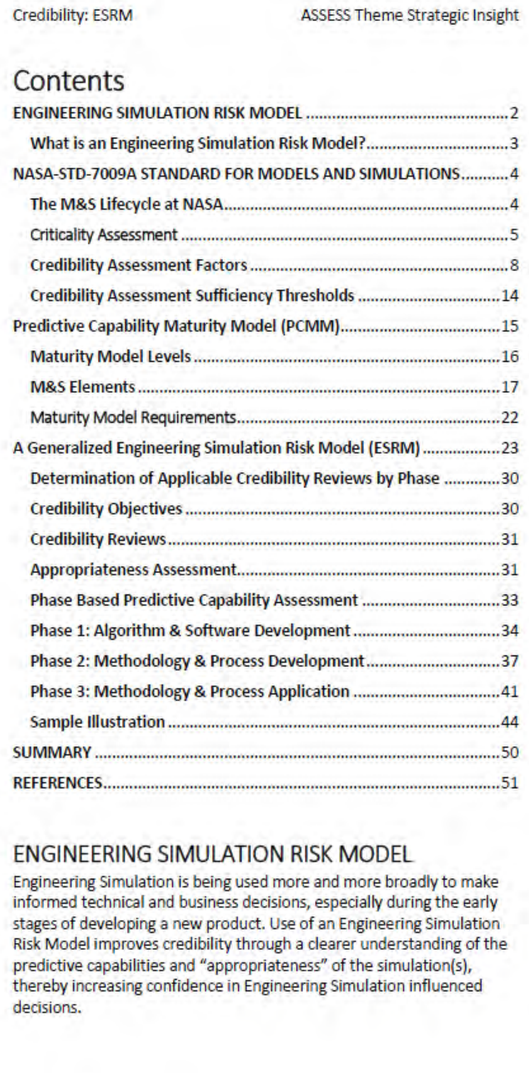
The ASSESS Initiative has defined multiple focus Themes to enable a significant increase in the use and benefit of Engineering Simulation. The specific theme for this paper is Engineering Simulation Credibility.

This Theme will explore different concerns, issues, and activities that are associated with establishing appropriate trustworthiness of Engineering Simulation predictions for business decision making. The enhancement of Engineering Simulation Credibility will positively impact product quality, development efficiency, risk, and safety.

Confidence is internal to the trust of the team performing the Engineering Simulations and that the Engineering Simulations performed are appropriate to support the business decisions at hand.

ASSESS Initiative Activities

- Engineering Simulation **Credibility**
  - Credibility Theme Strategic Insight Paper – ***"Understanding an Engineering Simulation Risk Model"***
    - Reviews NASA 7009A Standard for Models & Simulation
    - Reviews Sandia Predictive Capability Maturity Model



Credibility: ESRM ASSESS Theme Strategic Insight

Contents

ENGINEERING SIMULATION RISK MODEL

Engineering Simulation is being used more and more broadly to make informed technical and business decisions, especially during the early stages of developing a new product. Use of an Engineering Simulation Risk Model improves credibility through a clearer understanding of the predictive capabilities and "appropriateness" of the simulation(s), thereby increasing confidence in Engineering Simulation influenced decisions.

Engineering Simulation as defined by NAFEMS is "The use of numerical, physical or logical models of systems and scientific problems in predicting their response to different physical conditions."

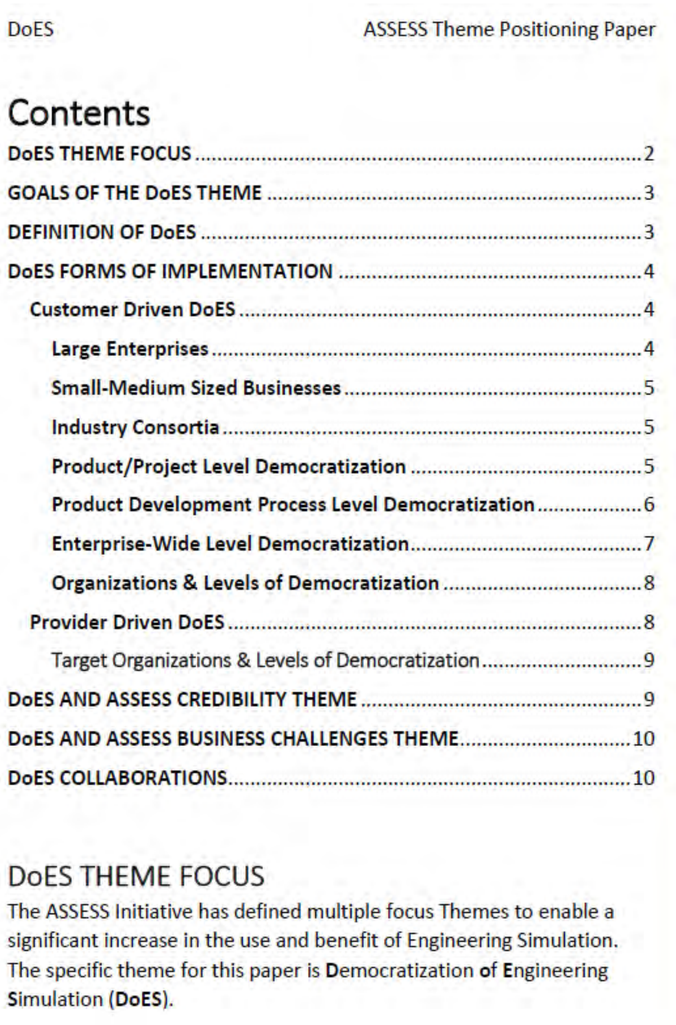
ASSESS Initiative Activities

- Engineering Simulation **Credibility**
  - ***"Understanding an Engineering Simulation Risk Model"***
    - Proposes a new generalized risk model
      - Three separate phases with different Credibility Reviews
      - Proposed Usage Impact Objectives
      - Proposed calculation of an "Appropriateness index"

Usage Impact Credibility Objectives						
Engineering Simulation Influence Ranking	5	3	3.5	4	4.5	5
	4	2.5	3	3.5	4	4.5
	3	2	2.5	3	3.5	4
	2	1.5	2	2.5	3	3.5
	1	1	1.5	2	2.5	3
		1	2	3	4	5
		Decision Consequence Ranking				

ASSESS Initiative Activities

- Democratization of Engineering Simulation (**DoES**)
  - Significant increase in the use of Engineering Simulation for all users
  - DoES Theme Positioning Paper
    - What is democratization?
    - Different forms & levels
      - Product/Project level
      - Process level
      - Enterprise-wide level



DoES ASSESS Theme Positioning Paper

Contents

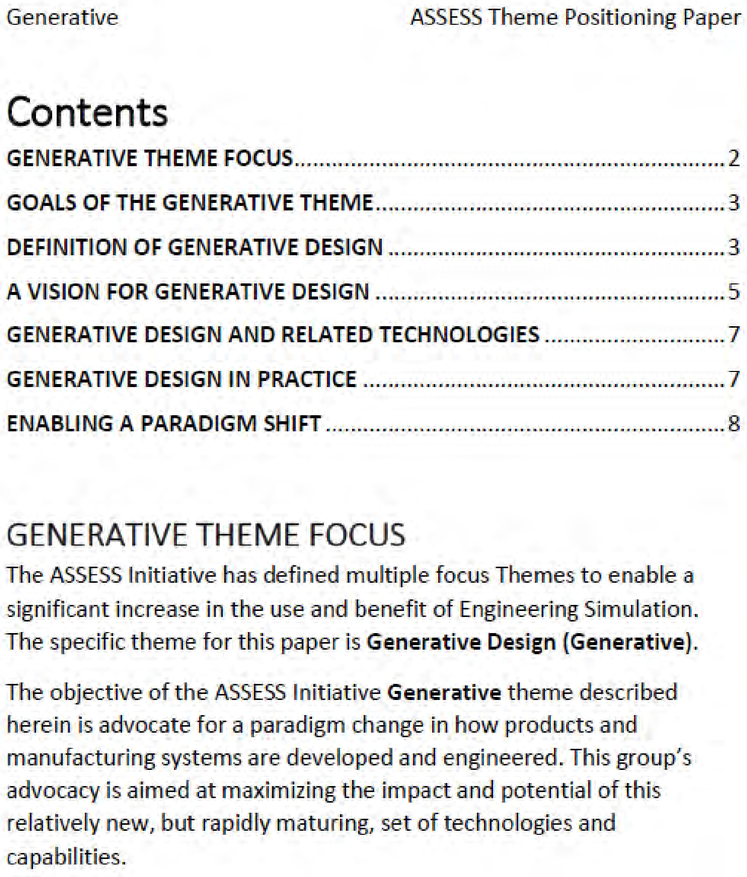
DoES THEME FOCUS

The ASSESS Initiative has defined multiple focus Themes to enable a significant increase in the use and benefit of Engineering Simulation. The specific theme for this paper is **D**emocratization **o**f **E**ngineering **S**imulation (**DoES**).

The objective of the ASSESS Initiative DoES theme described herein is to advocate for a significant increase in the use of Engineering Simulation by all users, for whom access to the power of Engineering Simulation would be beneficial.

ASSESS Initiative Activities

- **Generative** Design
  - Paradigm change in how products are developed
  - Generative Theme Positioning Paper
    - What is Generative Design?
    - Vision = Potential paradigm shift
    - Current practice
    - What is nee4ded?



Generative ASSESS Theme Positioning Paper

Contents

GENERATIVE THEME FOCUS

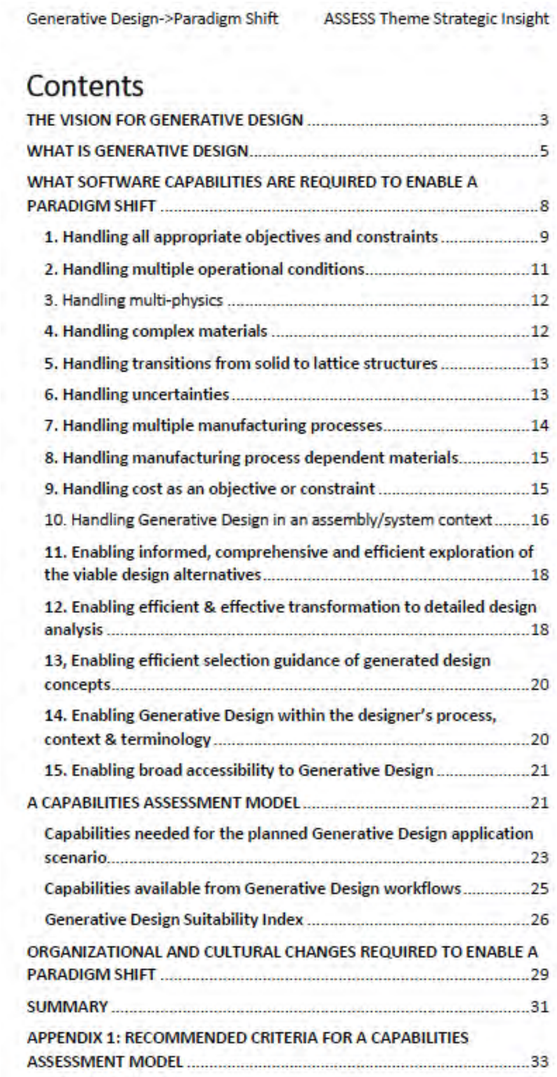
The ASSESS Initiative has defined multiple focus Themes to enable a significant increase in the use and benefit of Engineering Simulation. The specific theme for this paper is **Generative Design (Generative)**.

The objective of the ASSESS Initiative **Generative** theme described herein is advocate for a paradigm change in how products and manufacturing systems are developed and engineered. This group's advocacy is aimed at maximizing the impact and potential of this relatively new, but rapidly maturing, set of technologies and capabilities.

The objective of the ASSESS Initiative Generative theme described herein is to describe and advocate for a paradigm change in how products and manufacturing systems are developed and engineered.

ASSESS Initiative Activities

- **Generative** Design
  - Generative Theme Strategic Insight Paper – ***"Understanding a Generative Design Enabled Design Process Paradigm Shift"***
    - 15 software capabilities to enable a paradigm shift
      - Detailed criteria for all 15 capabilities
    - Organizational & cultural changes needed to enable a paradigm shift



Generative Design->Paradigm Shift ASSESS Theme Strategic Insight

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The vision for Generative Design is to enable a significant paradigm shift in the current design processes via the creation of computer-generated designs as early as the concept stage by Design Engineers.

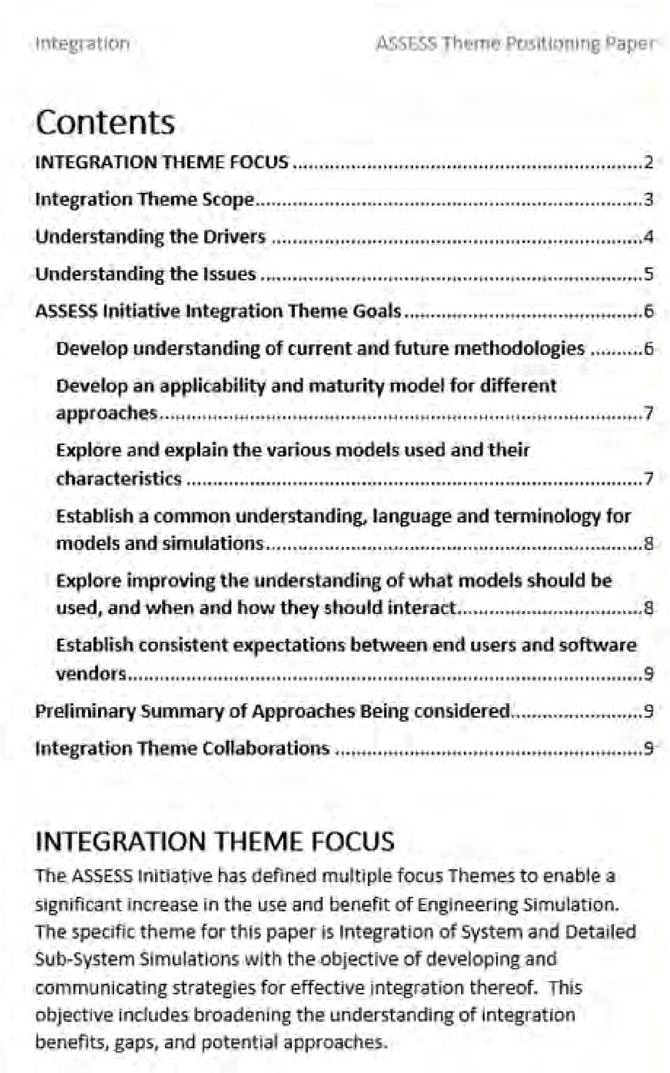
ASSESS Initiative Activities

- **Generative** Design
  - Generative Theme Strategic Insight Paper – ***"Understanding a Generative Design Enabled Design Process Paradigm Shift"***
    - Capabilities assessment model
      - Required capabilities for a design scenario
      - Generative Design workflow capabilities
      - "Suitability index"

Sample Workflow Suitability Index	Application 1 Suitability	Application 2 Suitability
Handling all appropriate objectives and constraints	1.30	1.05
Handling multiple operational conditions	1.14	1.00
Handling multi-physics	2.00	1.00
Handling complex materials	1.33	1.33
Handling transitions from solid to lattice structures	1.00	0.35
Handling uncertainties	1.00	1.00
Handling multiple manufacturing/assembly/construction processes	0.48	0.38
Handling manufacturing process dependent materials	1.00	1.00
Handling cost as an objective or constraint	1.00	0.34
Handling Generative Design in an assembly / system context	2.33	2.33
Handling informed, comprehensive and efficient exploration of the viable design space alternatives	0.86	0.68
Enabling efficient and effective transformation to detailed validation	0.34	0.34
Enabling efficient selection guidance of design concepts generated	1.33	1.05
Enabling Generative Design within the designer's process, context & terminology	0.81	0.75
Enabling broad accessibility to Generative Design	1.00	1.00
Mean Suitability Index	1.13	0.91
Minimum Suitability Index	0.34	0.34

ASSESS Initiative Activities

- Integration of Systems and detailed Sub-System Simulations
  - o Strategies for effective integration
  - o Integration Theme Positioning Paper
    - Characteristics of model types
    - Common understanding and terminology
    - Consistent expectations
    - What models when?



Integration ASSESS Theme Positioning Paper

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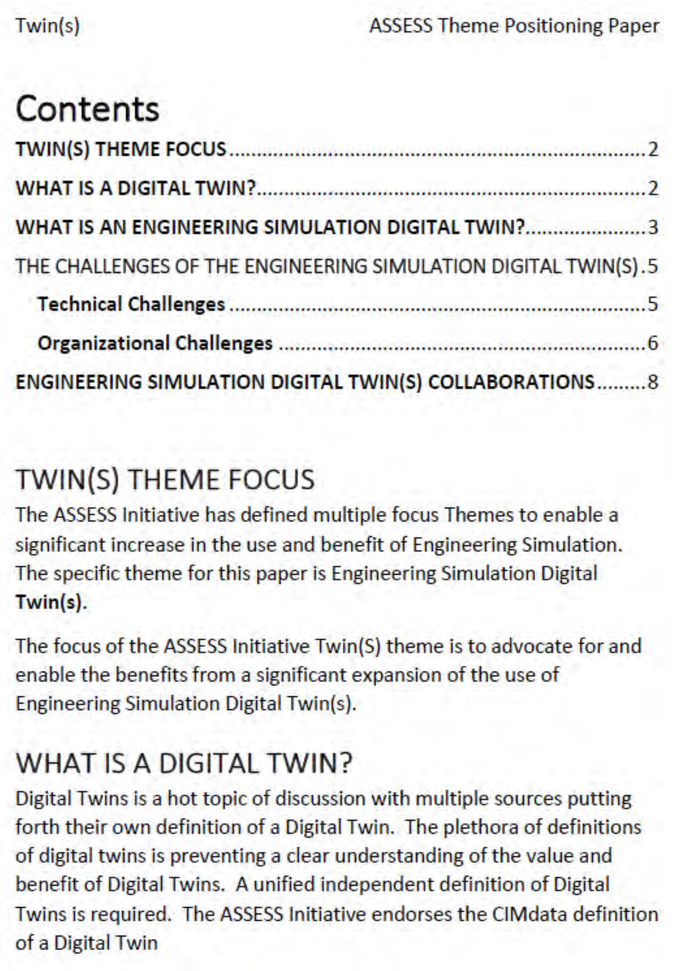
INTEGRATION THEME FOCUS

The ASSESS Initiative has defined multiple focus Themes to enable a significant increase in the use and benefit of Engineering Simulation. The specific theme for this paper is Integration of System and Detailed Sub-System Simulations with the objective of developing and communicating strategies for effective integration thereof. This objective includes broadening the understanding of integration benefits, gaps, and potential approaches.

The objective of the ASSESS Initiative Integration theme described herein is to develop and communicate strategies for effective integration of systems and detailed sub-systems simulations. This objective includes broadening the understanding of integration benefits, gaps, and potential approaches.

ASSESS Initiative Activities

- Engineering Simulation Digital **Twin(s)**
- Enable benefits from use of Engineering Simulation Digital Twins
- Twin(s) Theme Positioning Paper
  - What is a Digital Twin?
  - Digital Twin(s) come in many forms
  - What is an Engineering Simulation Digital Twin?
    - Challenges



Twin(s) ASSESS Theme Positioning Paper

Contents

TWIN(S) THEME FOCUS

The ASSESS Initiative has defined multiple focus Themes to enable a significant increase in the use and benefit of Engineering Simulation. The specific theme for this paper is Engineering Simulation Digital **Twin(s)**.

The focus of the ASSESS Initiative Twin(S) theme is to advocate for and enable the benefits from a significant expansion of the use of Engineering Simulation Digital Twin(s).

WHAT IS A DIGITAL TWIN?

Digital Twins is a hot topic of discussion with multiple sources putting forth their own definition of a Digital Twin. The plethora of definitions of digital twins is preventing a clear understanding of the value and benefit of Digital Twins. A unified independent definition of Digital Twins is required. The ASSESS Initiative endorses the CIMdata definition of a Digital Twin

The focus of the ASSESS Initiative Twin(S) theme is to advocate for and enable the benefits from a significant expansion of the use of Engineering Simulation Digital Twin(s).

ASSESS Initiative Collaborations

ASSESS Initiative Collaborations

ASSESS Initiative Congresses

ASSESS Initiative Congresses

- **ASSESS Summit**

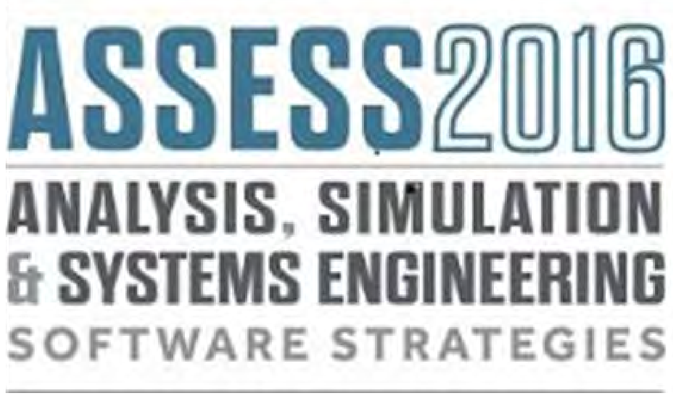
  (Sante Fe Institute, Sante Fe, NM)

  - 40 Industry leading Ambassadors
  - 1 Keynote presentation
  - 5 Working Groups
  - 8 key issues were highlighted

- **ASSESS 2016 Congress**

  (Bolger Center, Potomac, MD)

  - 85 Industry leading participants
  - 4 Keynote presentations
  - 26 Technology Briefings
  - 7 Theme based working sessions



ASSESS Initiative Congresses

- **ASSESS 2017 Congress**

  (Bolger Center, Potomac, MD)

  - 80 Industry leading participants
  - 2 Keynote presentations
  - 10 Technology Briefings
  - 16 Theme based working sessions

- **ASSESS 2018 Congress**

  (Chateau Elan, Braselton, GA)

  - 87 Industry leading participants
  - 2 Keynote presentations
  - 10 Notes From the Front Presentations
  - 14 Theme based working sessions

ASSESS Initiative Congresses

- **ASSESS 2019 Congress**

  (Chateau Elan, Braselton, GA)

  - 91 Industry leading participants
  - 2 Keynote presentations
  - 1 Invited presentation
  - 8 Notes From the Front Presentations
  - 14 Theme based working sessions

ASSESS 2020 Planned Activities

ASSESS Initiative 2020 Planned Activities

- **ASSESS 2020 Congress**

  (Chateau Elan, Braselton, GA)

  - 2 Keynote presentations
  - 8 Notes From the Front Presentations
  - 14 Theme based working sessions
- **ASSESS 2020 Workshops**
  - 2-4 Theme focused 1-day workshops
    - GA Tech ASDL
    - Princeton University
- **ASSESS 2020 Strategic Insight Papers**
  - 2-3 Theme focused Strategic Insight Papers

ASSESS Initiative Membership

ASSESS Initiative Membership Program

- **Membership Program Launched January 2018**
  - Access to key information from the ASSESS Initiative
    - ASSESS initiative Strategic Insight Papers
    - ASSESS Congress Presentations
    - ASSESS Congress Working Session Reports
    - ASSESS Survey Results
  - Invitation to Annual Congress & Workshops
  - Discount on Annual Congress
- **Multiple levels of membership**
    - Individual
    - Groups of 3, 5, or 10
- **Join the Simulation Revolution !!!**

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