



**2022**  
Annual **INCOSE**  
international workshop  
**HYBRID EVENT**  
Torrance, CA, USA  
Jan 29 - Feb 1, 2022

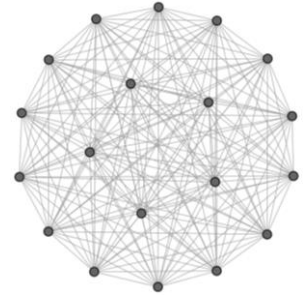
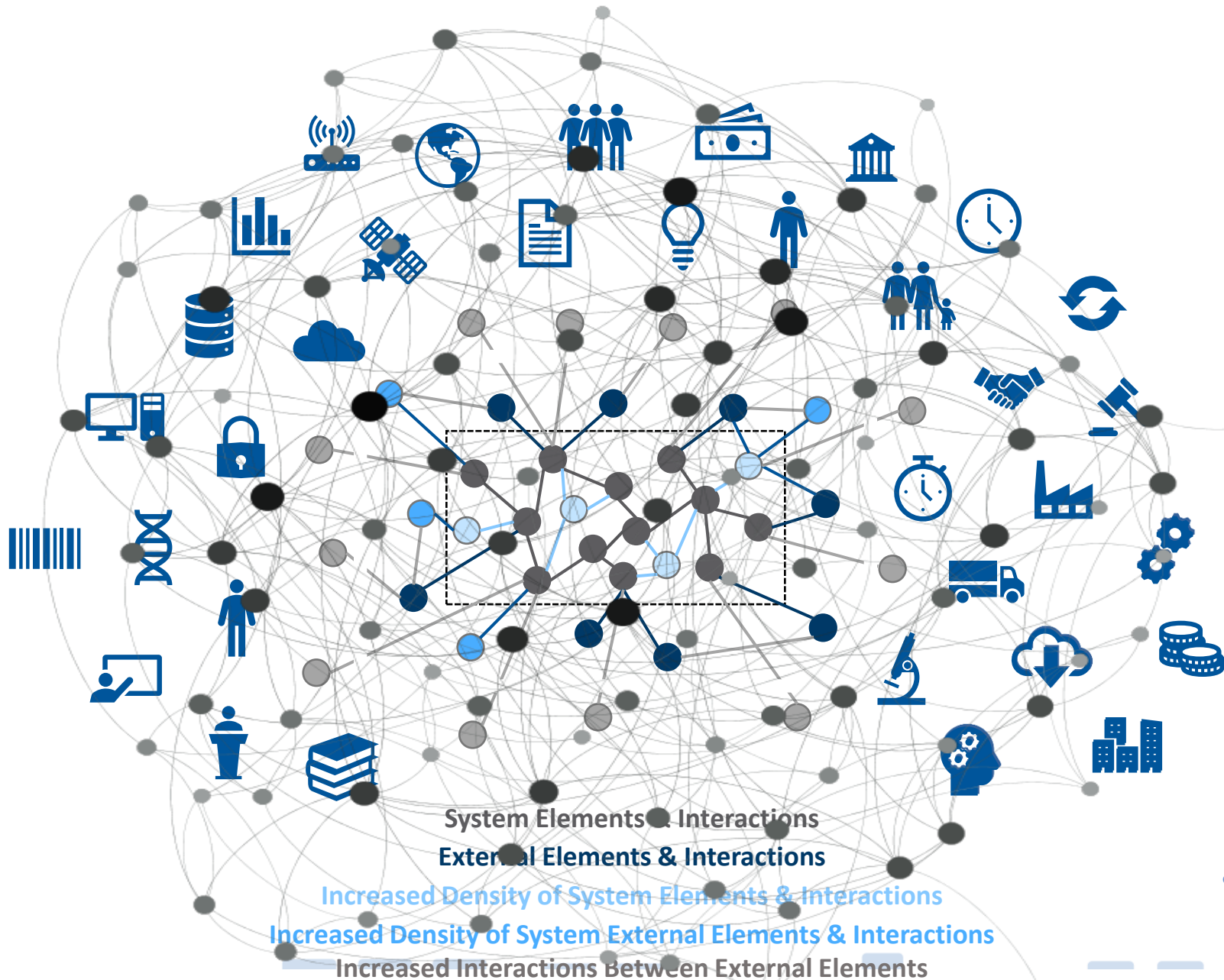
INCOSE IW: MBSE Workshop

# Transformation

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[www.incose.org/IW2022](http://www.incose.org/IW2022)

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Nodes = 19, potential links = 171, unique configurations =  $2^{171}$

*Number of known atoms in the universe ~  $2^{158}$  and  $2^{246}$*

System Elements & Interactions  
External Elements & Interactions  
Increased Density of System Elements & Interactions  
Increased Density of System External Elements & Interactions  
Increased Interactions Between External Elements  
Expanding System Domain Boundary Increasing Interactions



<https://www.stallion51.com/mustang-flight-ops/mustang-facts/#---text=The%20P%2D51%20Mustang%20was, and%20built%20in%20102%20days.>

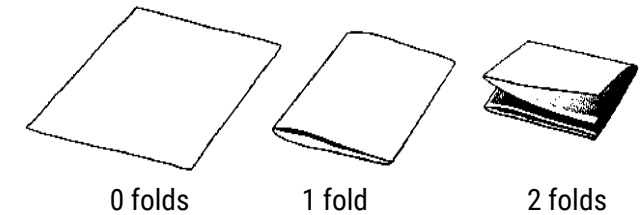
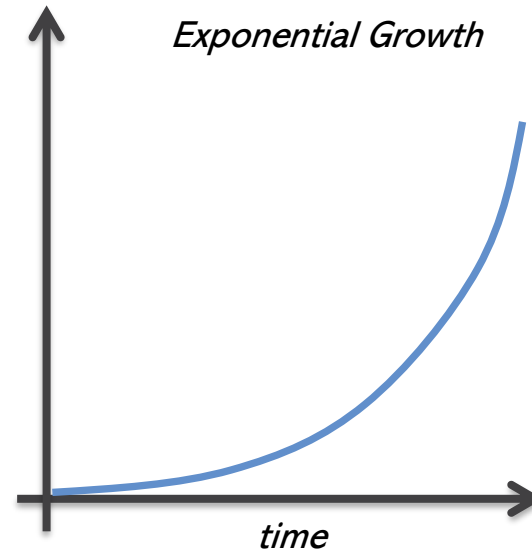
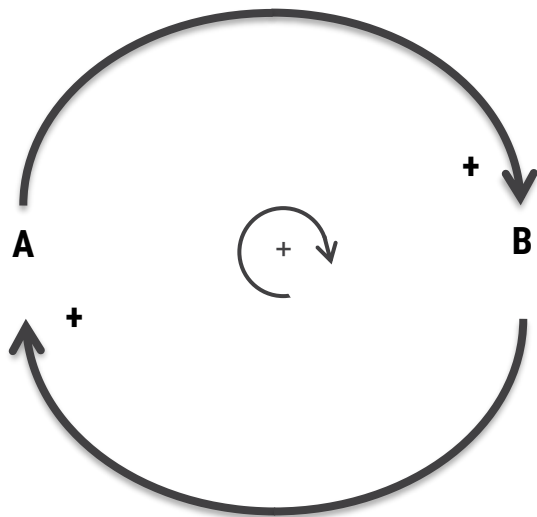


P-51 Mustang	Delta	F-35 Lightning
First Flown: October 26, 1940	<b>+60 years</b>	First Flown: October 2000
Retired from Service in US: 1978 (38 years)	<b>2x</b>	Projected Retirement: 2070 (70 years)
Maximum take off weight: 12,000 lbs	<b>6x</b>	Maximum take off weight: 70,000 lbs
Maximum speed: 440 mph	<b>3x</b>	Maximum speed: 1,200 mph
Lines of Code: 0	<b>8Mx</b>	Lines of Code: 8,000,000
1940 Cost: \$50,000.00 (CV ~\$1M each)	<b>2000x</b>	Cost: \$100M
Contract to Prototype: 102 days	<b>48x</b>	Contract to Prototype: 4929 days



## *Traditional development methods do not adequately address the complexity of systems today*

The explosive growth of cyber-physical systems has rapidly and dramatically increased complexity all around us. Seamlessly intertwining computational algorithms and physical components, these systems have significantly increased the demands on engineering rigor to ensure safety, quality, security, sustainability, adaptability, and more, all while delivering products more rapidly.

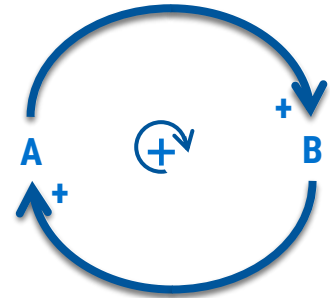


*We routinely underestimate the power of exponential growth.*

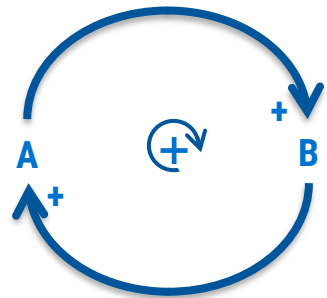
What is the thickness of a piece of paper after folding it 42 times?  
What about 100 times?

***Connected Devices | Electronics/ Sensors Usage | SLOC  
Technology Adoption | Automation | Autonomy***

***42x = 440,000 km thick  
100x = 850T \* distance to our sun***

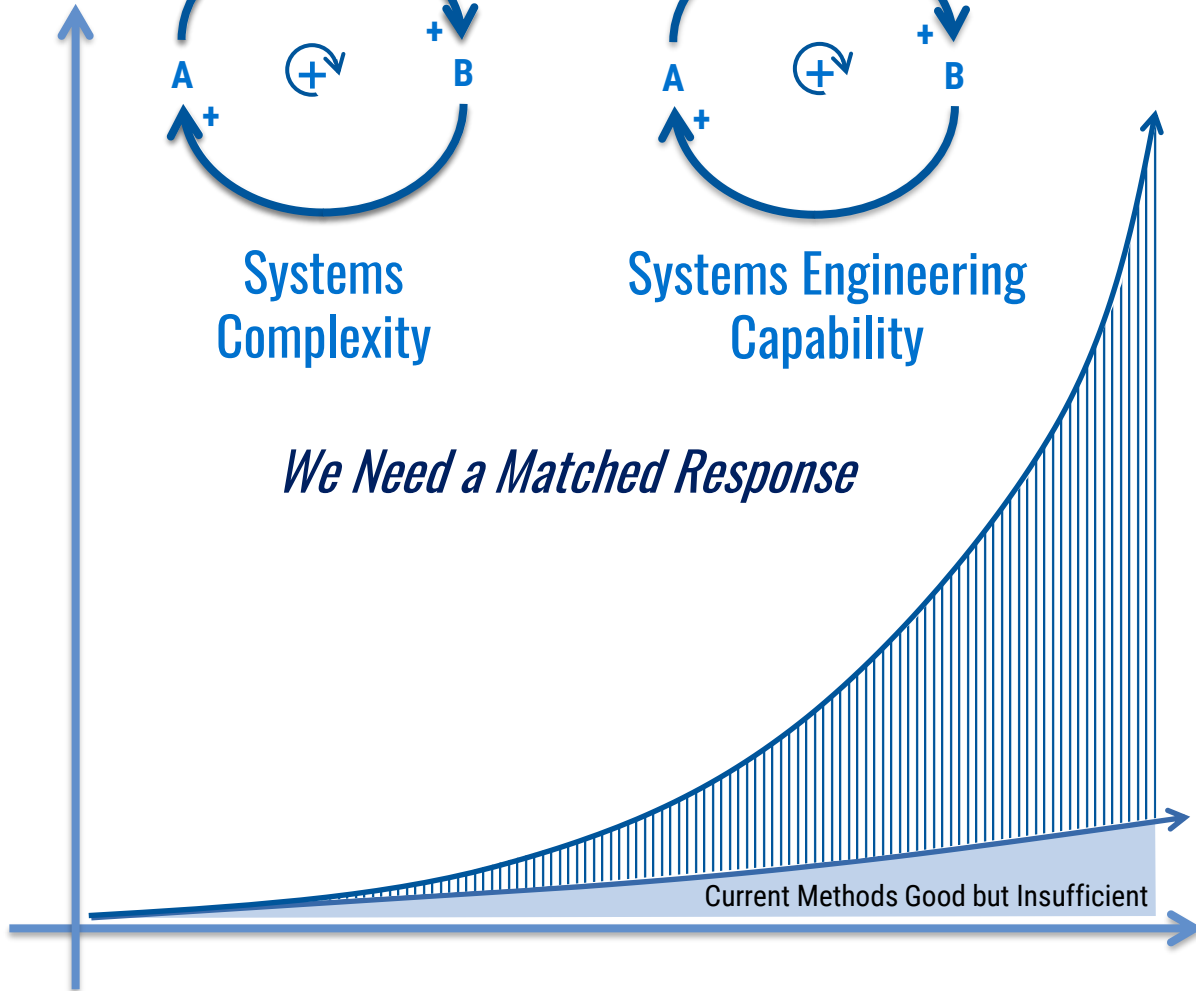


Systems Complexity

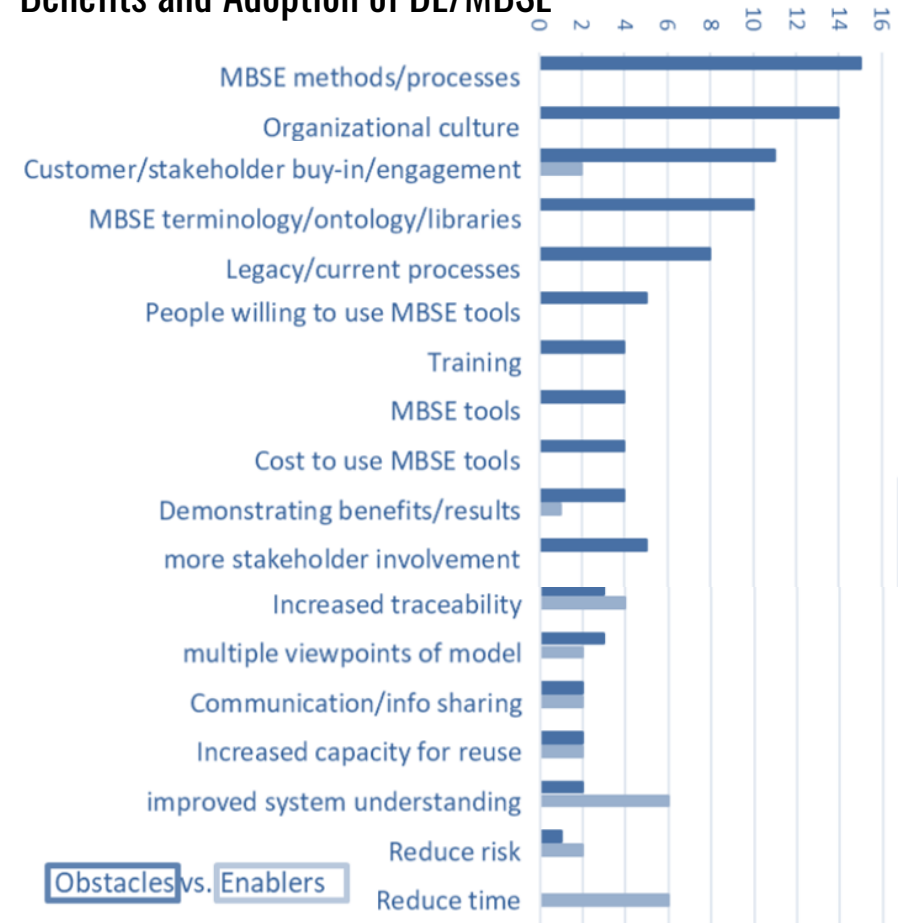


Systems Engineering Capability

*We Need a Matched Response*



## Benefits and Adoption of DE/MBSE





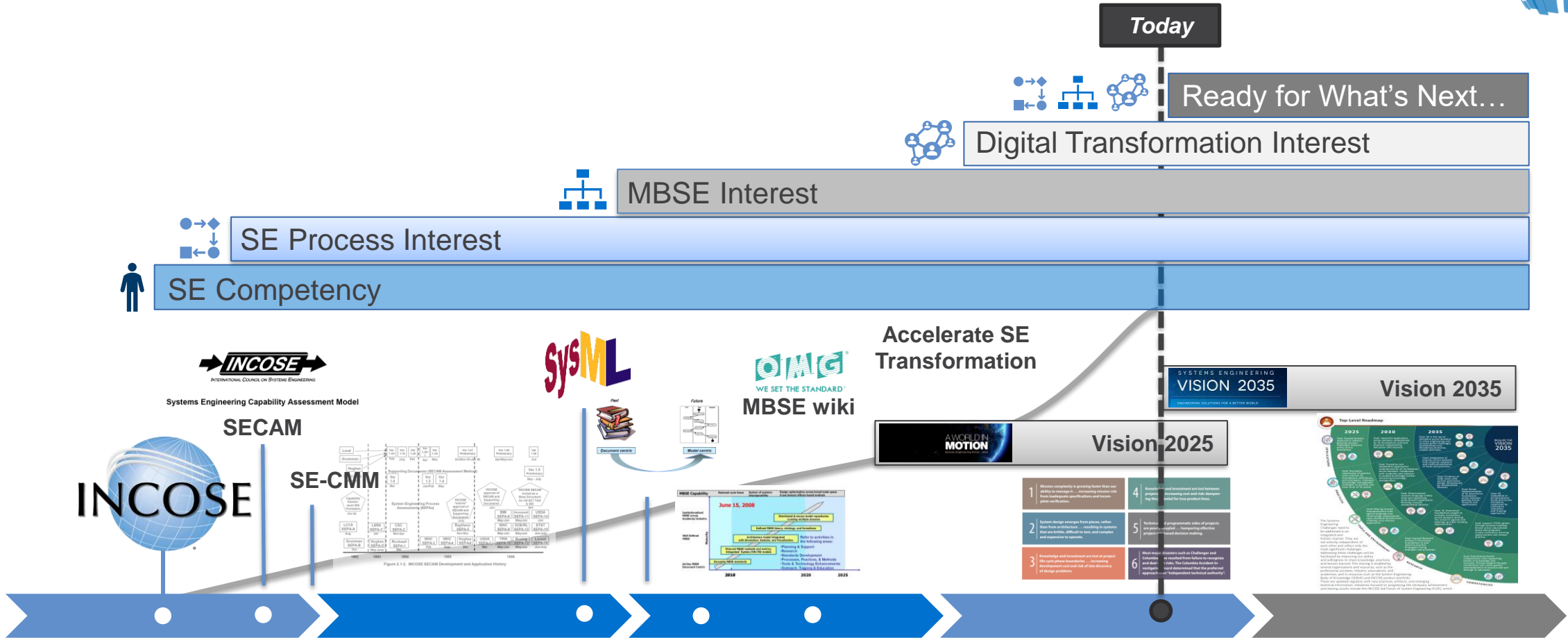
**Gartner**

Observation from  
2020 Gartner Study

From Gartner's perspective, "the transformation journey is ***taking large enterprises especially at least twice as long and costing twice as much as they originally anticipated.***" In large part this is due to cultural readiness







1990

2000

2010

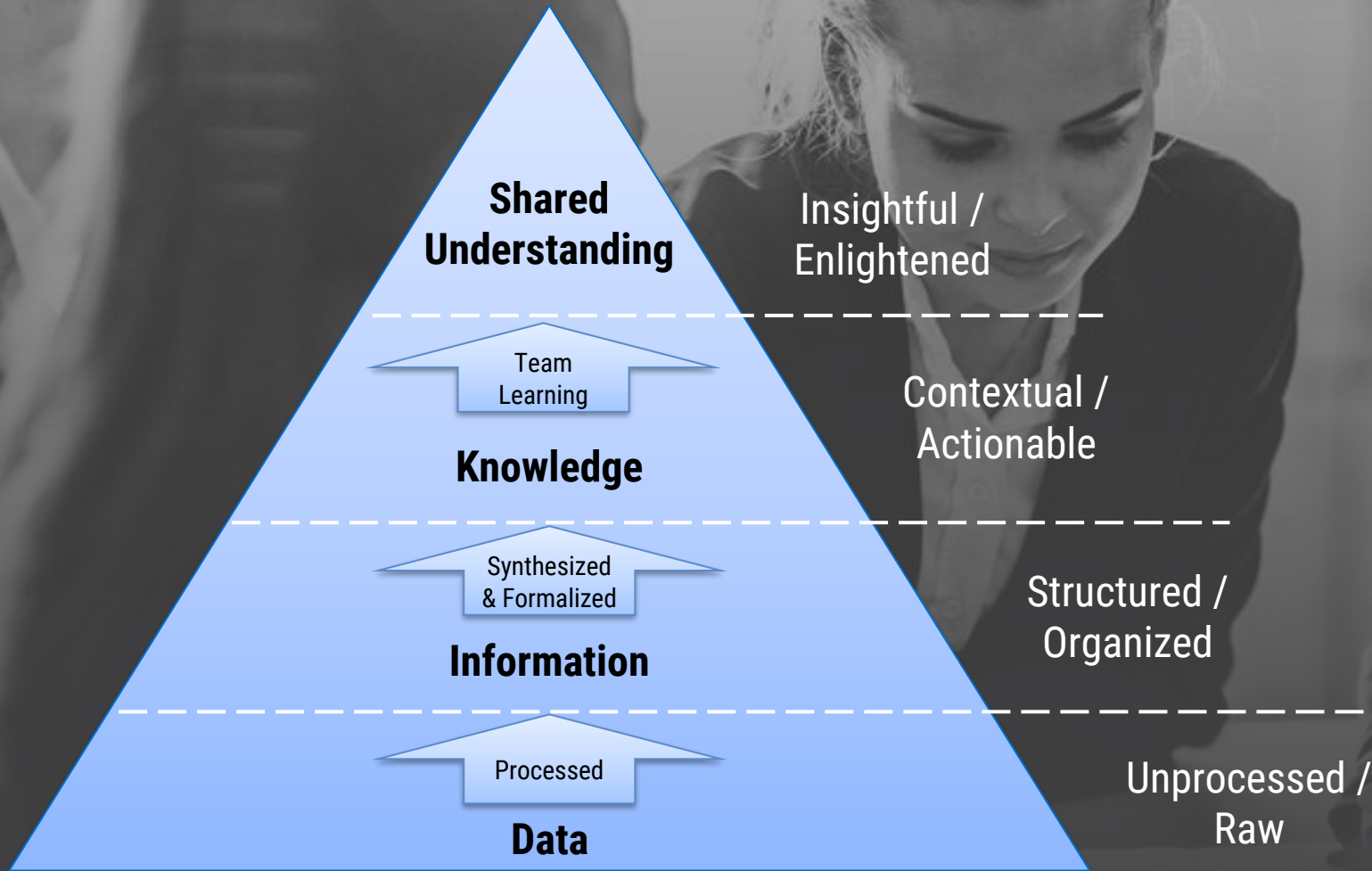
2020

2030





# Build a Shared Understanding



**From:** ...Limitations of document-based approaches, but is still in an early stage of maturity similar to the early days of CAD/CAE.

**To:**...The use of internet-driven knowledge representation and immersive technologies enable highly efficient and **shared human understanding** of systems in a virtual environment that span the full life cycle from concept through development, manufacturing, operations, and support.

# Lead Organizational Change



WHAT ARE YOUR BELIEFS?

WHAT ARE OTHER'S BELIEFS?

Leadership

Experience

**Environment**

**Behaviors**

HOW ARE YOU CHANGING BELIEFS?

Collaboration

Funding

Organization

**Culture**

Language

**Systems Engineering is a Human Endeavor**

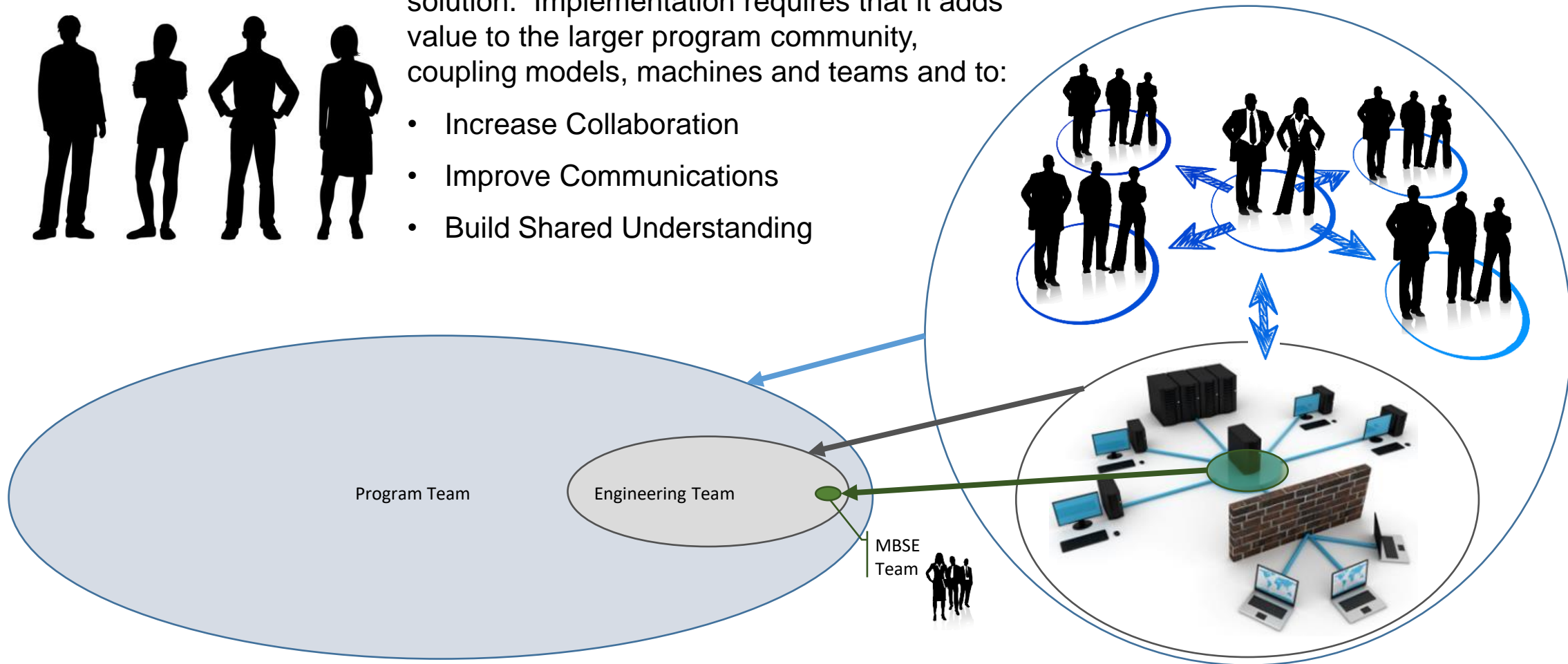


# Aid the Larger Stakeholder Community



MBSE effectiveness is more than a technical solution. Implementation requires that it adds value to the larger program community, coupling models, machines and teams and to:

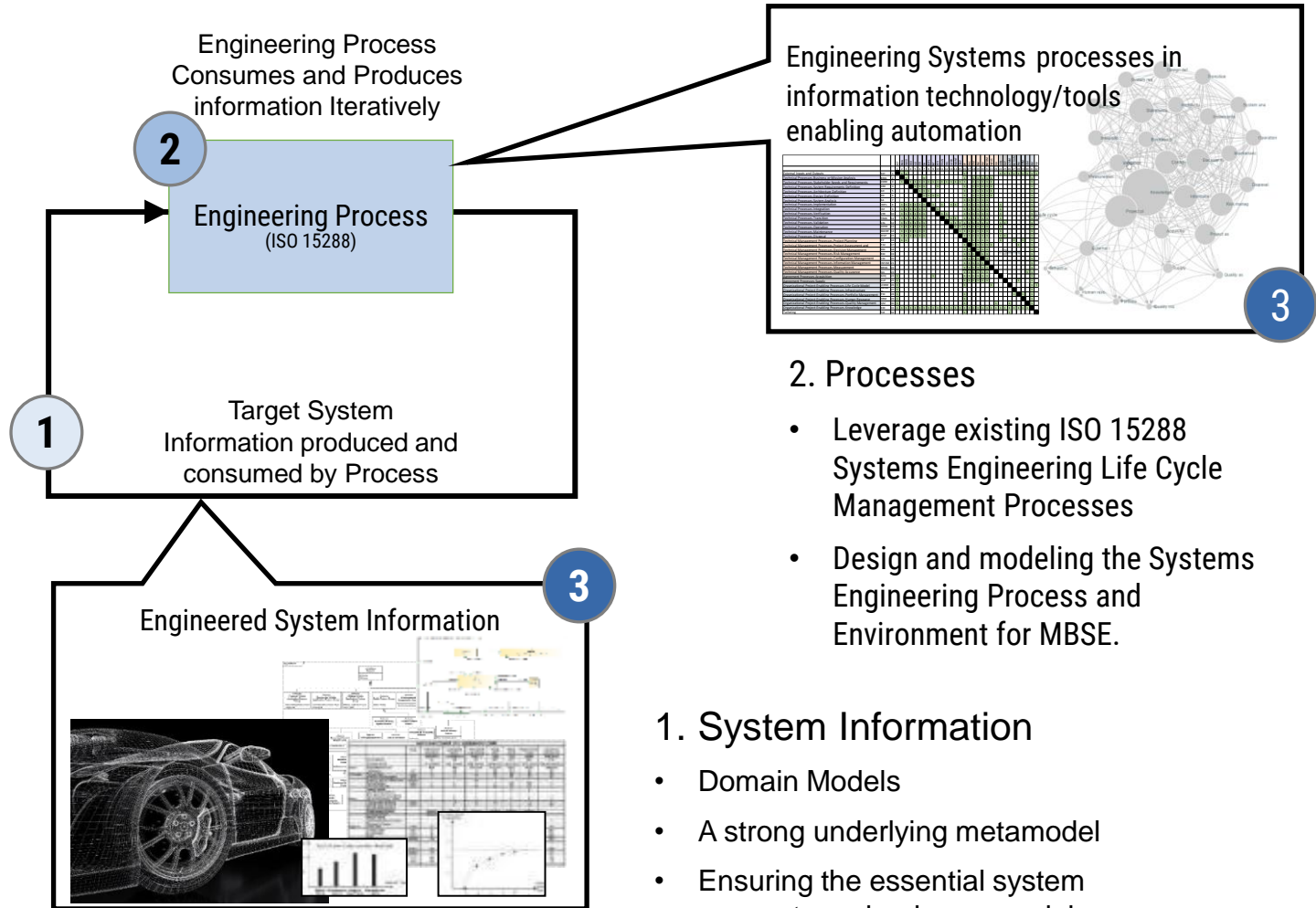
- Increase Collaboration
- Improve Communications
- Build Shared Understanding



# Imperative: Flip the Script



- 1 Content**  
Key system information that must be produced, consumed and maintained consistently across the life cycle
- 2 Process**  
Interrelated activities that direct what information goes where, when and to whom
- 3 Automation**  
Digital federation, integration, automation through the use of tooling, standards, common interfaces etc.



<http://www.omgwiki.org/MBSE/doku.php?id=mbse:pbse>

*Remember: Automating junk, makes more junk automatically*



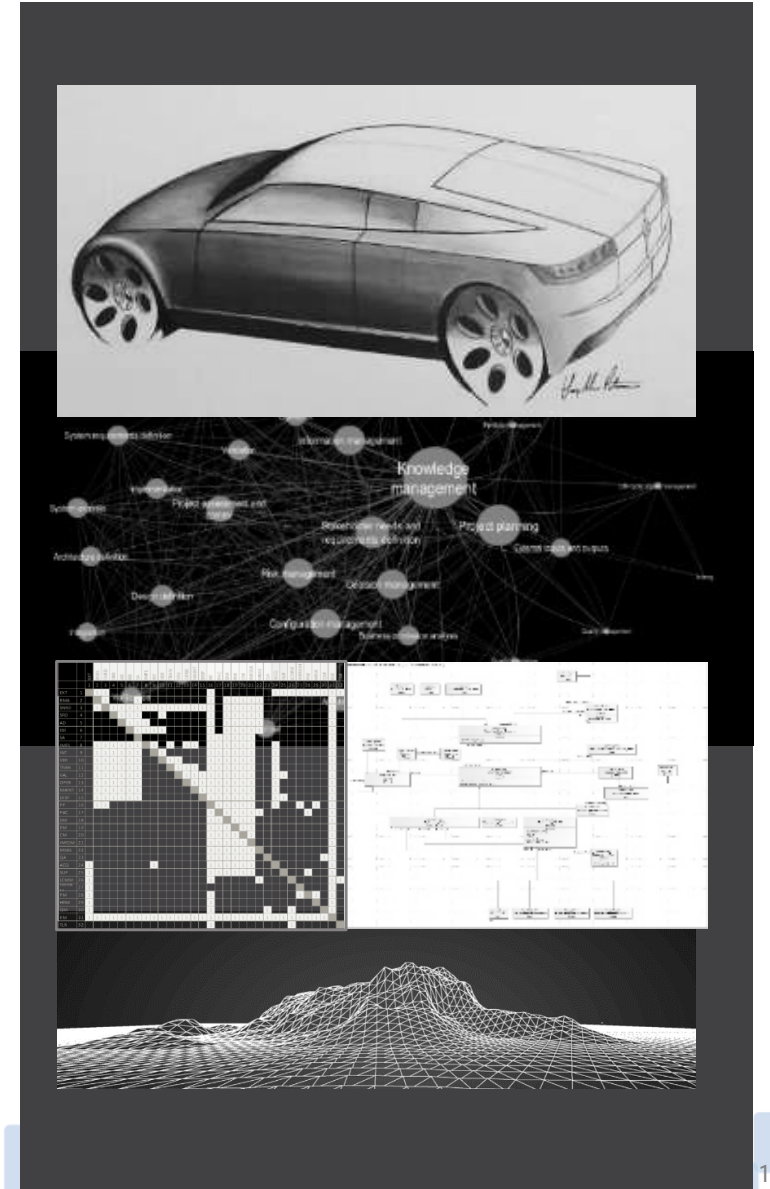
# Imperative: Use Multiple Models



*Evidence shows that people who think with models consistently outperform those who don't. And, moreover people who think with lots of models outperform people who use only one.*

Scott E. Page “Model Thinking” Course Description

*Models are powerful; they help us understand the world, they provide a path forward for our ideas, and they invoke action.*





# Imperative: Don't dig a hole, know where you want to go



*"Would you tell me, please," Alice asks the cat, "which way I ought to go from here?"*

*"Well", responds the Cheshire Cat, "That depends a good deal on where you want to get to."*

*"Oh, I don't much care where –" says Alice.*

*The Cheshire Cat responds "If you don't care where you are going, then it really doesn't matter which way you go."*

*Have a Goal  
Know where you want to go...*

*The model is not the end game  
Improved outcomes are...*

*Poor SE dooms MBSE  
MBSE multiplies good SE*

***Lesson: Don't be Alice & Remember: Automating junk makes more junk automatically!***

# Imperative: Employ Augmented Intelligence (Aul)



- Reinforce knowledge in formal models and pattern based methods with Aul
- Maximize Human + Machine Collaboration
- Allocate work based on strengths
- The Human + Machine combined “team” is more effective than either is in isolation.



Remember:  $Aul = Human + AI$   
 $Aul > Human$   
 $Aul > AI$

*Kasparov's Law*

weak human + machine + better process  
**beats**  
strong human + machine + inferior process.

# Leverage INCOSE Resource and Activities



Unprecedented change and growing systems complexity is driving the need for digital transformation and most notably in how we innovate or perform systems engineering.

INCOSE is leading many activities to help accelerate the necessary transformation, some of these include:

- FuSE
- Many impactful Working Group and related products
- INCOSE Collaborations and products ex. SysML v2
- MBSE Initiative/Incubator - Transformation

## What's Next:

- Vision 2035
- Strengthen and apply SE Foundations
- Systems Engineer the Engineering System
- Augmented Systems Engineering
- Exponential Improvements in Systems Engineering



*It is an exciting time for systems engineers and the discipline of systems engineering. We are at a tipping point, and a timely one.*

## Systems Engineering: Cracking the Code of Digital Transformation

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### ABSTRACT

While complex systems transform the landscape, the systems engineering discipline is also experiencing a transformation to a model-based discipline. In alignment with this, the International Council on systems engineering (INCOSE) is strategically accelerating this transformation by building a broad community that promotes and advances model-based methods to manage the high rate of change and complexity of systems today. This paper addresses contextual drivers for transformation, describes INCOSE activities aligned with accelerating the transformation, and makes the case that model-based systems engineering can help businesses crack the code of Digital Transformation as it pertains to innovation.

**Key Words:** Systems Engineering, Digital Transformation, Model-Based Systems Engineering (MBSE), Change

### UNPRECEDENTED CHANGE

The world is changing all around us at an unprecedented rate and scale. This is affecting how we work, live, and think. From a system engineering perspective, the rate and scale of change created a condition where the needs and expectations of stakeholders are continually in flux. This challenges traditional engineering methods which tend to be top-down, linear, and slow; lacking the agility necessary to adapt and keep pace today.

At the same time that systems are changing faster than before they are also exceedingly more interconnected. So, while we need to change and adapt faster, the changes we make can have extend an unintended propagation path of increasing risk. These risks range from loss of market share to safety-critical conditions potentially leading to loss of life. It's for this reason companies are diligently working to make both developed systems and the development process more agile, adaptable and robust to accommodate change and reduce risk.

There are limits however to how much developed systems can adapt to changing needs. When new needs, risks or opportunities are uncovered outside the working envelope of the system of interest engineering teams, need to rapidly develop and

deploy engineered solutions. Agility and resilience are measured not only by the system's ability to endure and adapt in context but also the ability of the engineering enterprise, and all of its life cycle management activities, to rapidly respond with verified and validated solutions (Dove 2013).

Over 50 years ago Christopher Alexander in his book *Notes on the Synthesis of Form* (Alexander 1964) stated that "...more and more design problems are reaching insoluble levels of complexity" and that they are changing "faster than before." He further noted that "Trial-and-error design is an admirable method. But, it is just real-world trial and error which we are trying to replace by a symbolic method (models). Because trial and error is too expensive and too slow." These statements are more applicable today than they were 50 years ago, and they will be even more applicable 50 years from now.

### DIGITAL TRANSFORMATION

The situation outlined above has created a state of natural tension, the extent of which is related to a business's ability, or inability, to confidently meet needs in this new context. As a result, companies are seeking solutions to rapidly develop and match engineering capability and responsiveness to the rate of change. Many are

seeking to digitally transform business as a means to address the gap. An article in the *Harvard Business Review* on "The Digital Transformation of Business" (HBR 2015) noted that "companies that both identify which core business capabilities they need to differentiate and make a commitment to transform these core business capabilities with the right digital technology will greatly outperform competitors who don't." Furthermore, The World Economic Forum in its publication subtitled *Innovating in the Digital Economy* (Ballar, Dutta 2016) noted that "...the minds of business executives around the world are increasingly focused on innovation."

What core business capability could be more important to digitally transform than the innovation process itself? Systems engineering, and more specifically, model-based systems engineering (MBSE), is the core business capability to digitally transform for advantage. Just as the Rosetta Stone helped scholars crack the code of hieroglyphics, model-based systems engineering can help businesses crack the code of digital transformation. Multidisciplinary in nature, systems engineering spans over traditional boundaries providing an integrative view of the essential concepts required to innovate. Fundamentally, this includes parameterized models of stakeholder value, systems

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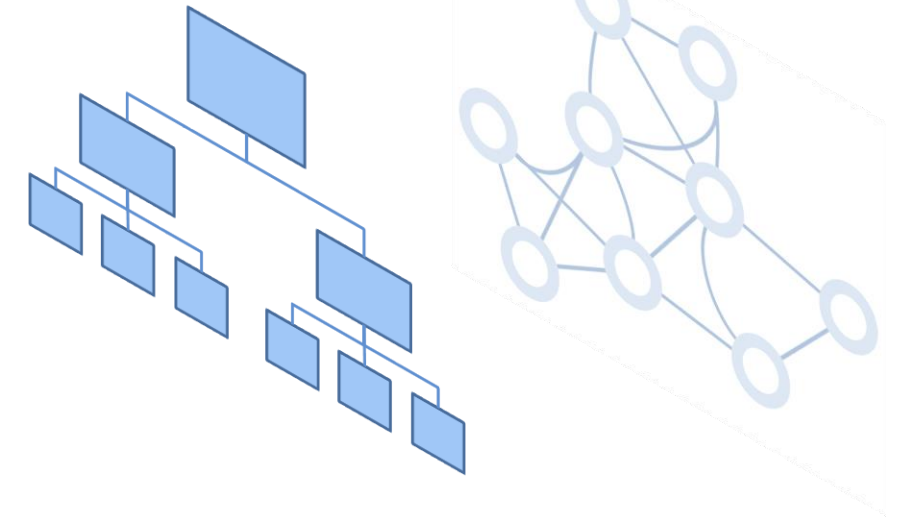
# Creating a Sense of Urgency



**Leading Change:** John P. Kotter

Eight-Step Process for undertaking major change.

1. **Creating a Sense of Urgency**
2. Building a Guiding Coalition
3. Developing a Strategic Vision and Initiatives
4. Expanding the Network of Change Agents
5. Empowering Broad-Based Action
6. Generating Short-Term Wins
7. Consolidating Gains and Producing More Change
8. Instituting Change in the Culture



**Accelerate:** John P. Kotter

Kotter's new book *Accelerate* refines principals and adds the concept of a “dual operating system”.

- One operating system is characterized by management, hierarchy and driven toward efficiency
- The other is characterized by leadership, networks, strategic acceleration and driven to innovate.
- Operating systems align nicely with the System of Innovation framework used in INCOSE's Agile and Patterns Working Groups where we see the distinct roles of executing and managing systems development and managing knowledge and what is learned in execution.





***If you want to truly understand something –  
try to change it.***

**Kurt Lewin**

***The best way to manage change is to create it.***

**Peter Drucker**



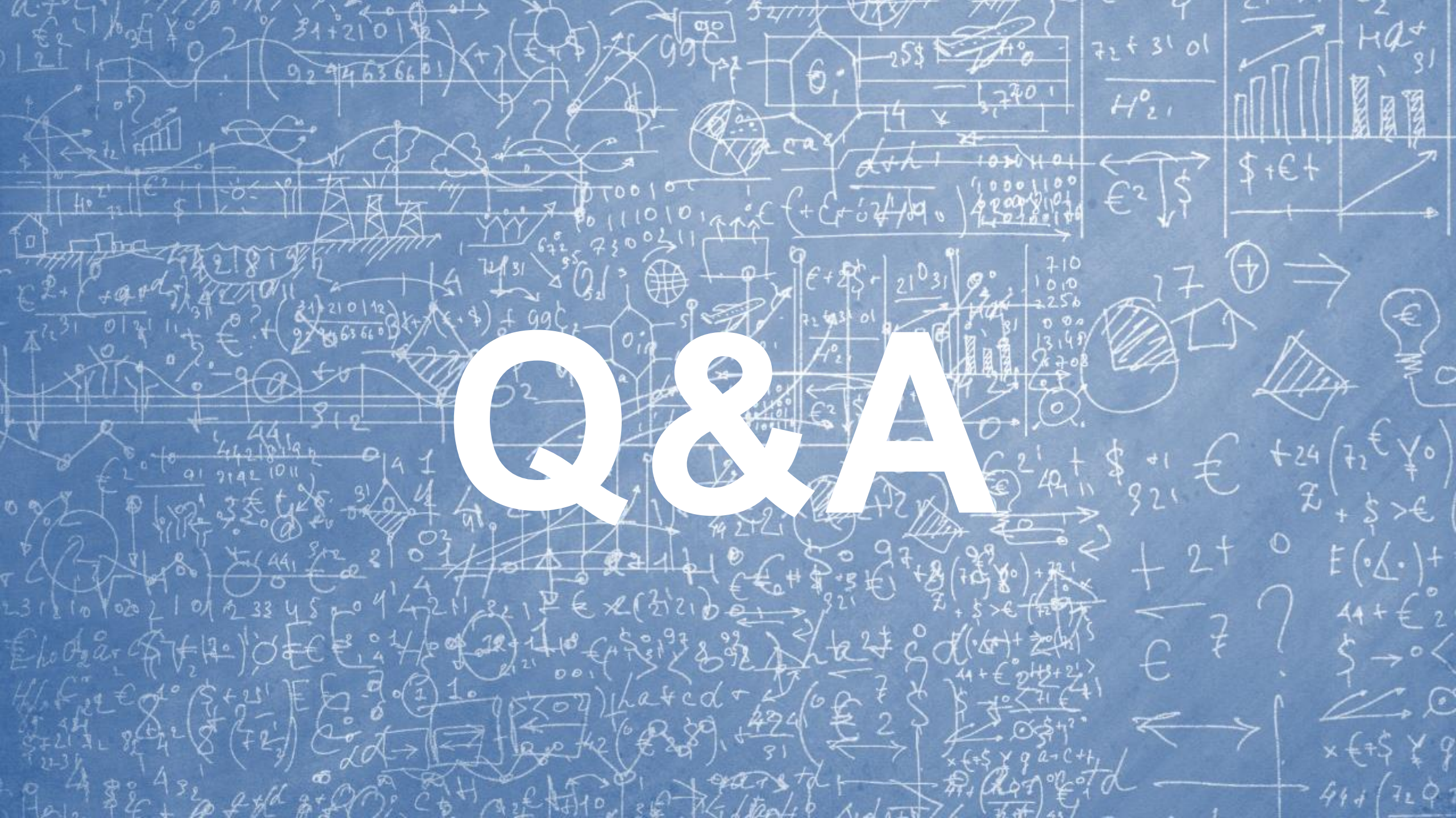




- It's a paradigm shift
- The previous state is unrecognizable
- It doesn't happen overnight, it takes time, and effort



# Q & A







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