Reimagining Systems Engineering

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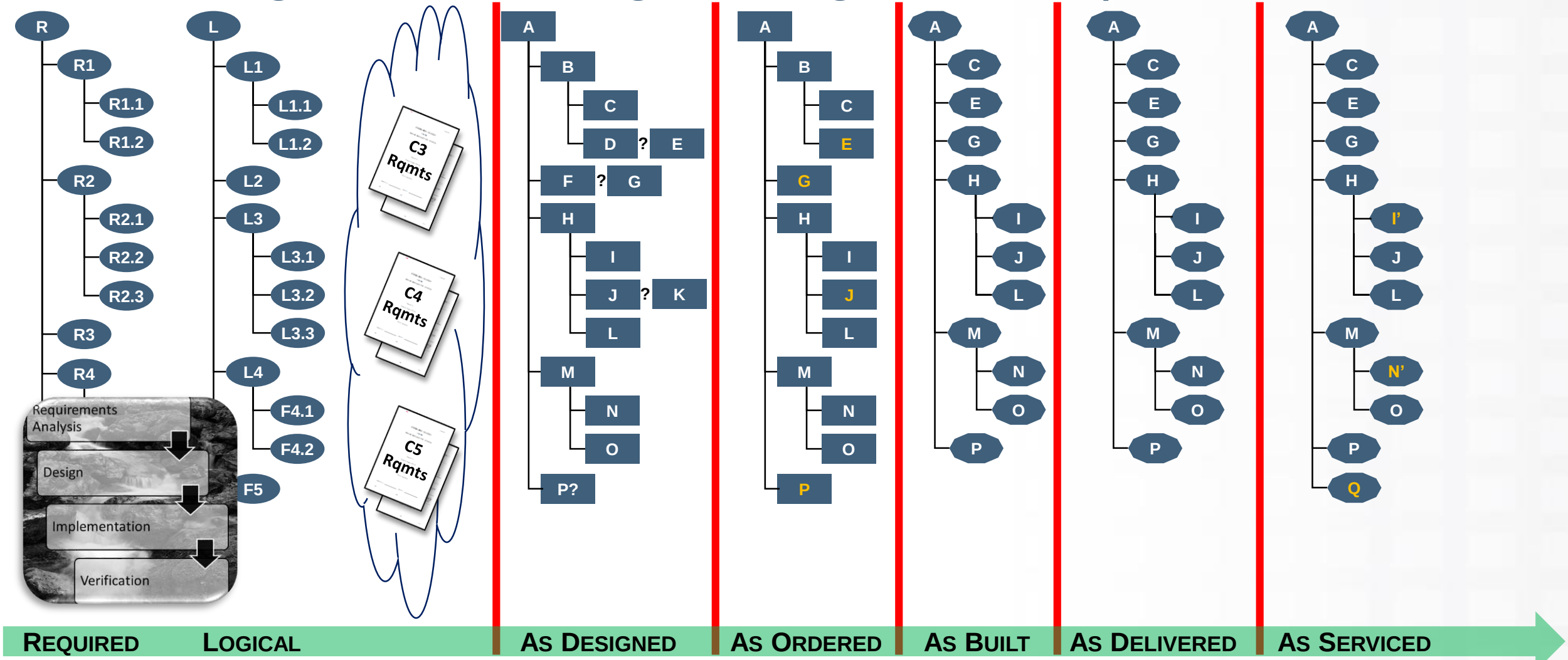
Executing Classical Engineering in a Complicated World



CONCEPT | DEVELOPMENT | PRODUCTION | UTILIZATION & SUPPORT | RETIRE

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Adapted from Aras Corporation, 2018.

An Age of Complicated, Complex, and Revolution

Image credit: Alisa Farr

Our Ability to Influence and Contribute: How Others See Systems Engineering

Process-Centric

“Big Bang” Delivery

Outdated

Non-responsive

Slow

Static

Inflexible

Irrelevant

Bureaucratic

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Systems Engineering

An engineering discipline whose responsibility is creating and executing an interdisciplinary process to ensure that the customer and stakeholder's needs are satisfied in a high quality, trustworthy, cost efficient and schedule compliant manner throughout a system's entire life cycle.

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Reimagining Ourselves for a Better Tomorrow

From Near-Obsolescence

to Relevance

to Essential

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Reimaging Ourselves Step-by-Step

1. Understand the changing context

Understanding Our Roots (the Root of Our Challenge)

Exceeding the Capabilities of Traditional SE: Capturing Knowledge, Responding to Change

System scale

Mission complexity

Project team complexity

Dynamic complexity

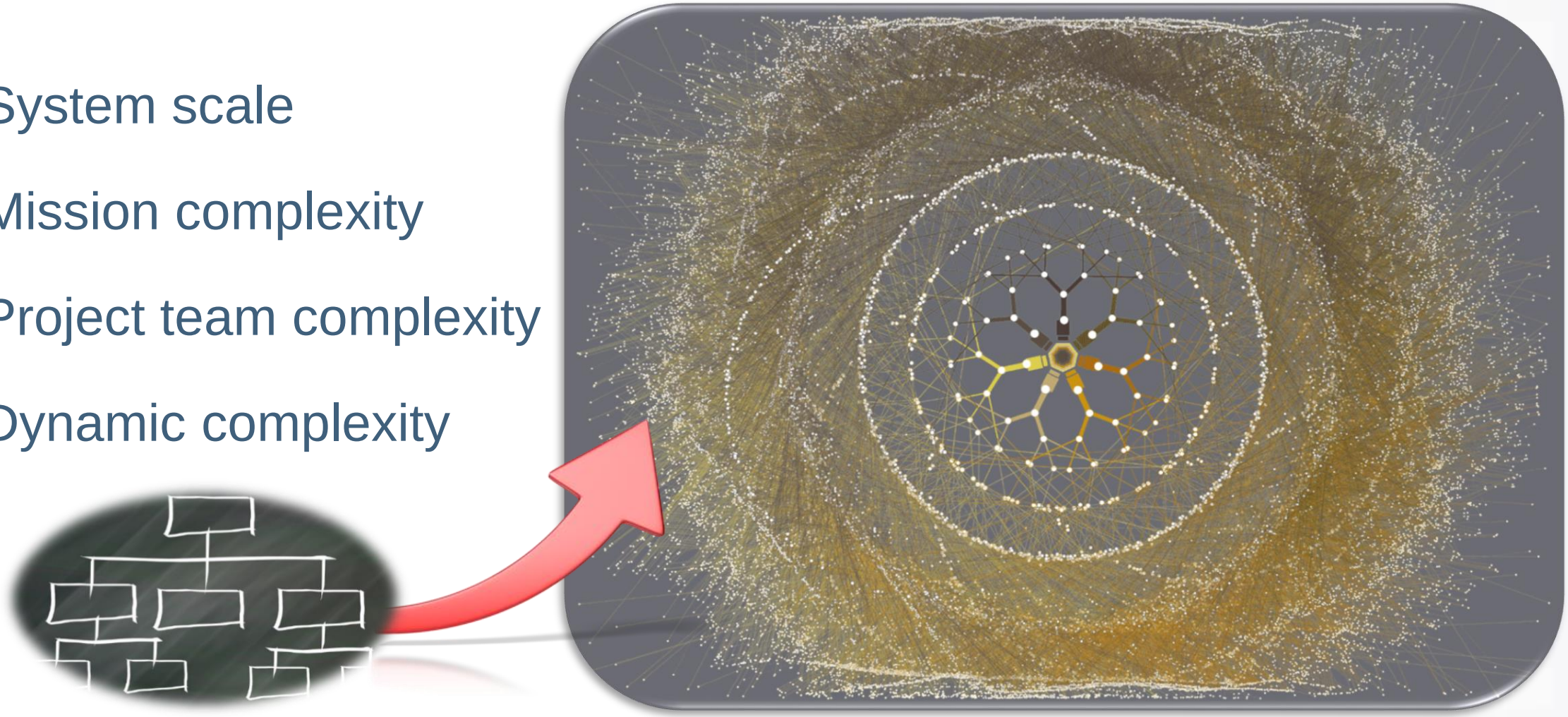
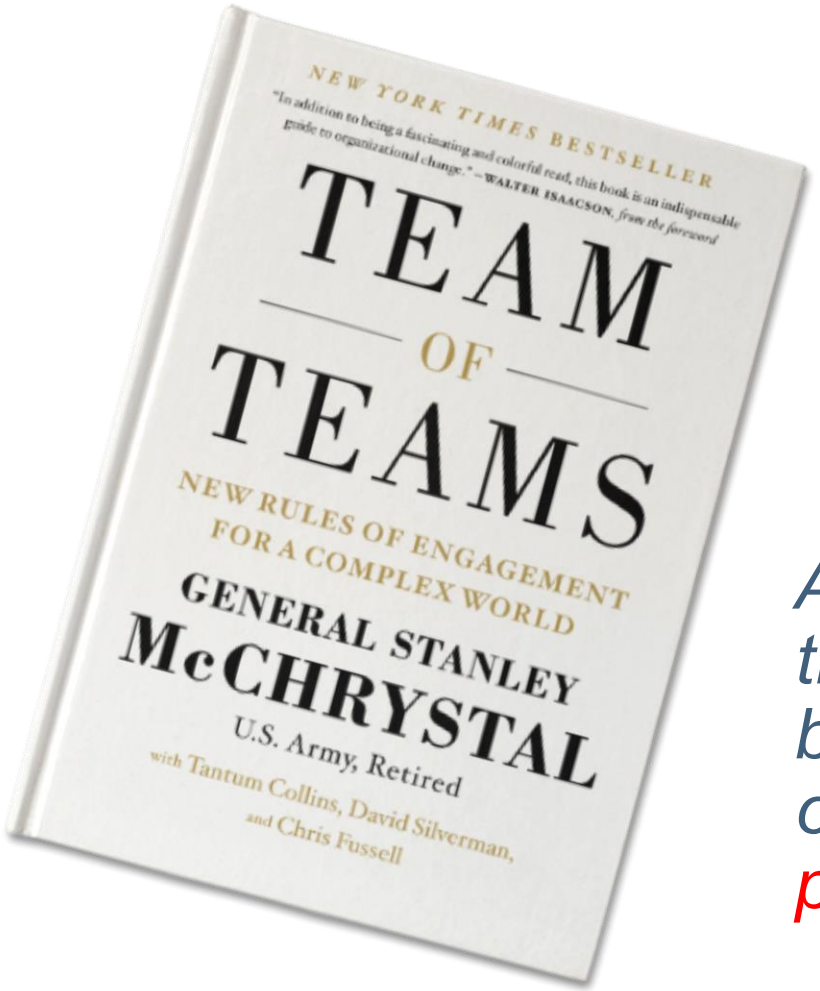


Image credit: Alisa Farr for Letter27. farrimages.com

Seeing the Mismatch between Modern Conditions and Classic Approaches



We tend to assume that technological advances will enable us to do what we have always done, only better. However these same technologies imbue our operating environment with escalating non-linearity, complexity, and unpredictability.

Attempts to control complex systems by using the kind of mechanical reductionist thinking … breaking everything down into component parts, or optimizing individual elements … tend to be pointless at best or destructive at worst.

Reimaging Ourselves Step-by-Step

1. Understand the changing context
2. Return to first principles

Connecting People, Disciplines, Insights, and Ideas

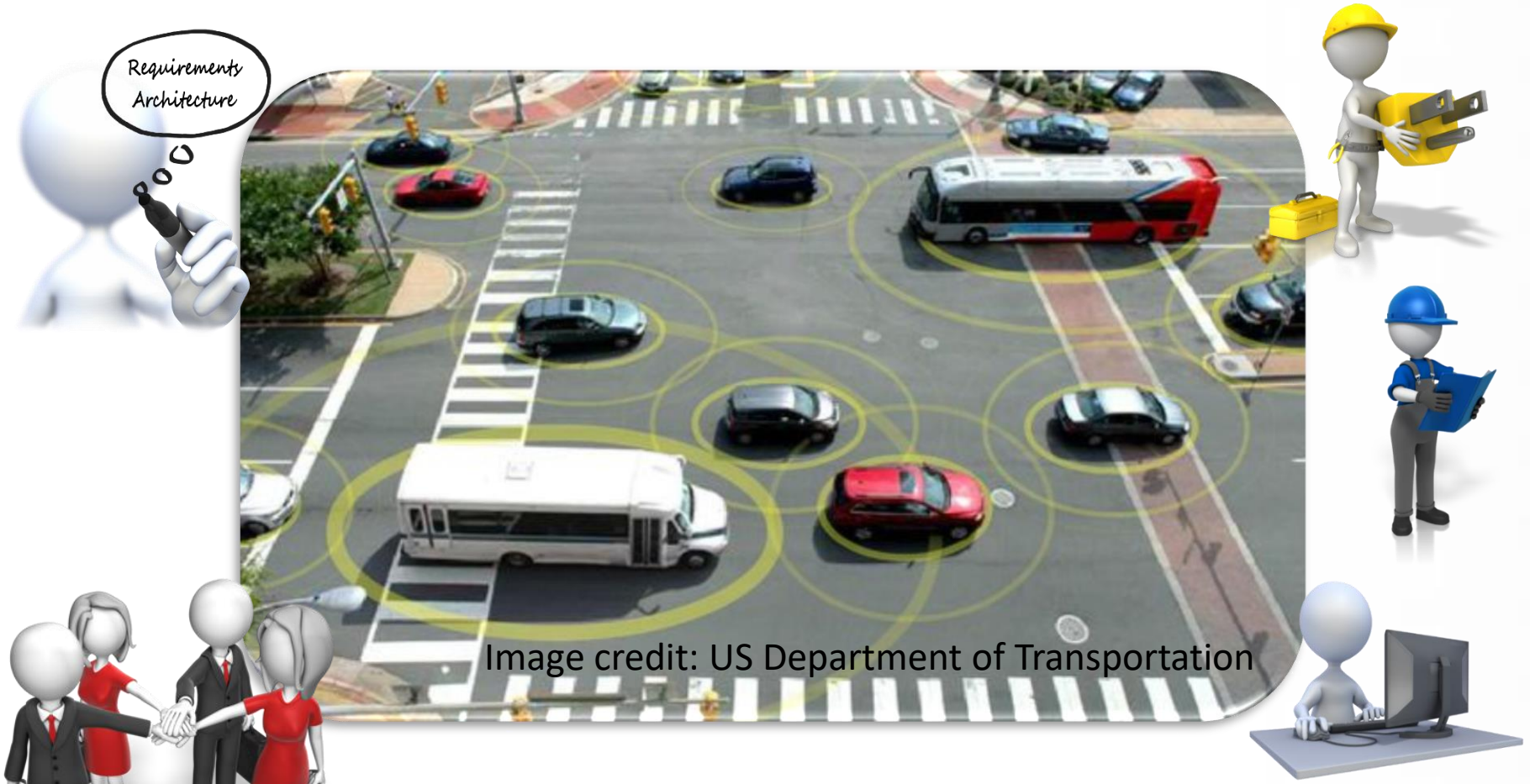
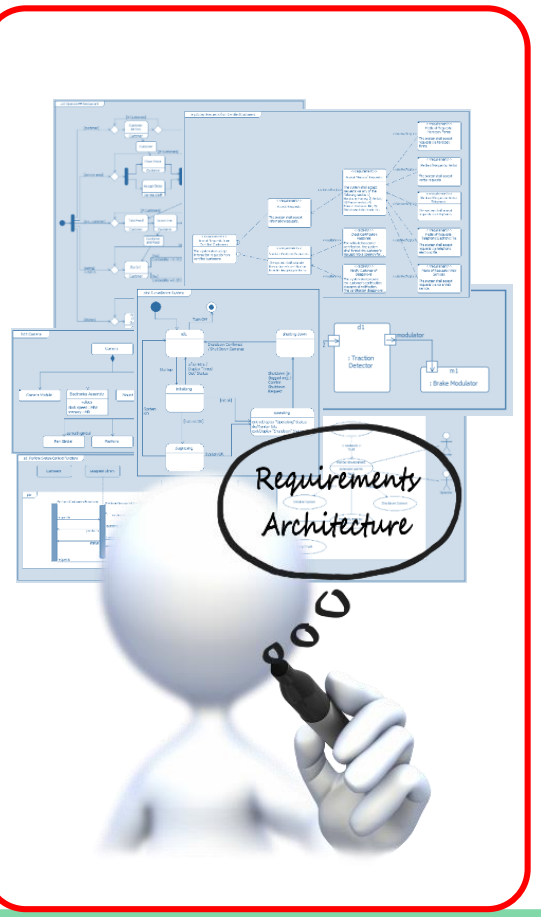


Image credit: US Department of Transportation

Systems engineering focuses on ensuring the pieces work together to achieve the objectives of the whole.

Systems Engineering Body of Knowledge (SEBoK)

Should we be Systems Engineering?



REQUIRED FUNCTIONAL LOGICAL

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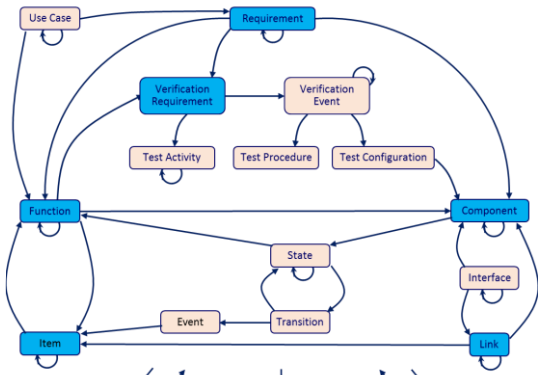
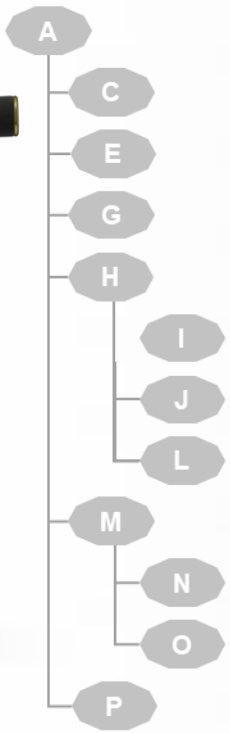
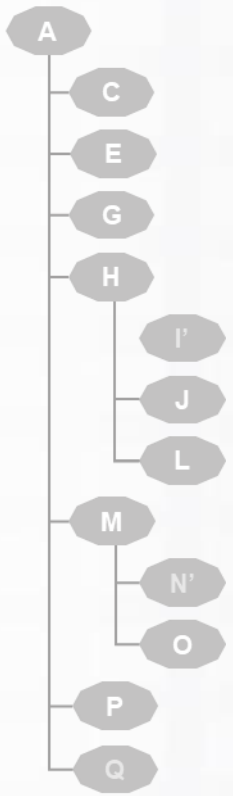
…or should we be Engineering Systems?







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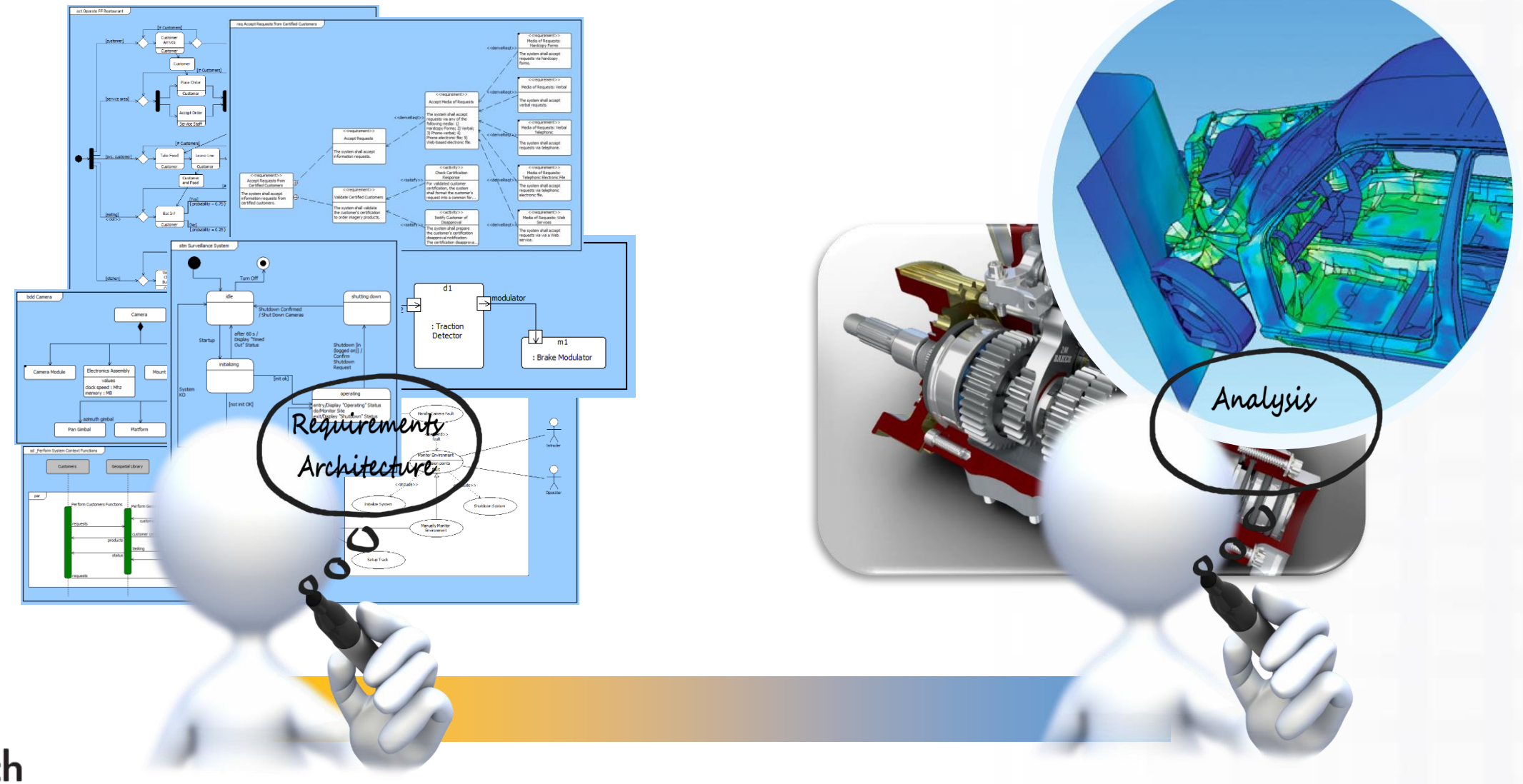
Embracing Both Systems and Engineering

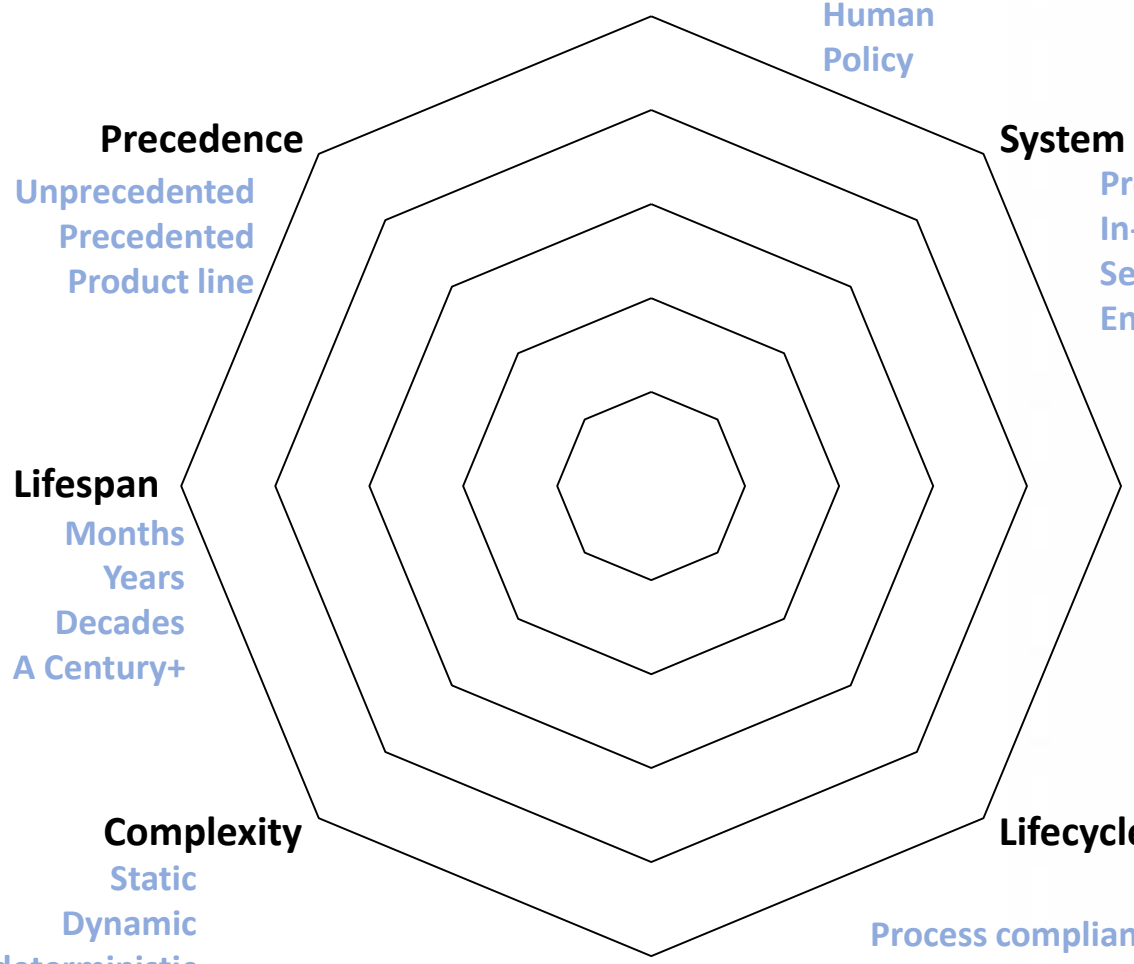


Keeping the Thinking and Systems in the Engineering of Systems

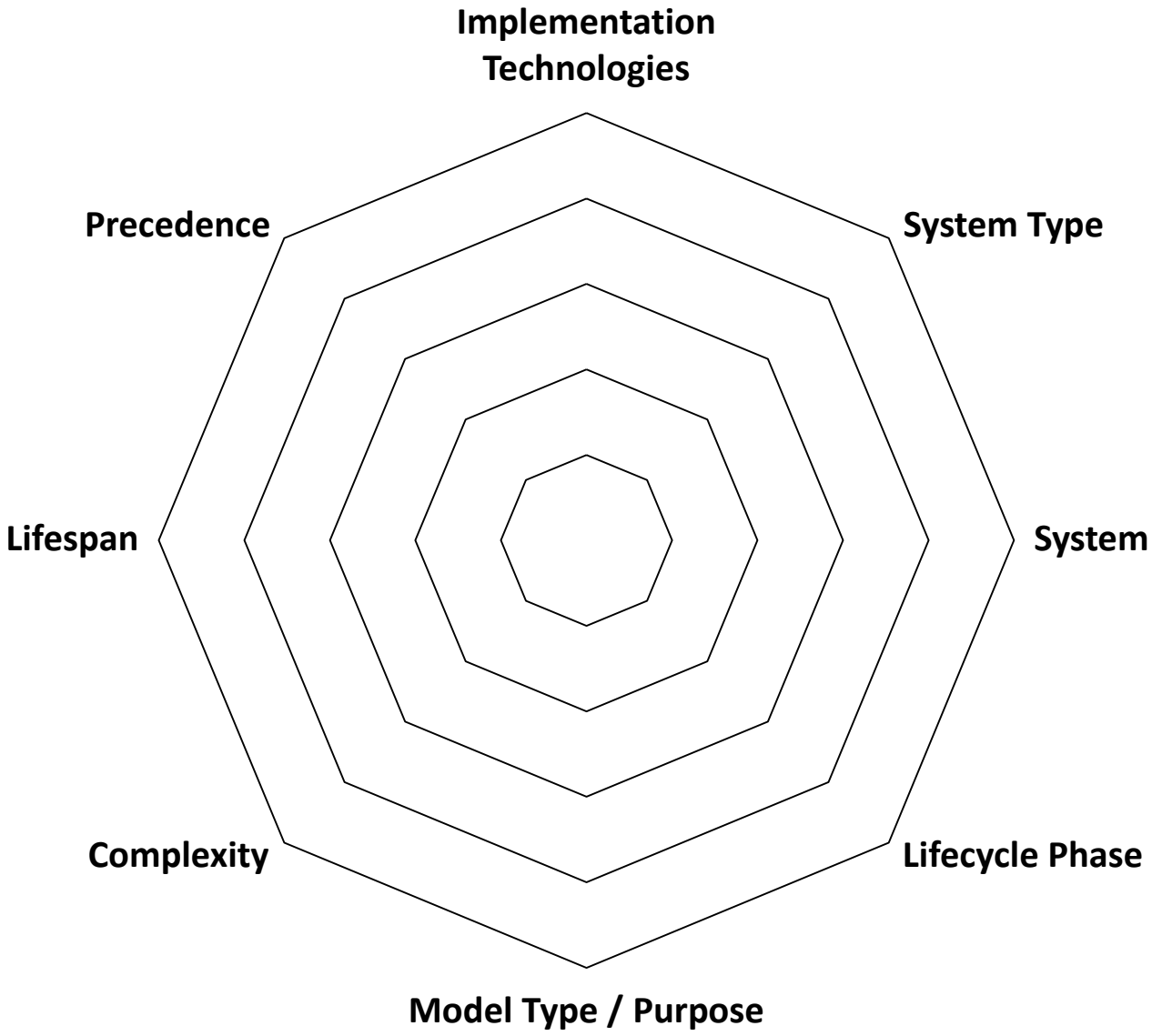
Reimaging Ourselves Step-by-Step

1. Understand the changing context
2. Return to first principles
3. Transform our practice

Recognizing 8+ Dimensions to Our Challenge



Pre-Tailoring and Communicating for the Business Need



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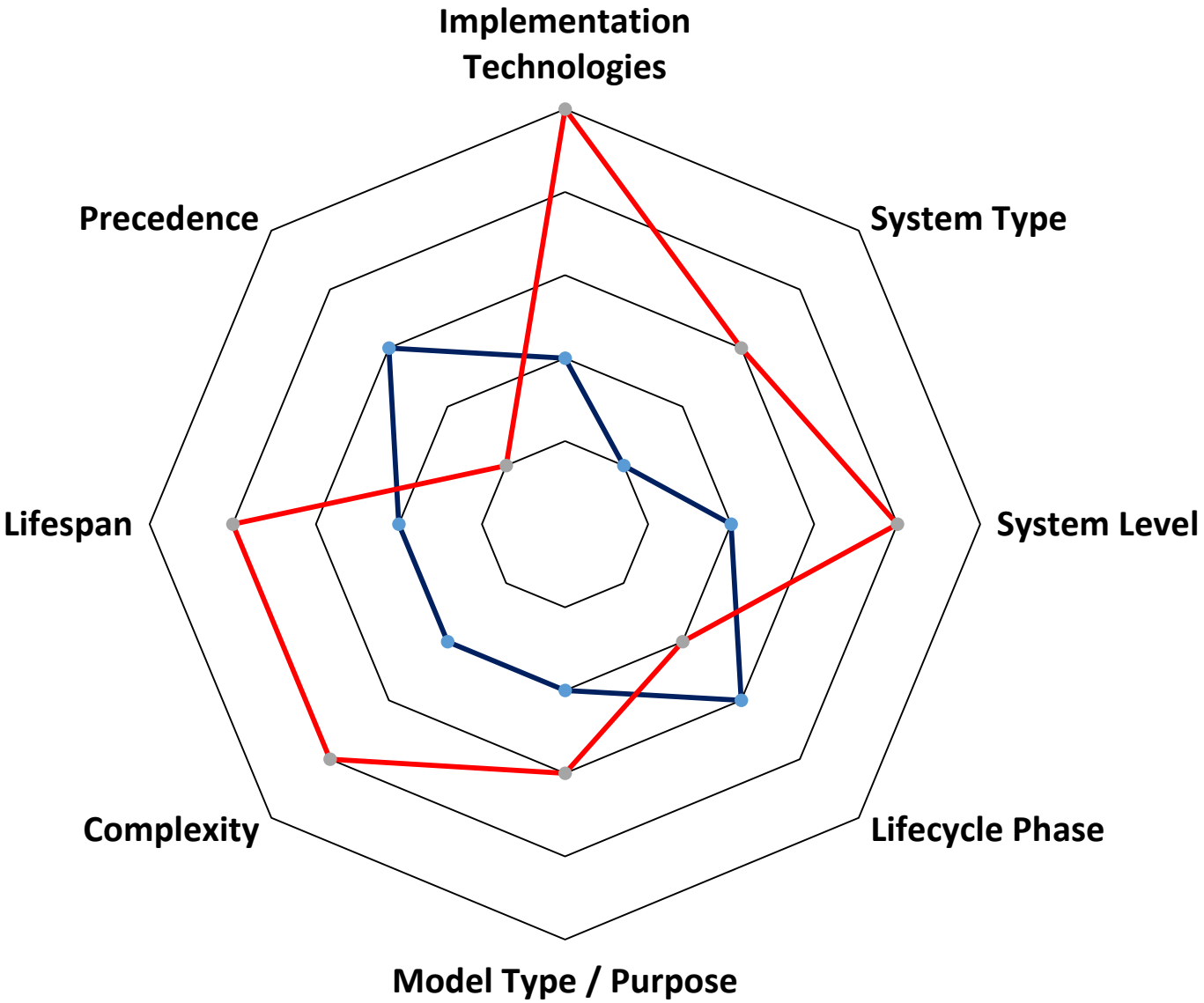
Pre-Tailoring for the Problem Archetypes



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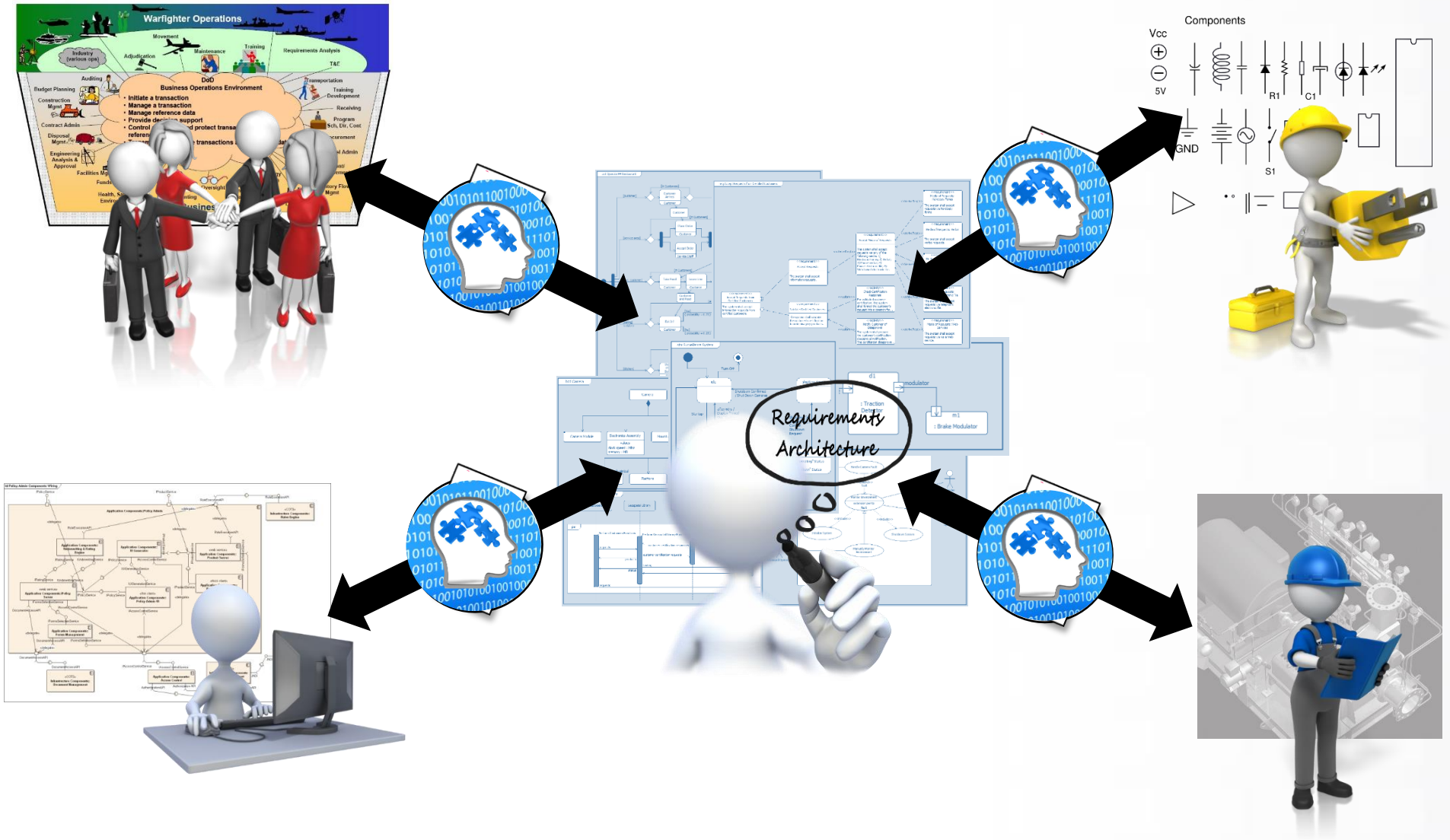
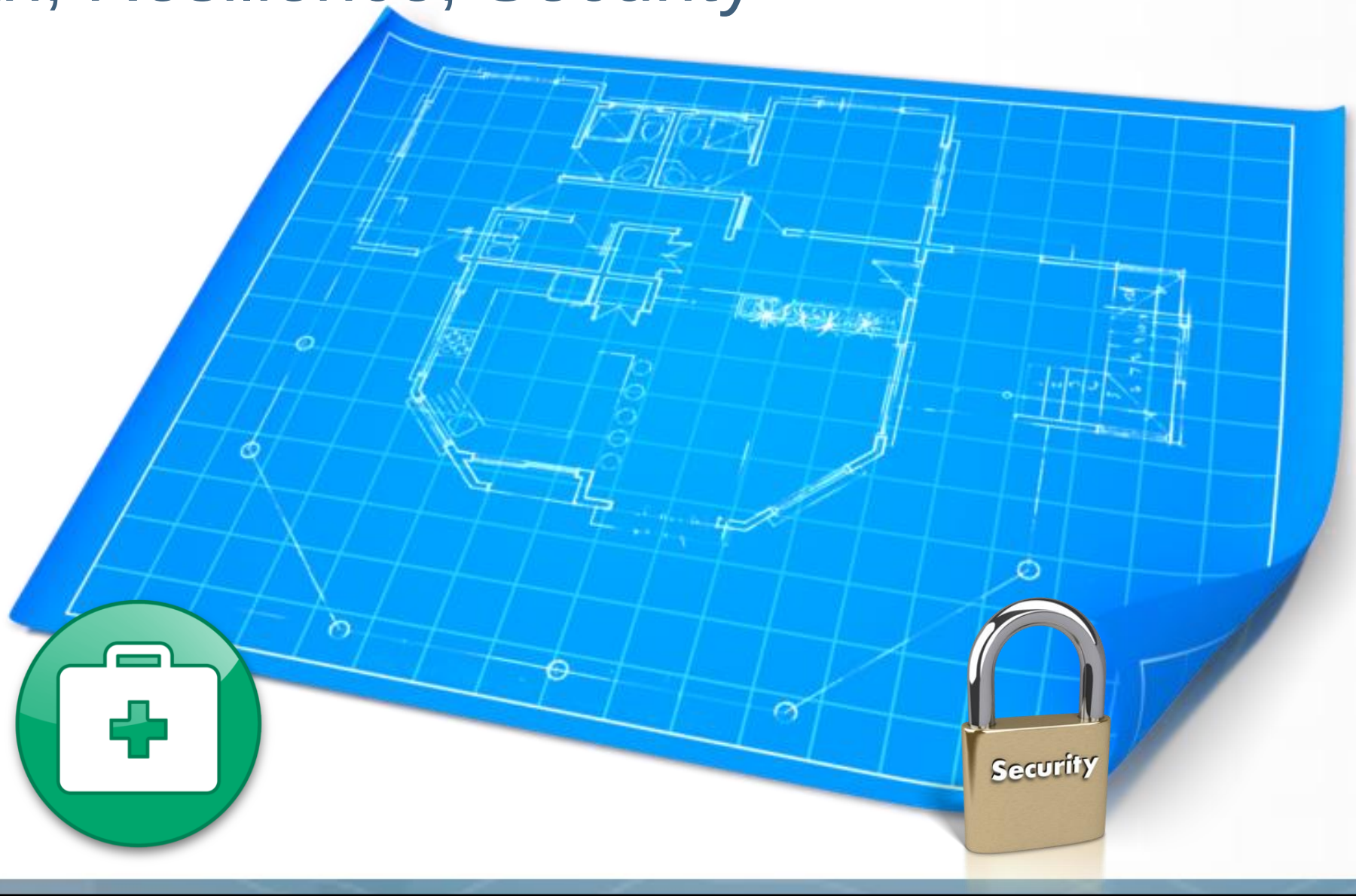
Moving from Ambiguity to Digital Clarity: Communications, Semantics, Analysis



Encoding and Applying Patterns for Health, Resilience, Security



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Moving from Custom-Built to Composability (and Design for Composability across Scales)

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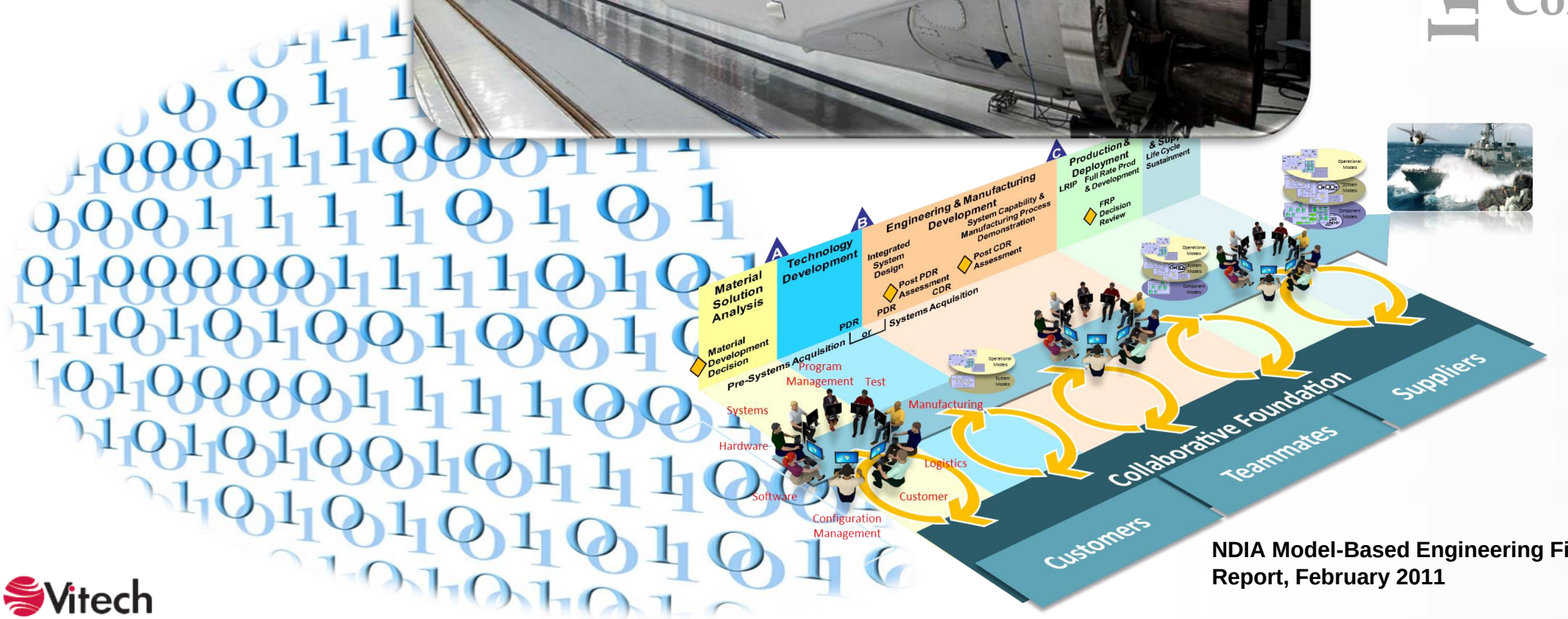
Meeting the Pace of Change

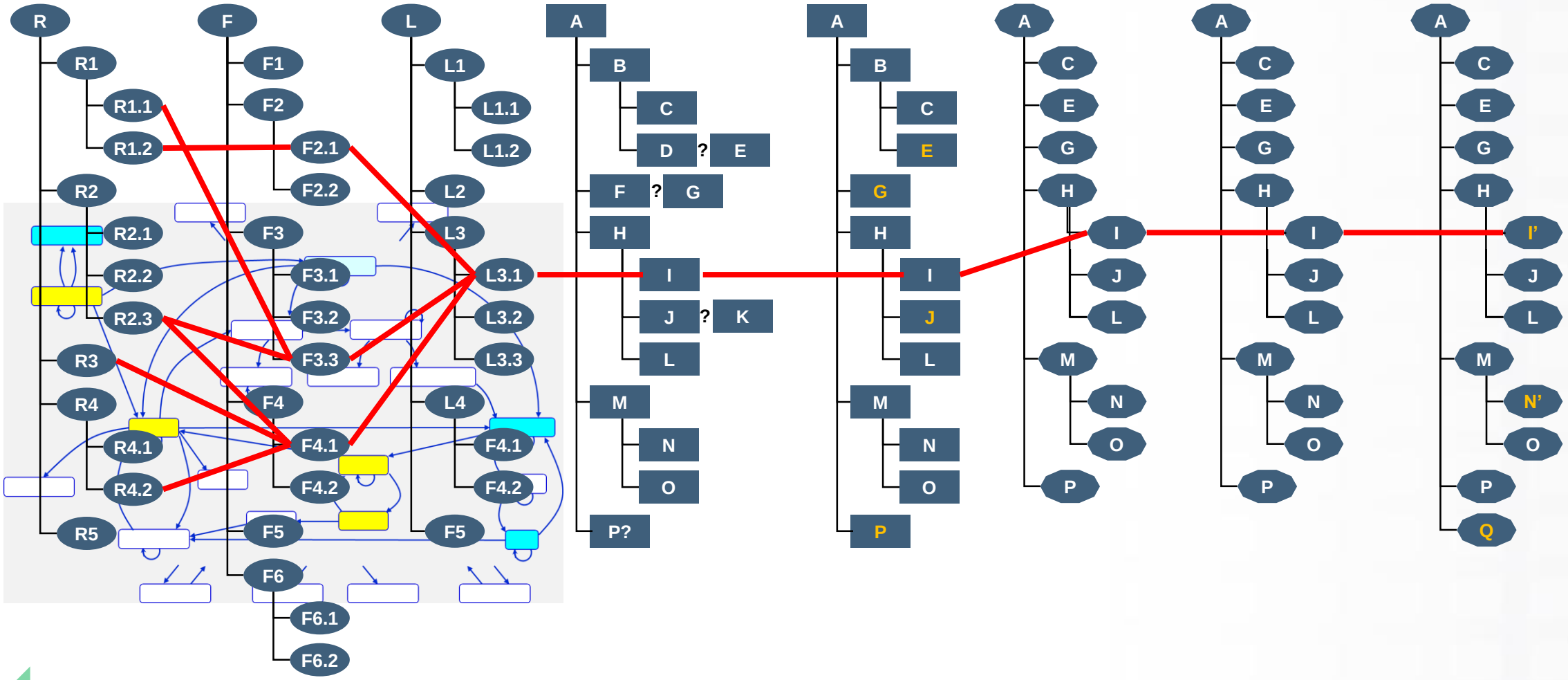
Photo credit:
Caroline Trump / SpaceX



NDIA Model-Based Engineering Final Report, February 2011

Moving from Built-to-Last to Built-to-Evolve

Enabling Connected Digital Engineering in a Complex World



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Drawing Inspiration from beyond Engineering

Semantic Science

Systems Science

Visualization

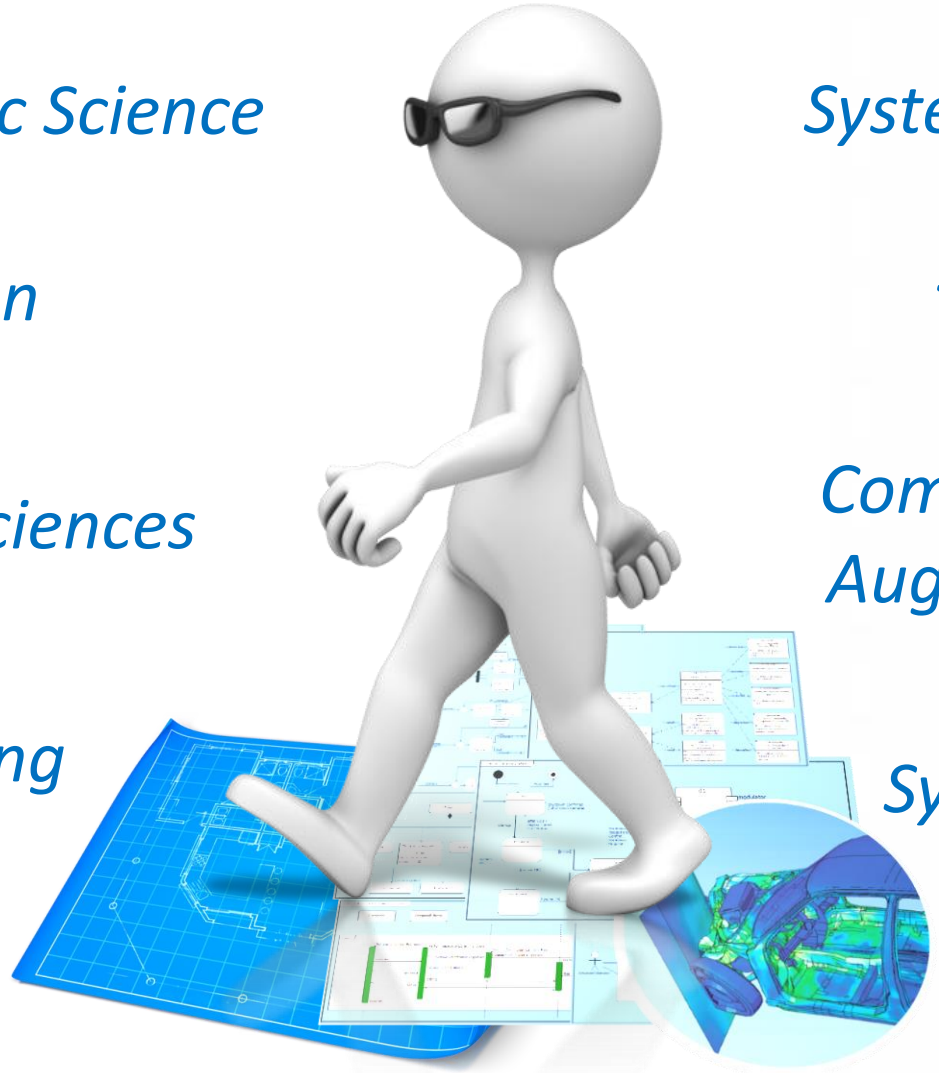
Sociology

Life Sciences

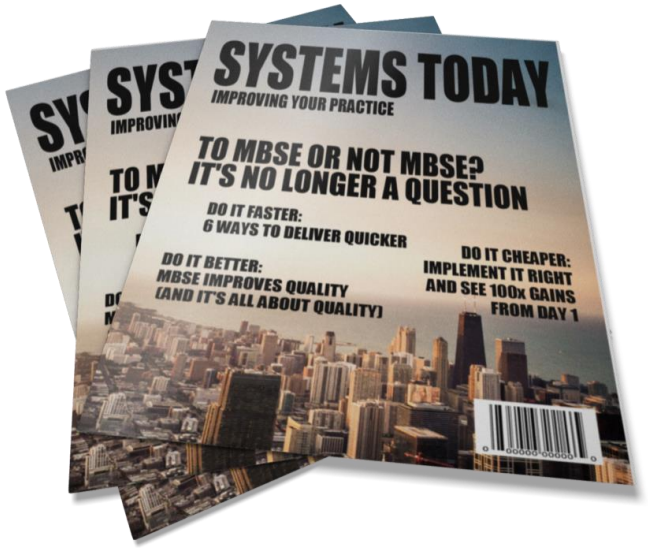
Computational Augmentation

Design Thinking and UX

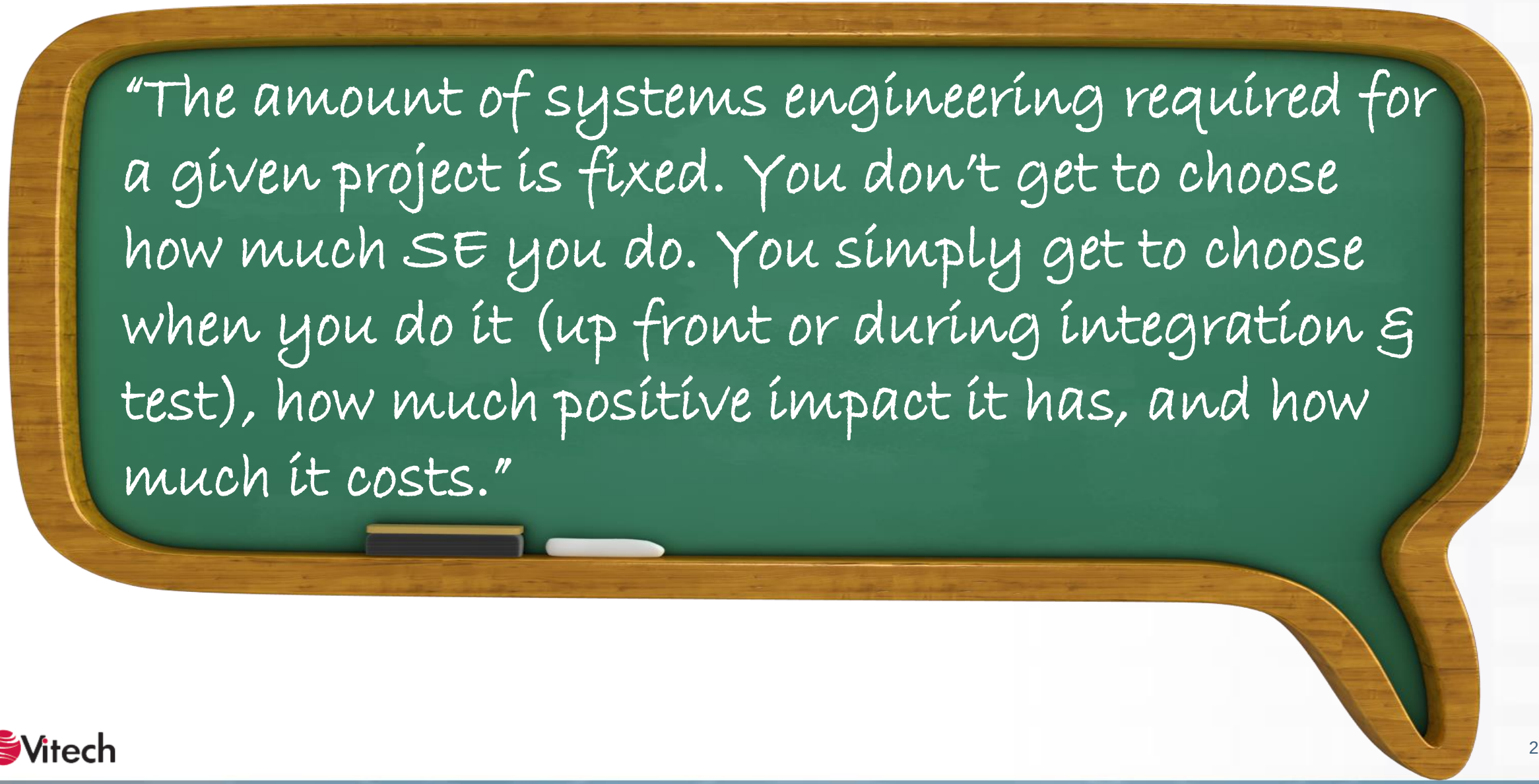
Systems Literacy for All



Building on Progress, not Reinventing the Wheel



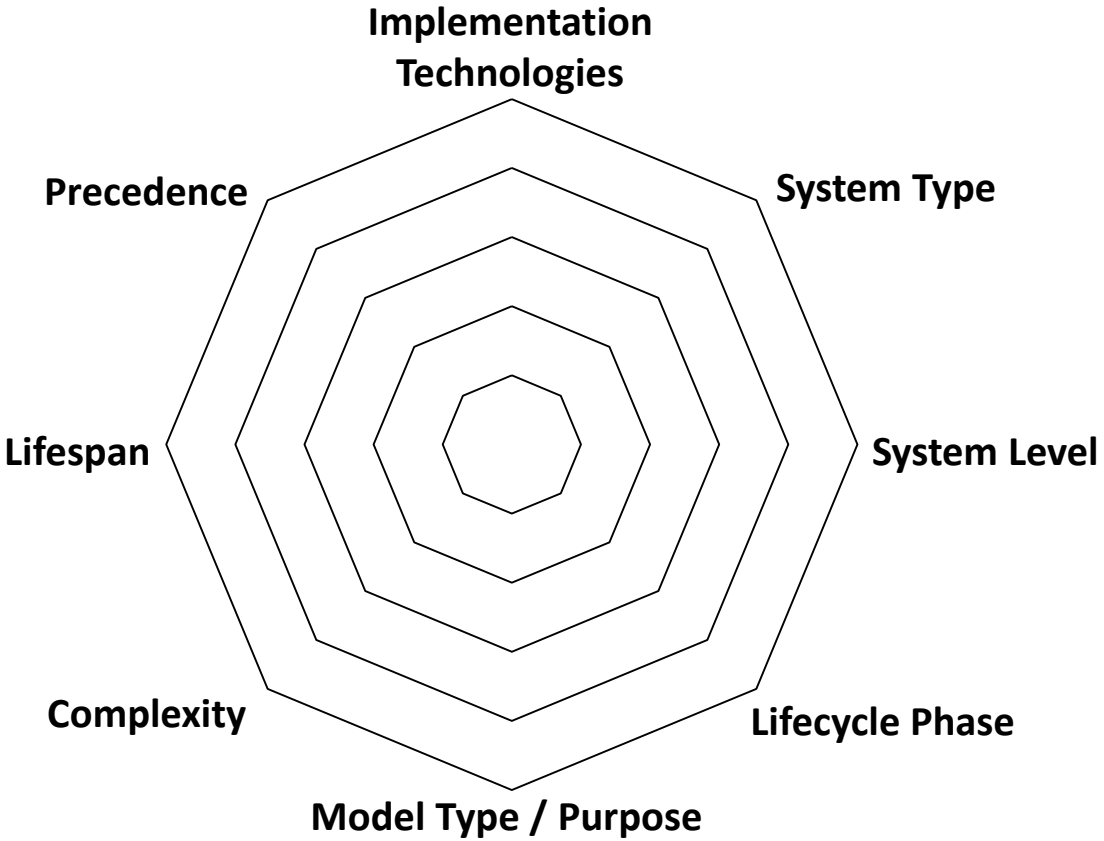
Remaining Grounded – The Law of Conservation of SE



Reimaging Ourselves Step-by-Step

1. Understand the changing context
2. Return to first principles
3. Transform our practice
4. Embrace our true scope

Embracing 21st Century Technologies and Specialists



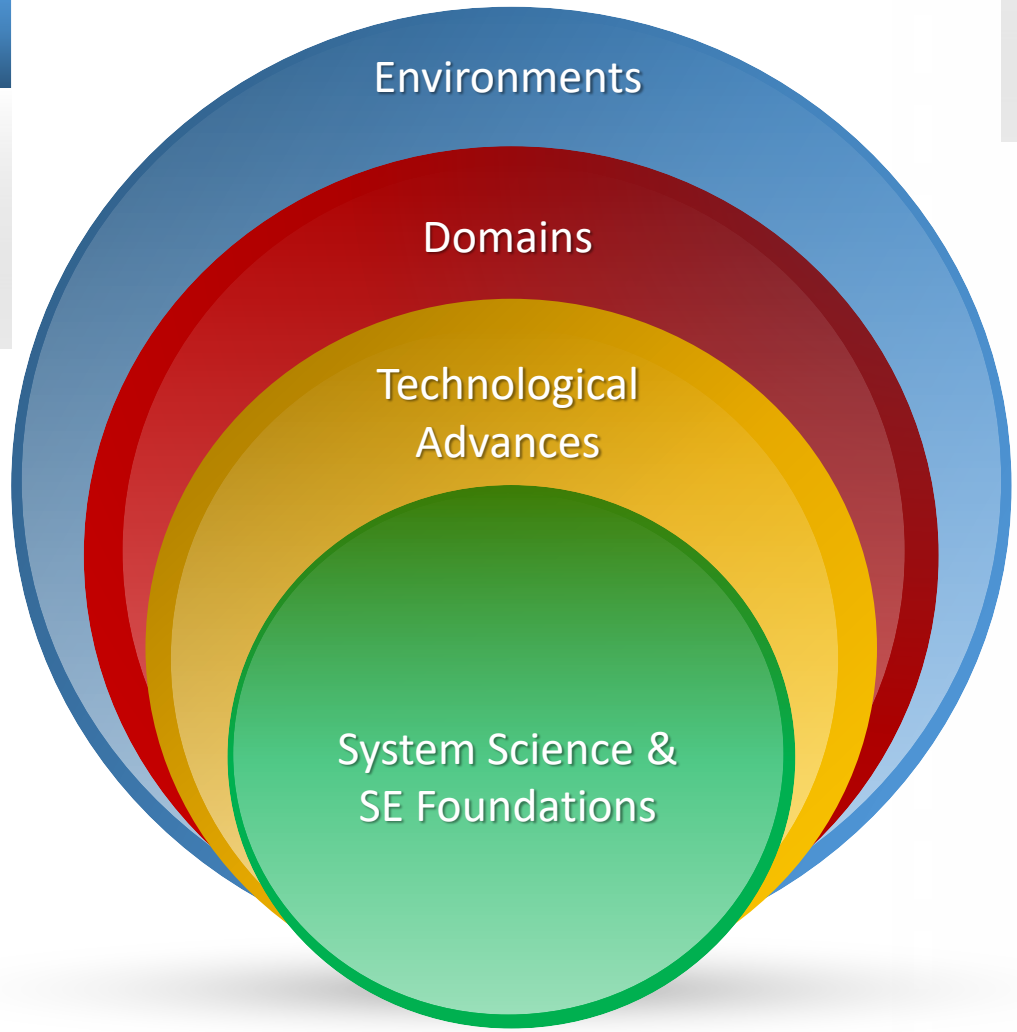
Systems Engineering of the Future
A Systems World Perspective of Context

Environments

- Ecosystems– Natural & Artificial/Manmade
- Economical Environment
- Political Environment
- Health Environment

Domains

- Defense
- Space
- Healthcare
- Games – serious games
- Transportation
- Communications
- Information
- Consumer Electronics
- Public Policy
- Biomedical
- Housing



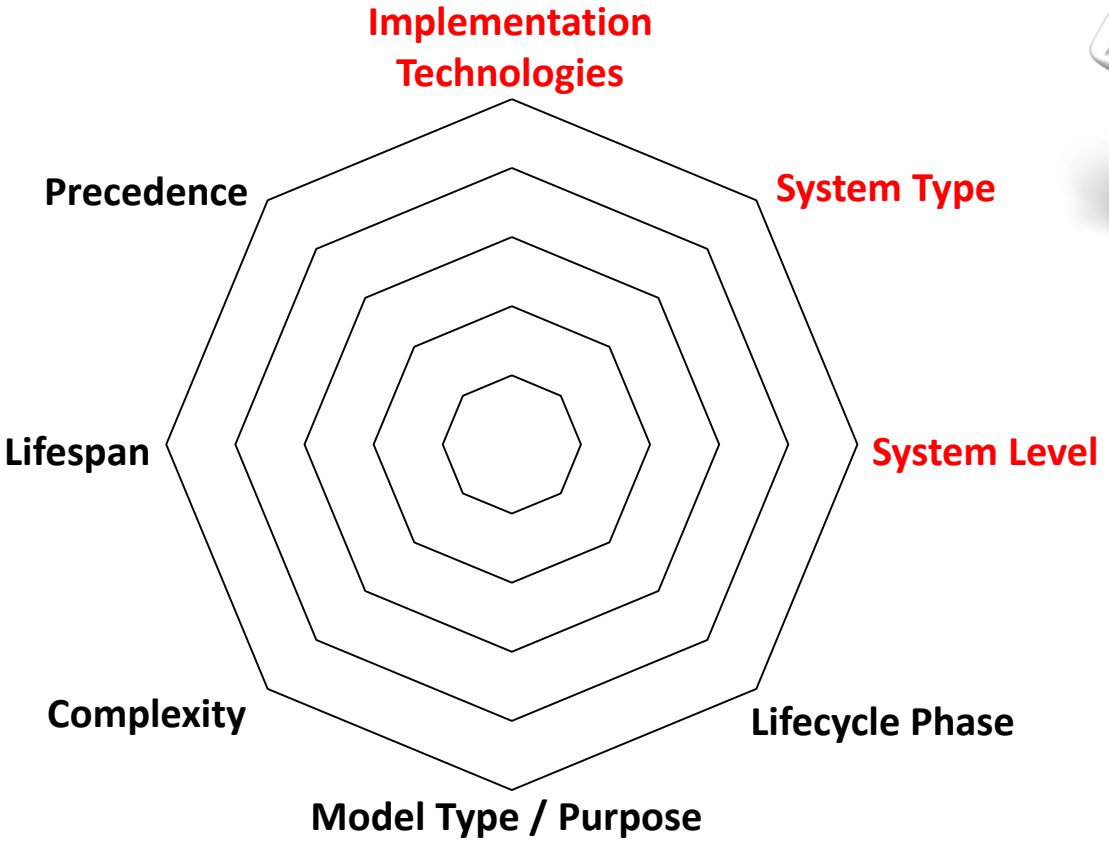
System Science & SE Foundations

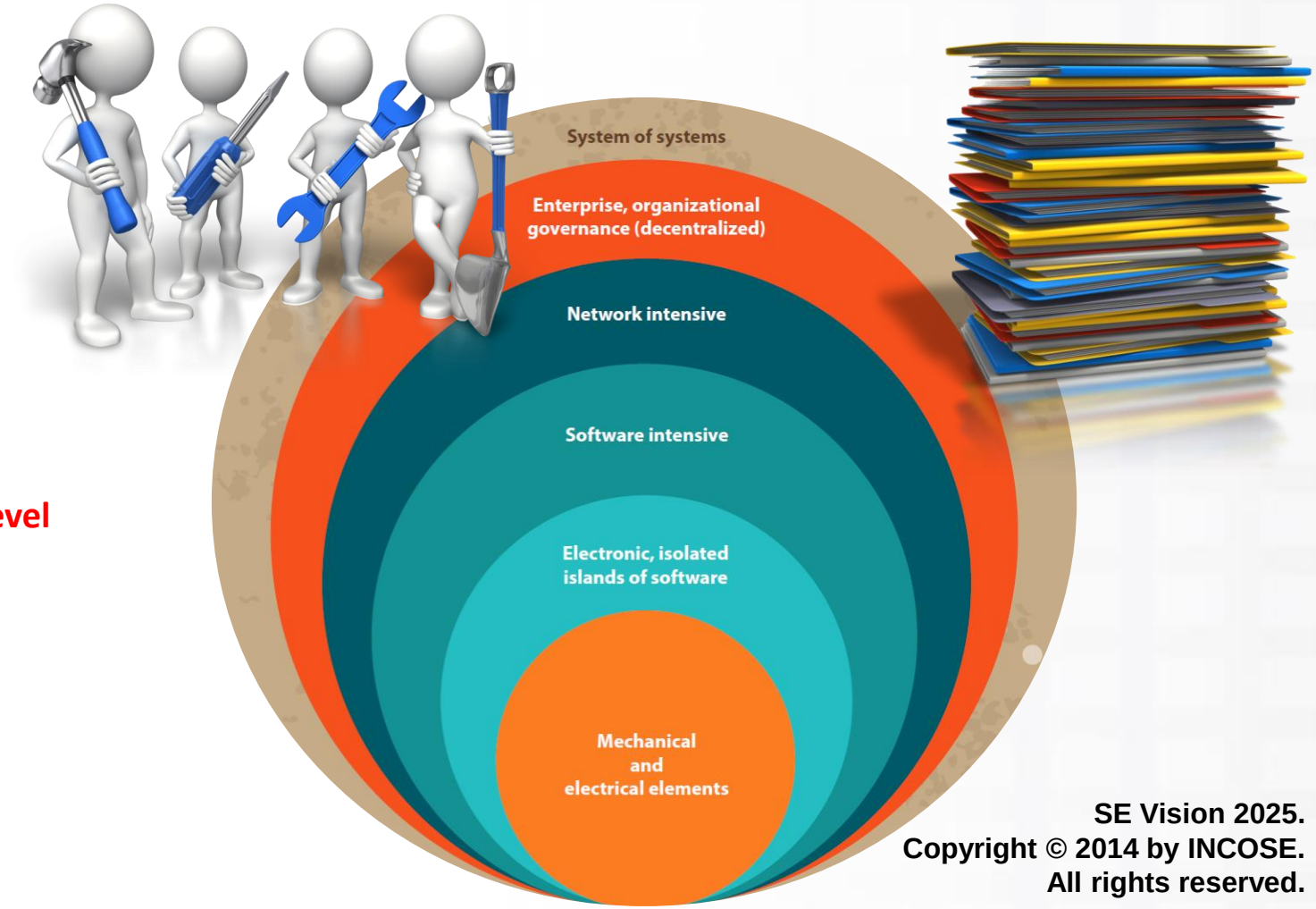
- Processes, Methods & Guidelines
- Models & Tools
- Standards
- Tailoring Guidance
- System Research & Theories

Technological Advances

- Artificial Intelligence (AI)
- Autonomy
- Big Data
- Internet of Things (IoT) / Smart Things
- Smart X (eg Smart Cities)
- Cloud Computing
- Ubiquitous Access to Information
- Power/Energy
- Augmented Virtual Reality
- Simulation/Stimulation
- Sustainment/Elegant Systems
- 3D Printing
- Cyber-Physical Systems
- Ability to find Unique (Old) via eBay, Amazon, etc

Moving Beyond Our Product-Centric Comfort Zone





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Reimaging Ourselves Step-by-Step

1. Understand the changing context
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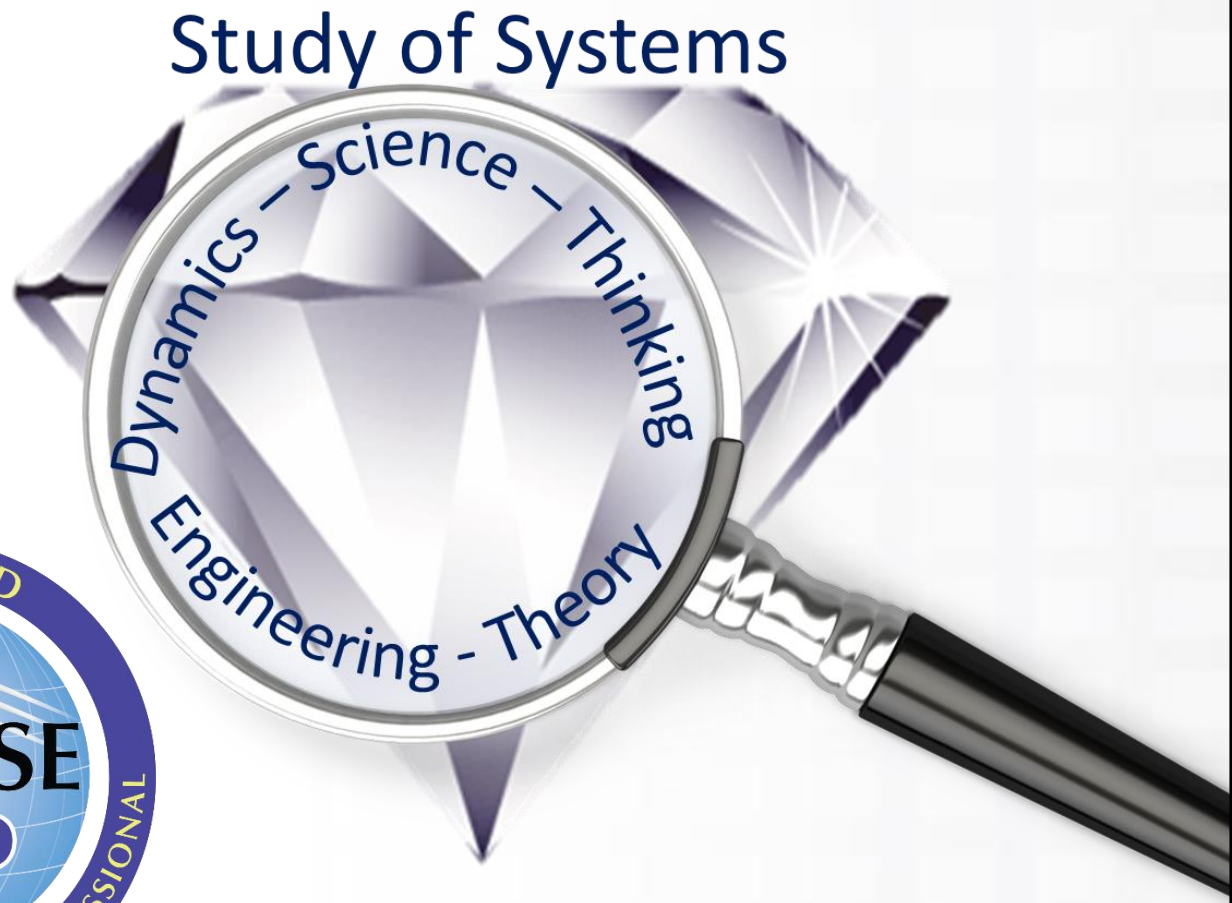
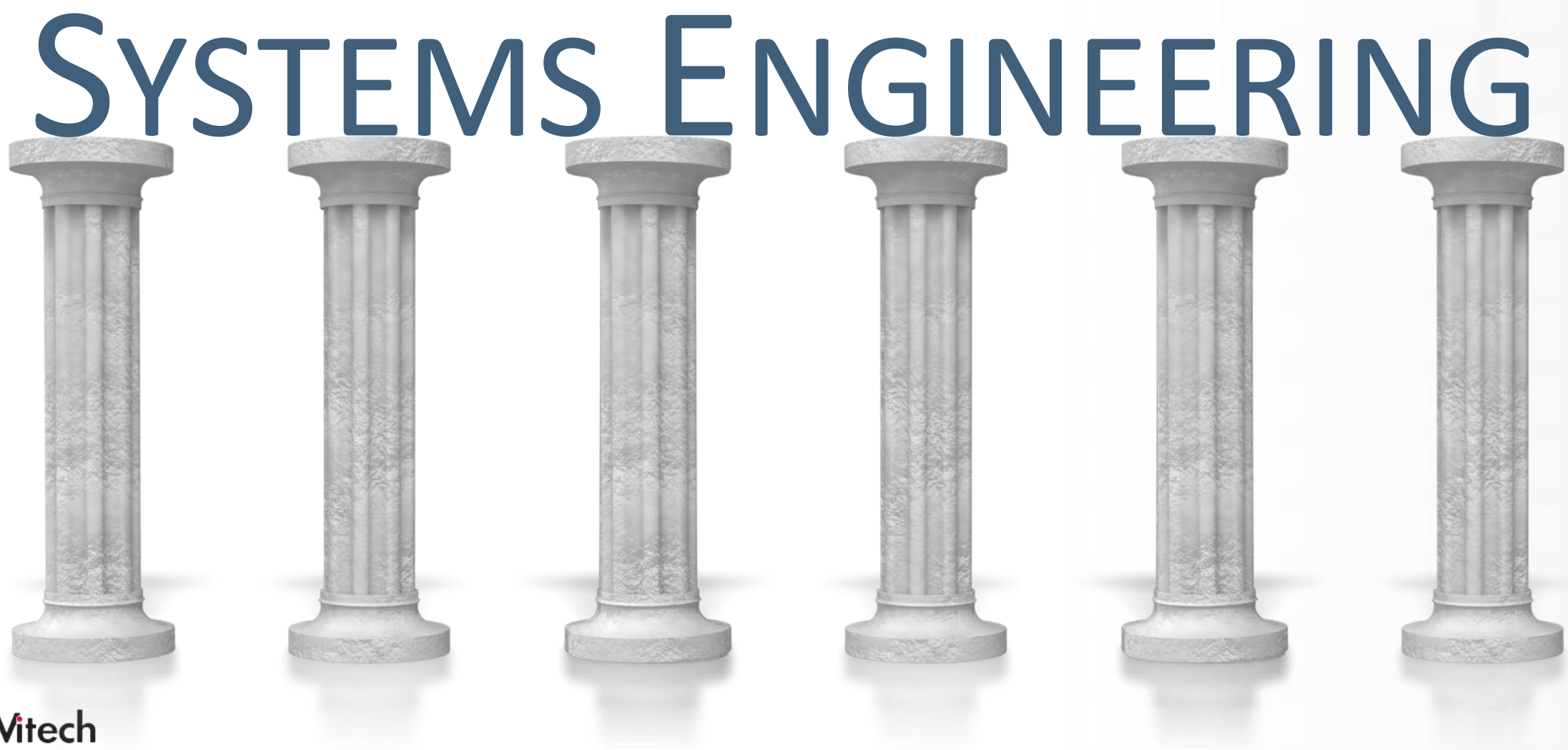
4. Embrace our true scope
5. Become a discipline

Solidifying Our Body of Knowledge

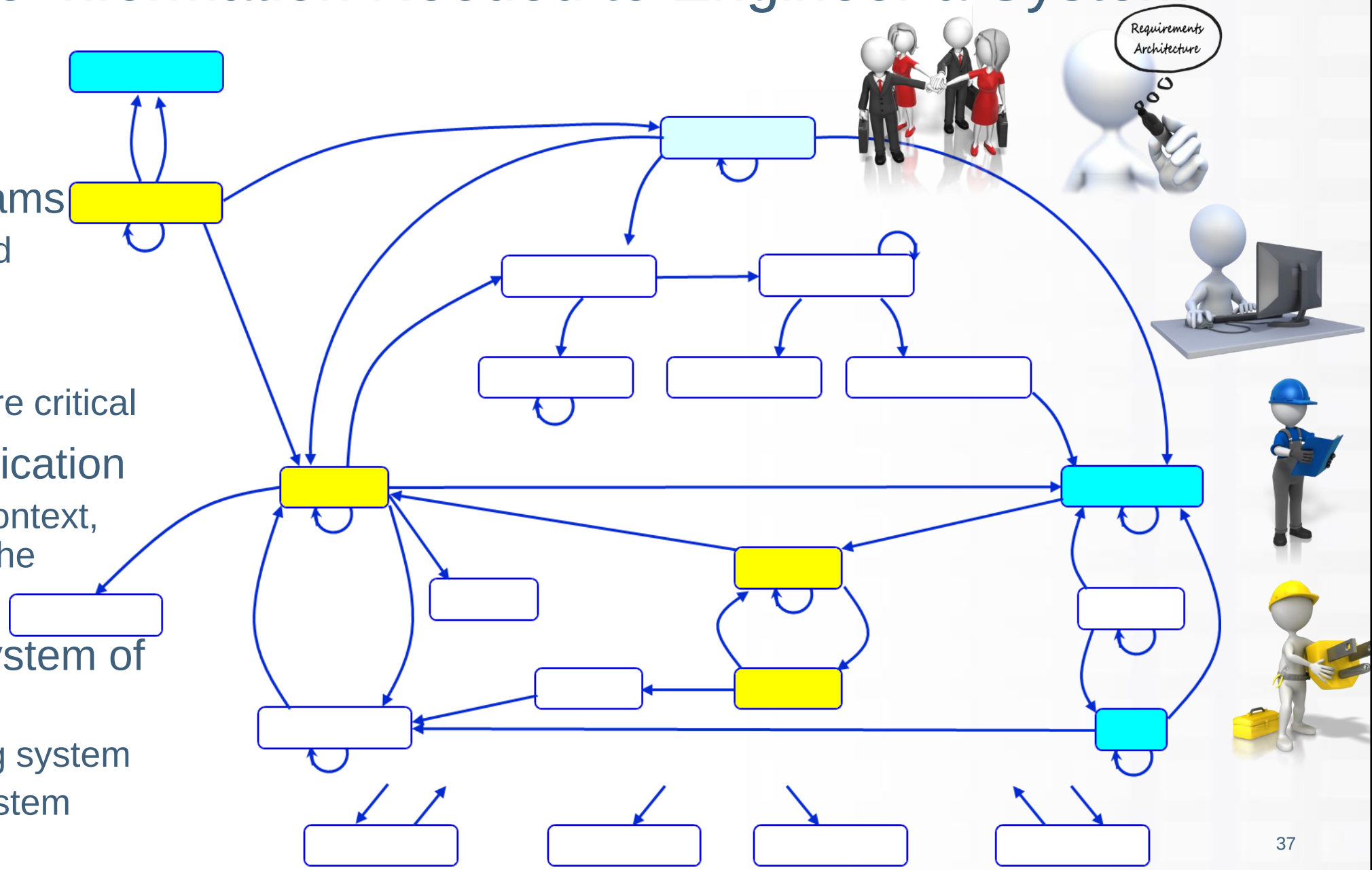


Identifying the Underpinning Principles



Defining the Information Needed to Engineer a System

- More than diagrams
  - Consistency and integration
- More than RFLP
  - Relationships are critical
- More than specification
  - Full rationale, context, and capture of the design journey
- More than the system of interest
  - The engineering system
  - The learning system



Engineering a Connected, Thru-Life Approach: Information, Workflow, Theory, Workforce, Trust

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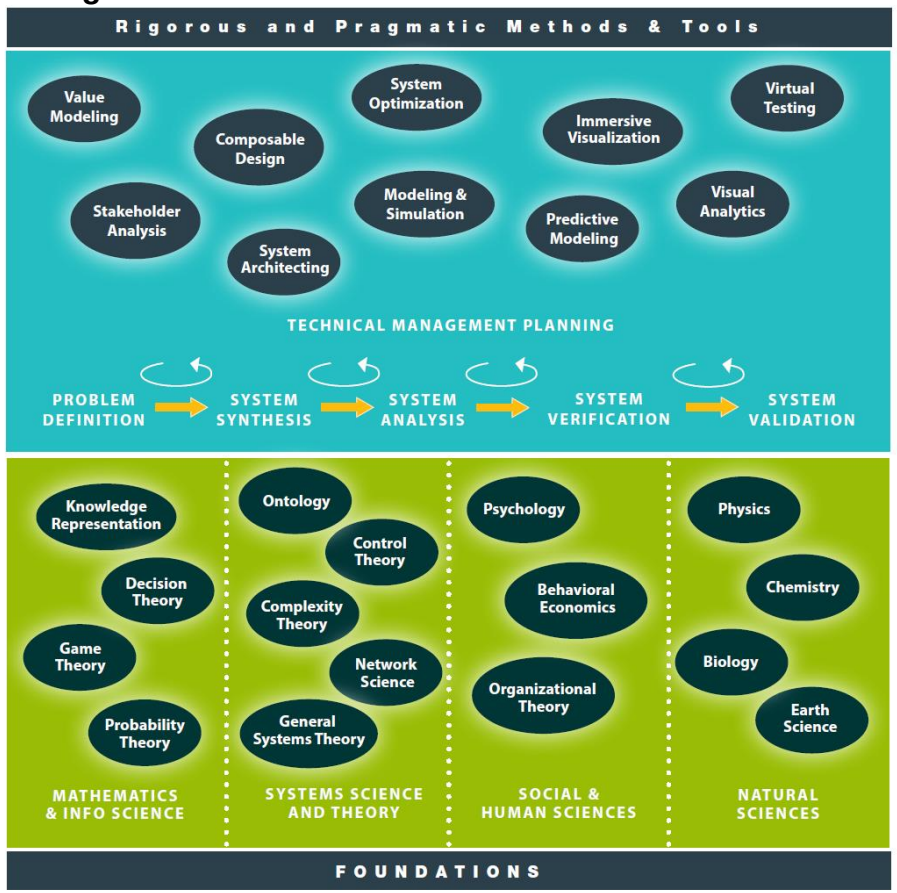

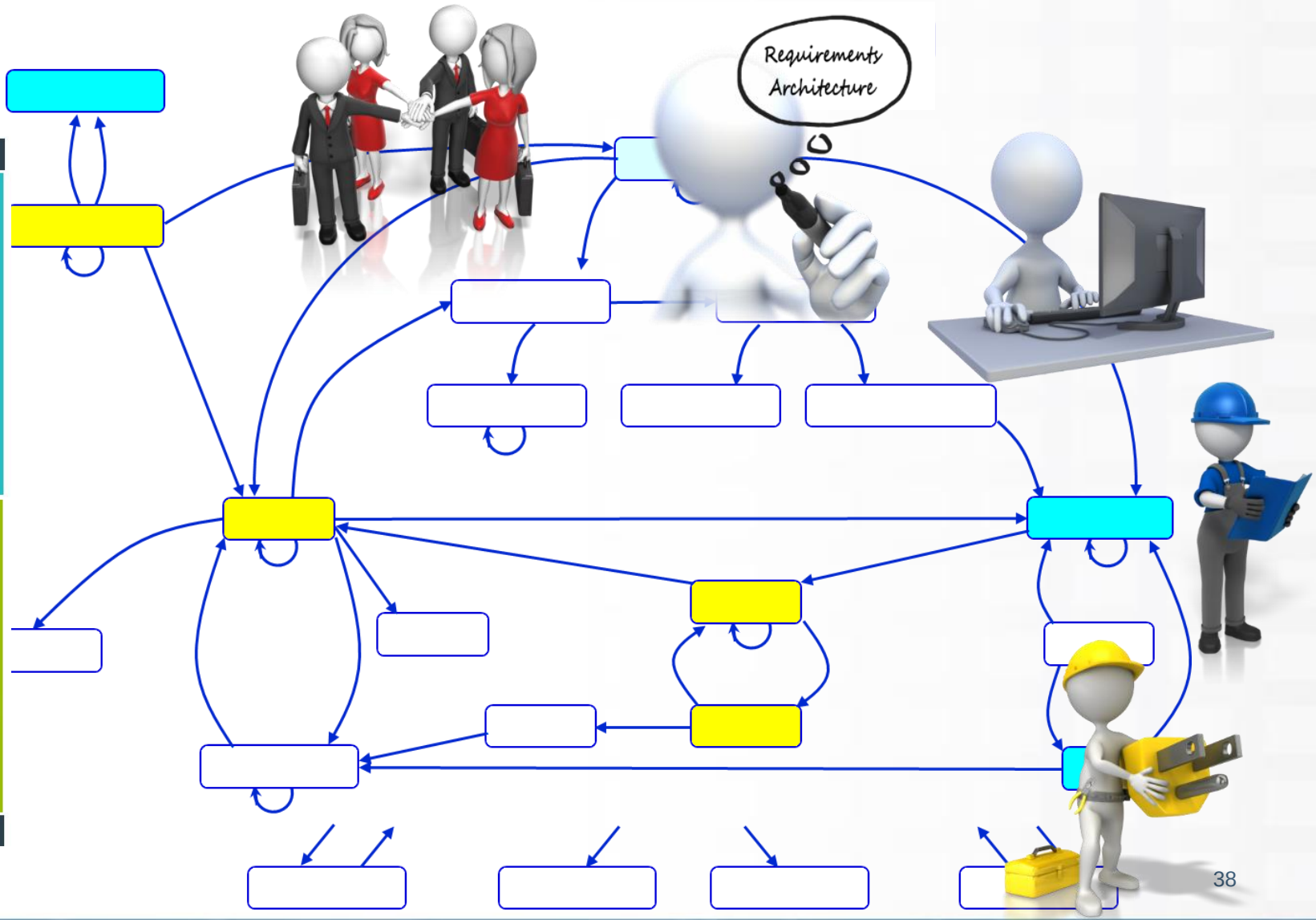

Reimaging Ourselves Step-by-Step

1. Understand the changing context
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4. Embrace our true scope
5. Become a discipline
6. Lead for a better tomorrow

Including Others by Reawakening the Fundamental Mindset

SYSTEMS ENGINEERING Research Center | HELIX

Important Characteristics of Effective Systems Engineers

1. **Paradoxical Mindset**
   - Big Picture Thinking *and* Attention to Detail
   - Strategic *and* Tactical
   - Analytic *and* Synthetic
   - Courageous *and* Humble
   - Methodical *and* Creative

2. **Effective Communication**
   - Modes *(oral and written; good speakers and listeners)*
   - Audience *(bridge between problem domain and solution domain)*
   - Content *(social, managerial, technical)*
   - Purpose *(understanding needs, negotiation, information brokering, technical arbitration, driving consensus)*

3. **Flexible Comfort Zone**
   - Open Minded
   - Rational Risk Taking
   - Multidisciplinary
   - Enjoys Challenges

4. **Smart Leadership**
   - Quick Learning and Abstraction
   - Knowing when to stop
   - Focused on 'Vision' for System
   - Ability to Connect the Dots
   - Patience

5. **Self Starter**
   - Curiosity
   - Passionate and Motivated
   - Eager to Learn

ix Workshop, Washington DC July 23, 2014

Helix Credit: Art Pyster, Deva Henry, Nicole Hutchison. Steven Institute of Technology, 2014

SYSTEMS ENGINEERING IS BROADLY APPLICABLE

- Systems thinking is used by many.
- Systems engineering is understood and embraced by all engineers.

- Systems engineering is a career for a few.

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Plotting the Journey: Engineer the Product, the Organization, and the Change

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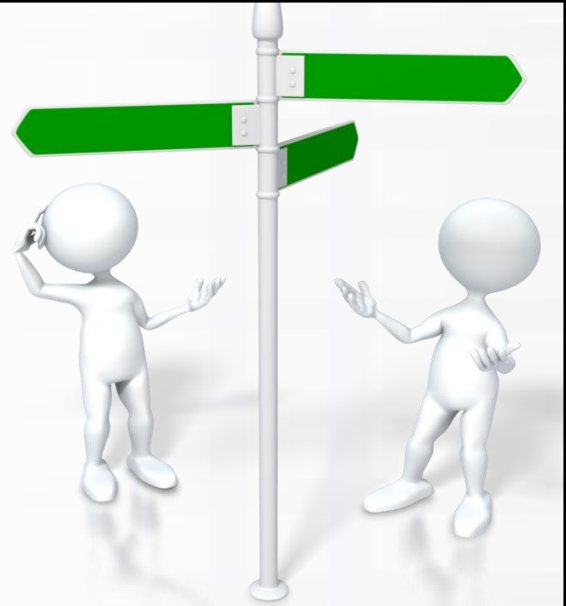
Leading the Change:
From Customers to the C-Level



- Drive better solutions through holistic understanding of the problem and the context / environment
- Move the conversation from cost to value
- Highlight the risk of unintended consequences (but don't apply scare tactics)
- Sell through attunement, buoyancy, clarity – "To Sell is Human"
- Connect and integrate – individuals, organizations, and technologies
- Champion and teach the systems perspective at every turn

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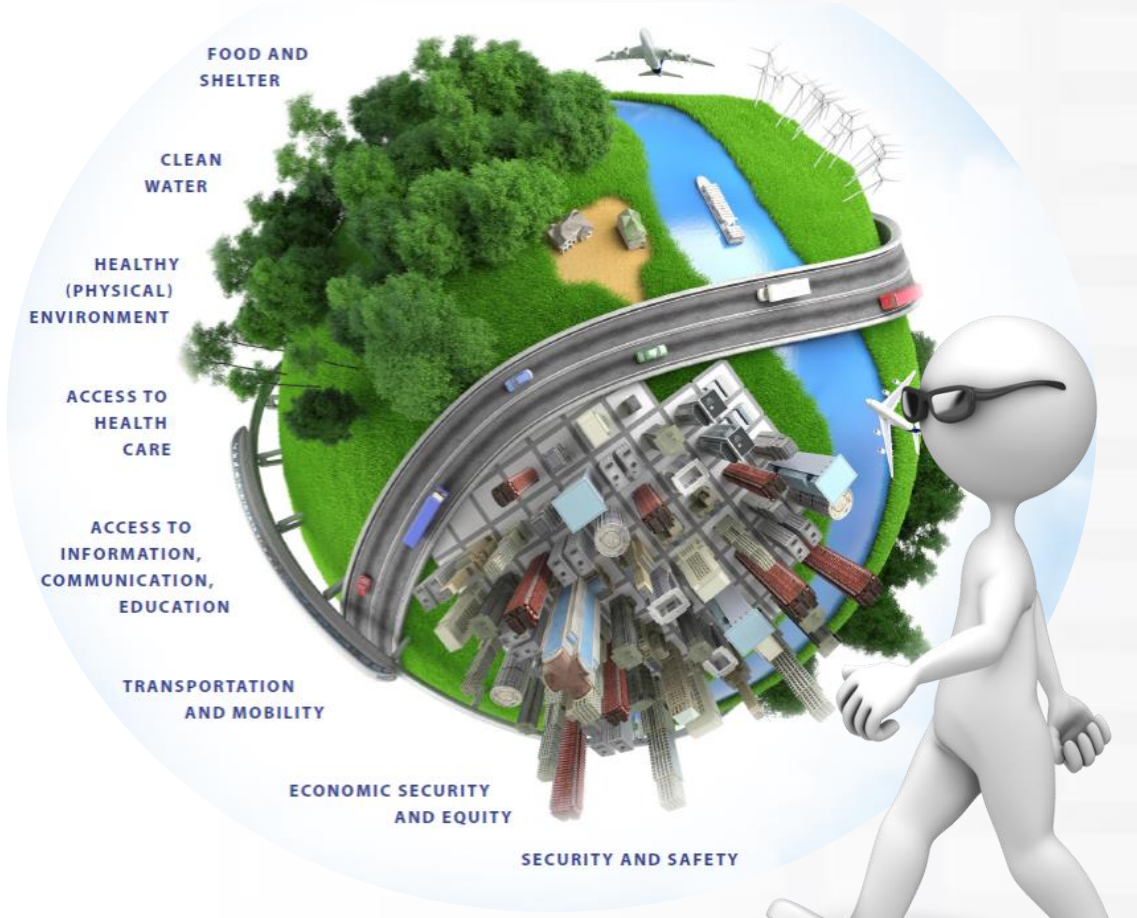
Reimagining SE for 21st Century Needs: Choosing Promise over Peril



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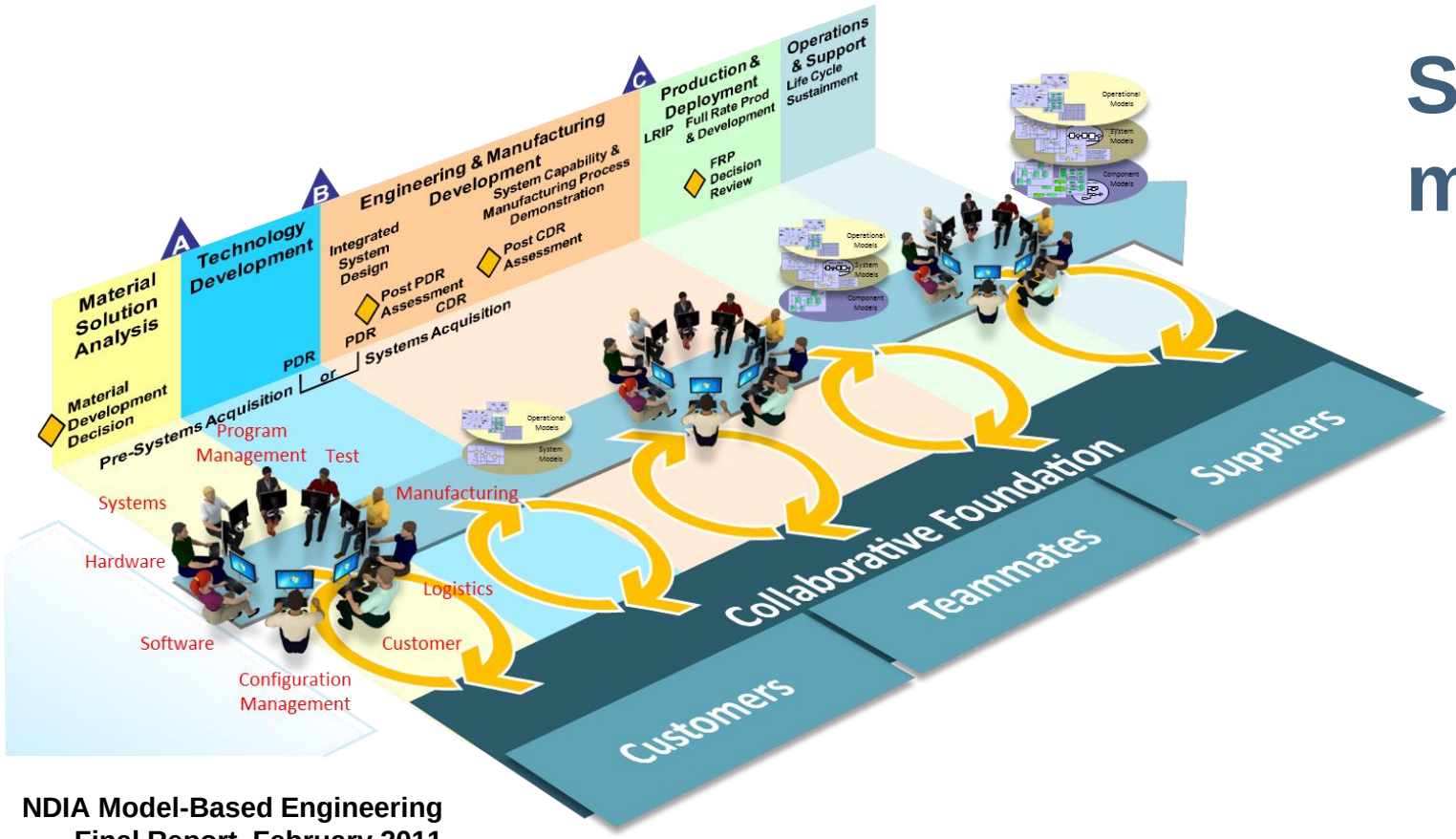
Engineering the Engineering of Systems: From Problem Definition through Capability Retirement



NDIA Model-Based Engineering Final Report, February 2011

Systems engineering must live above the silos

seeing the overlaps

addressing the gaps

defining the seams

preserving the why

Applying Our Practices to Ourselves and the Journey – Accidental, Assembled, or Engineered?

Develop into a discipline which is

knowledge-based,

value-centric, and

fit-for-purpose

in the collaborative engineering of systems

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Questions

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Insight through integration

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