SYSTEMS ENGINEERING RESEARCH CENTER

Georgia Institute of Technology

THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

Enterprise Systems-of-Systems Model for Digital Thread Enabled Acquisition

Sponsor: DASD(SE)

By

Tom McDermott (Stevens)

Molly Nadolski (Ga Tech), Paul Collopy (UAH), Chris Paredis (GT/Clemson)

SoSECIE Webinar Series

April 30, 2019

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10 YEARS of SERC

Agenda

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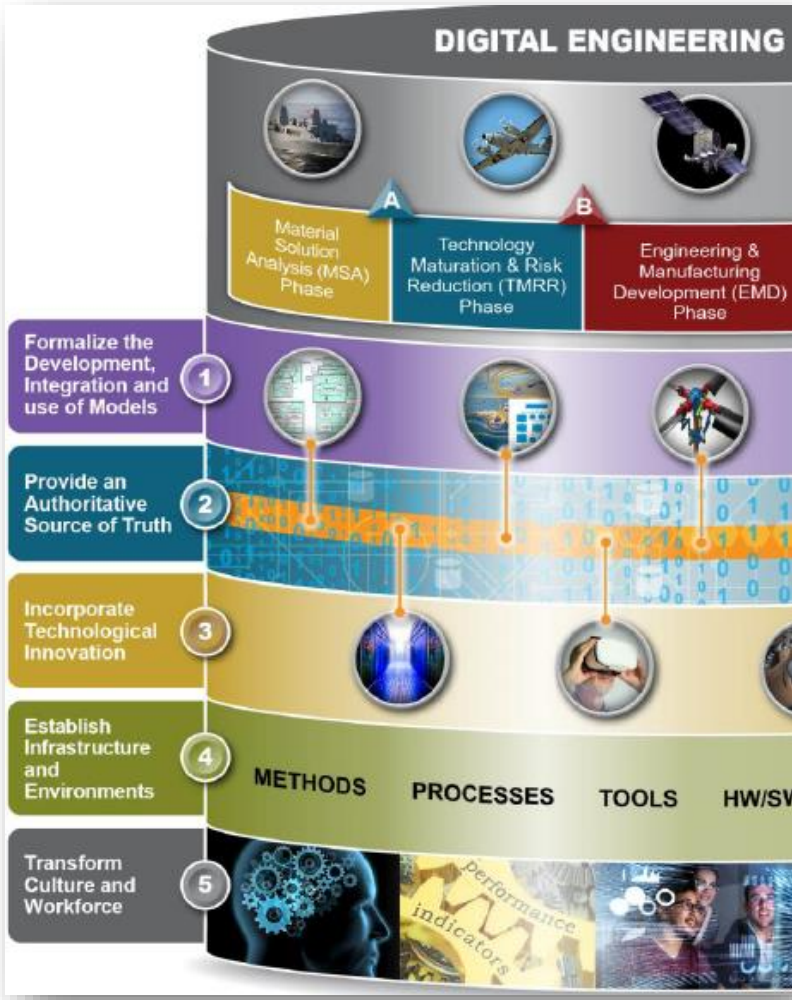
SERC Project RT-182 Digital Thread Enabled Acquisition



- Introduction
- Methodology: Multi-level Sociotechnical Modeling & Enterprise Systems Analysis
- Systemigrams
- Outcomes & Next Steps

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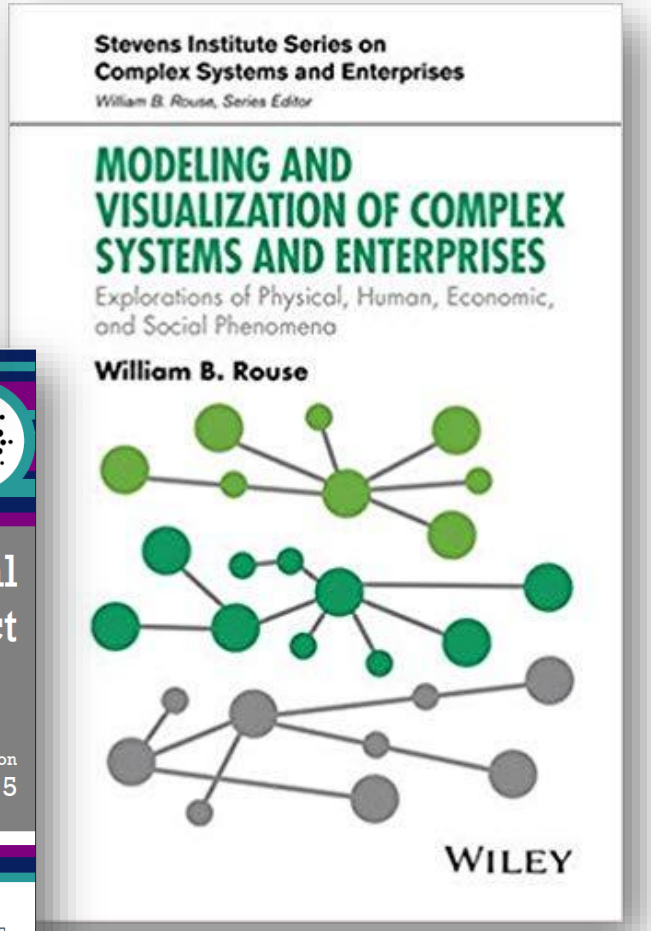
Background

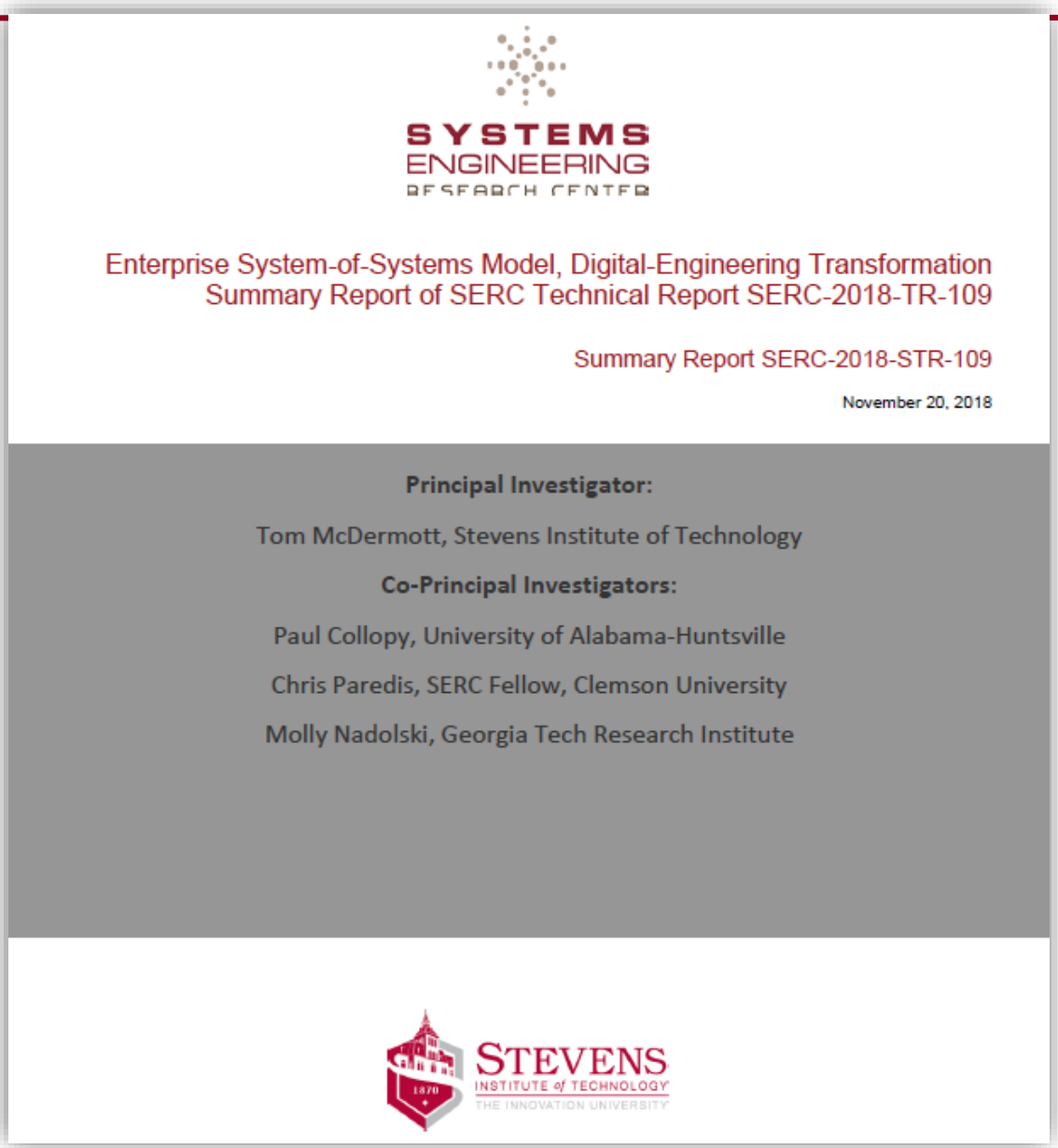


SERC Project RT-182 Digital Thread Enabled Acquisition

This research was conducted to evaluate the impacts of DE on current DoD acquisition enterprise processes. The following questions guided the research:

- What changes are likely to emerge from the transition to DE processes, methods, and tools?
- What are the enablers and barriers to such innovation in the DoD acquisition enterprise?
- What stakeholders will be affected and how will they likely embrace or oppose change?
- How might stakeholders be incentivized to embrace innovation and how will this be measured?
- What are the leading and long-term indicators of change?
- How might the value of such changes be predicted and measured?

Read Our Report



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Enterprise System-of-Systems Model, Digital-Engineering Transformation
Summary Report of SERC Technical Report SERC-2018-TR-109

Summary Report SERC-2018-STR-109

November 20, 2018

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Chris Paredis, SERC Fellow, Clemson University

Molly Nadolski, Georgia Tech Research Institute

STEVENS INSTITUTE of TECHNOLOGY
THE INNOVATION UNIVERSITY

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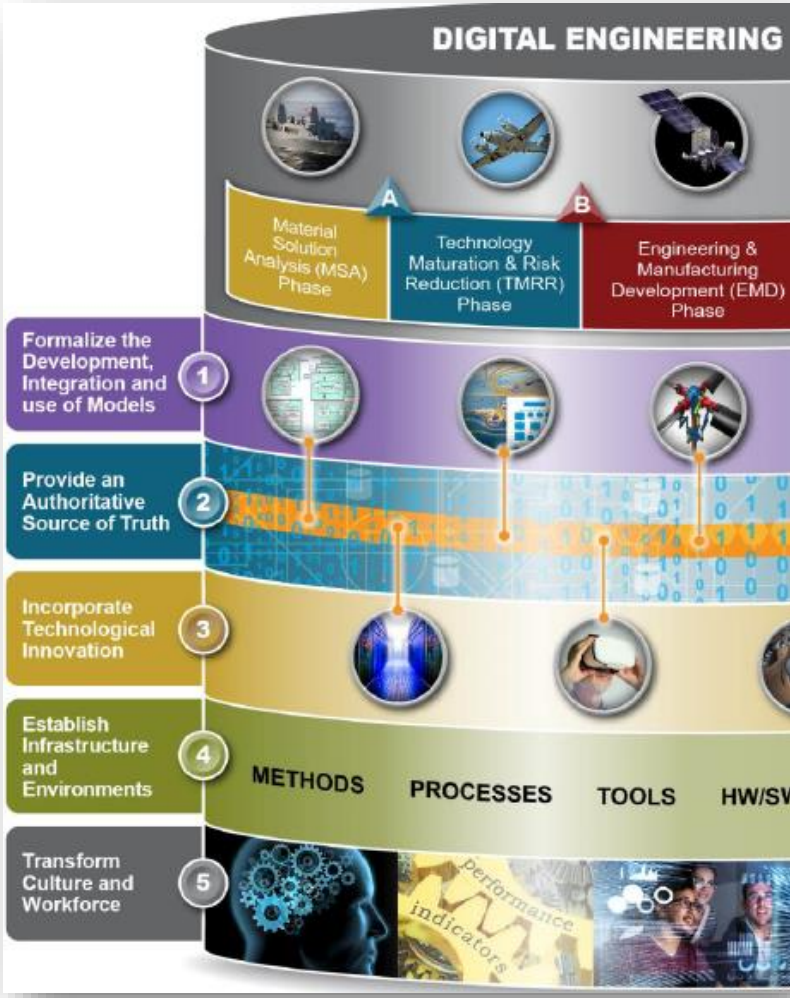

Enterprise SoS Process

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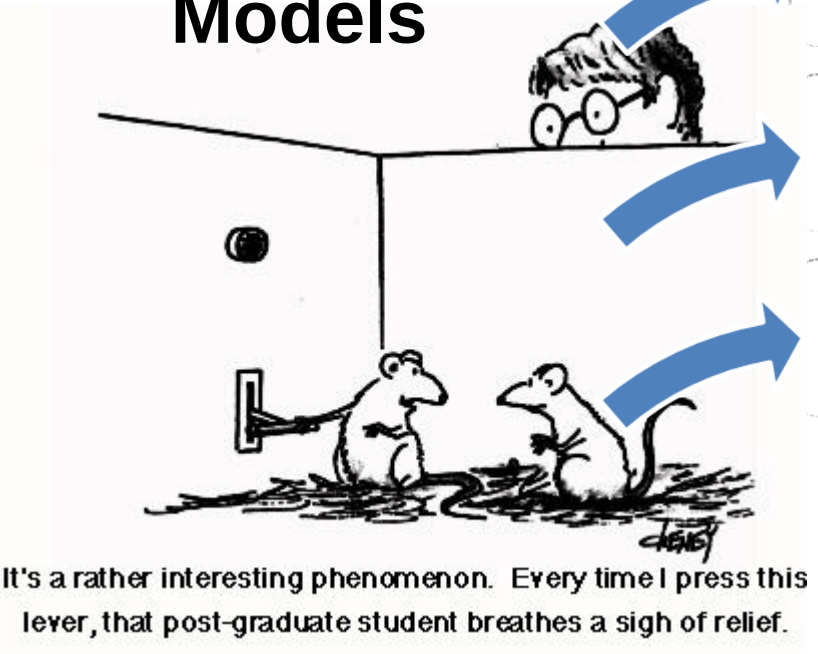
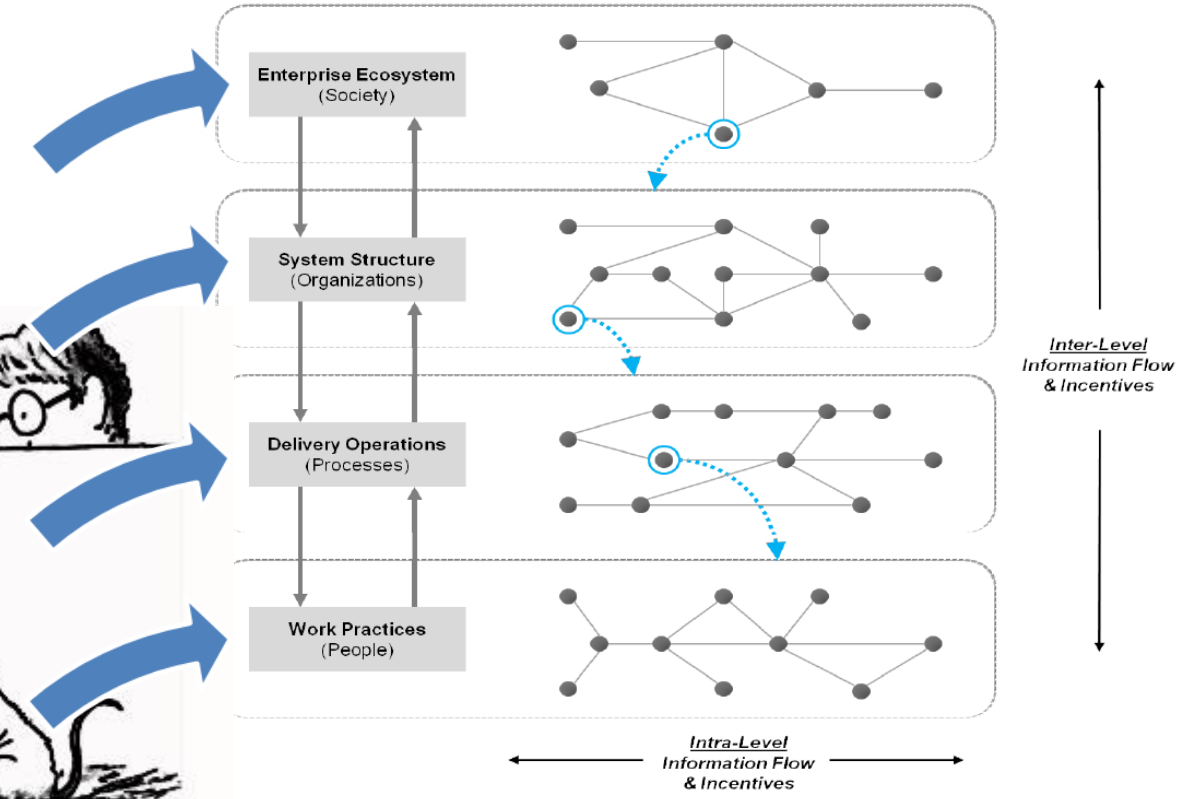
Multi-Level Models

Descriptive Models



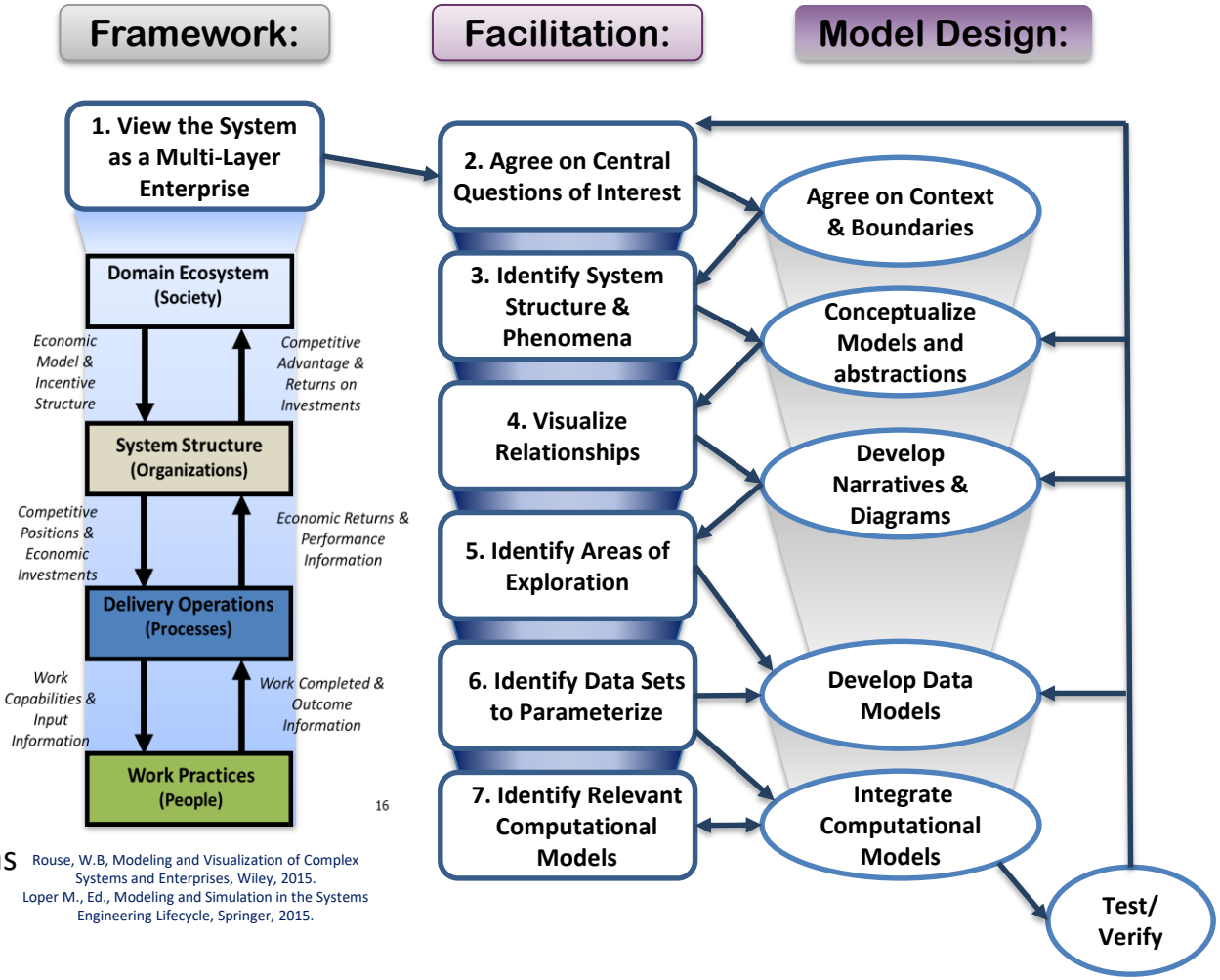
Graphic: smumn.edu/facpages/dbucknam/rat_cartoon.jpg



Graphic: W. Rouse & M. Pennock, Complex Enterprise Systems, 5th Annual SERC Sponsor Research Review February 25, 2014

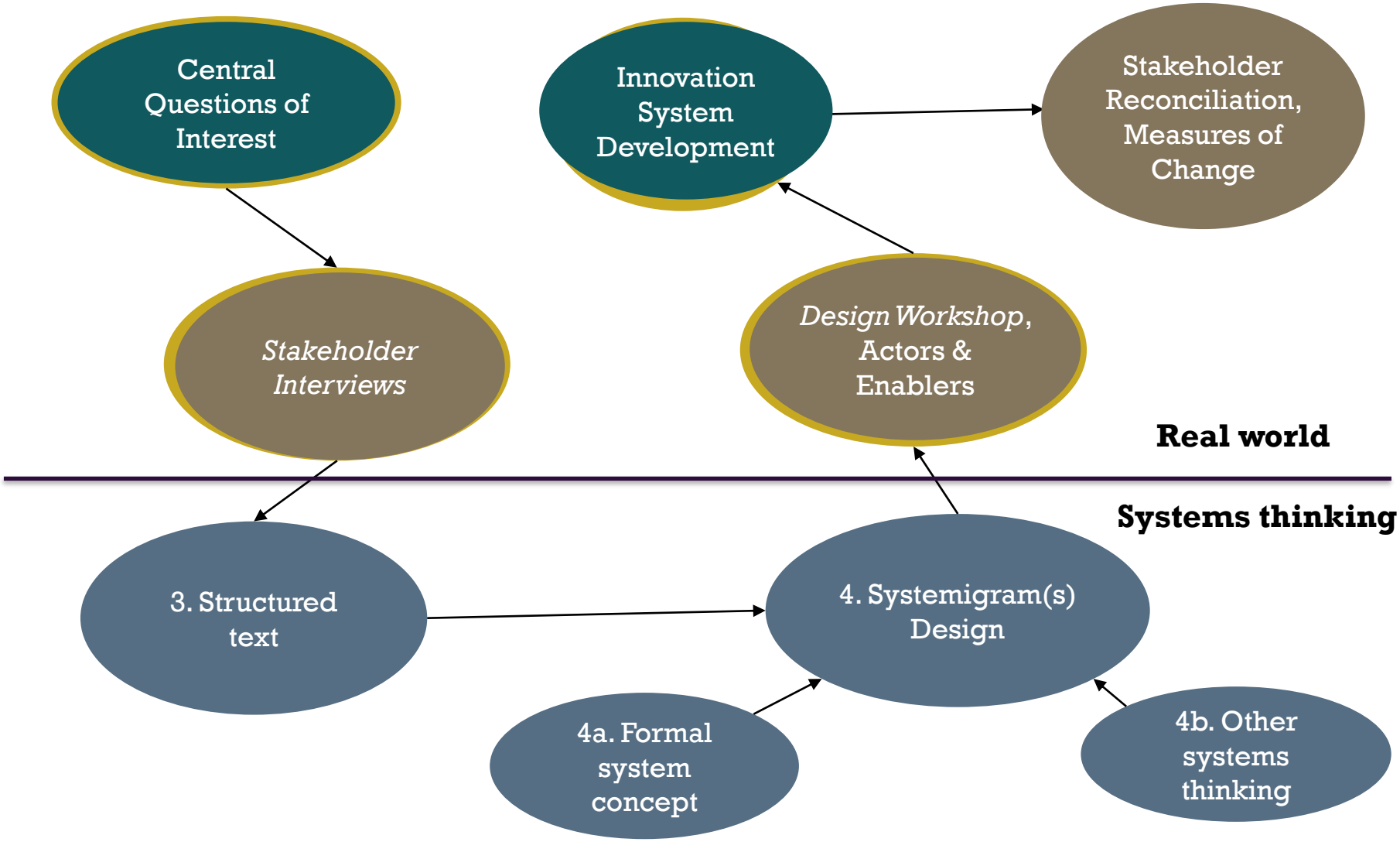
Full Process & Project Scope

1. **Context Analysis**
2. **Central Questions of Interest**
3. **Identify System Structure & Phenomena**
   - Background Research
   - Interviews
4. **Visualize Relationships**
   - Systemigram Narratives & Diagrams
5. **Identify Areas of Exploration**
   - Innovation System Analysis
   - Key stakeholders
   - Critical enablers & barriers to change
6. **Identify Data Sets to Parameterize**
   - What are the measurement areas that will drive change?
   - What measures are collected versus what should be collected



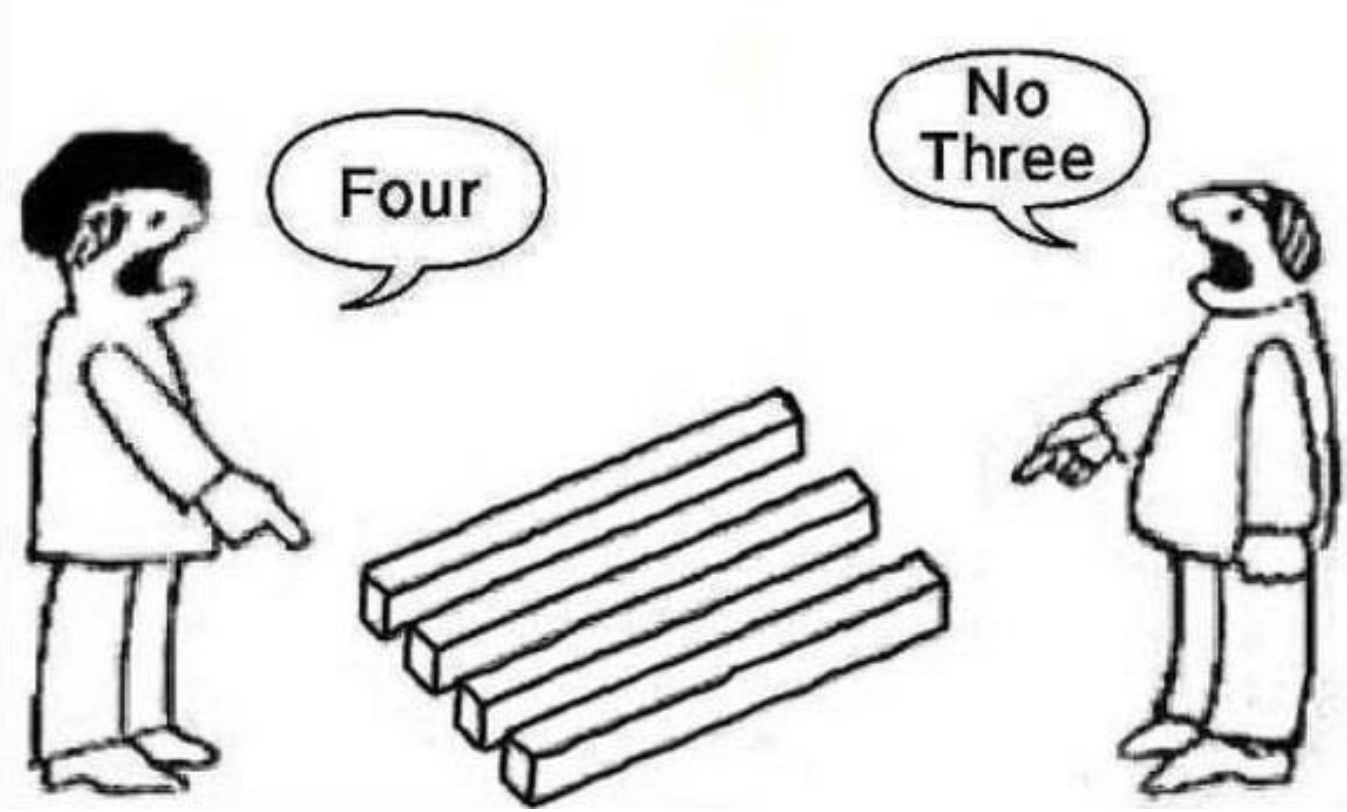
Rouse, W.B, Modeling and Visualization of Complex Systems and Enterprises, Wiley, 2015.
Loper M., Ed., Modeling and Simulation in the Systems Engineering Lifecycle, Springer, 2015.

In Practice: Enterprise Systemigrams



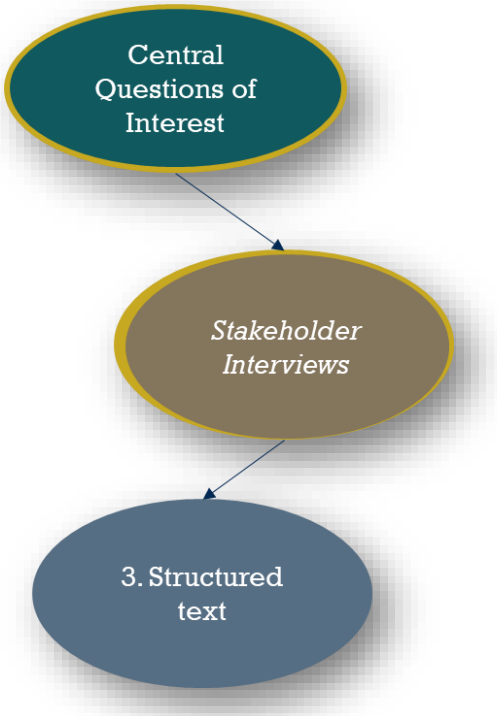
A qualitative stakeholder-driven process to produce quantitative goals

SoS Perspectives



Stakeholder Interviews & Research

- 15 Project Visits Completed, 25 People Interviewed
  - DASD/SE
  - Aerospace Corp
  - JHU APL
  - SAF/AQ
  - Army PM-Aviation
  - Army Future Vertical Lift Program Office
  - Ground-Based Strategic Deterrent Program Office
  - SPAWAR San Diego
  - TARDEC
  - J8 JCIDS office
  - DOT&E
  - NASA-Langley
  - NASA-Marshall
  - JPL



- Also:
  - ~50 documents reviewed
  - 6 facilitated meetings with DASD/SE team

Interview Process

Actors

The Present:
What cannot be sustained in the future we seek

The Future:
What characteristics of the system we aspire to create

The Transformation:
The zone of innovation, signals of the future in the present

Resources

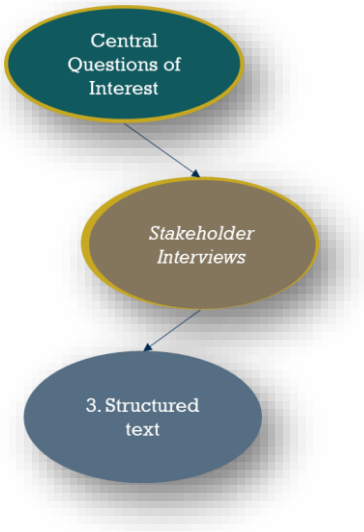
Technological Resources:
Tools and the knowledge to use them

Human Resources and Training Opportunities:
Trained people who can put science, technology, and innovation to work for problem solving

Institutional and Infrastructure Resources:
Organizations or functions that provide the structure and collective knowledge needed to innovate

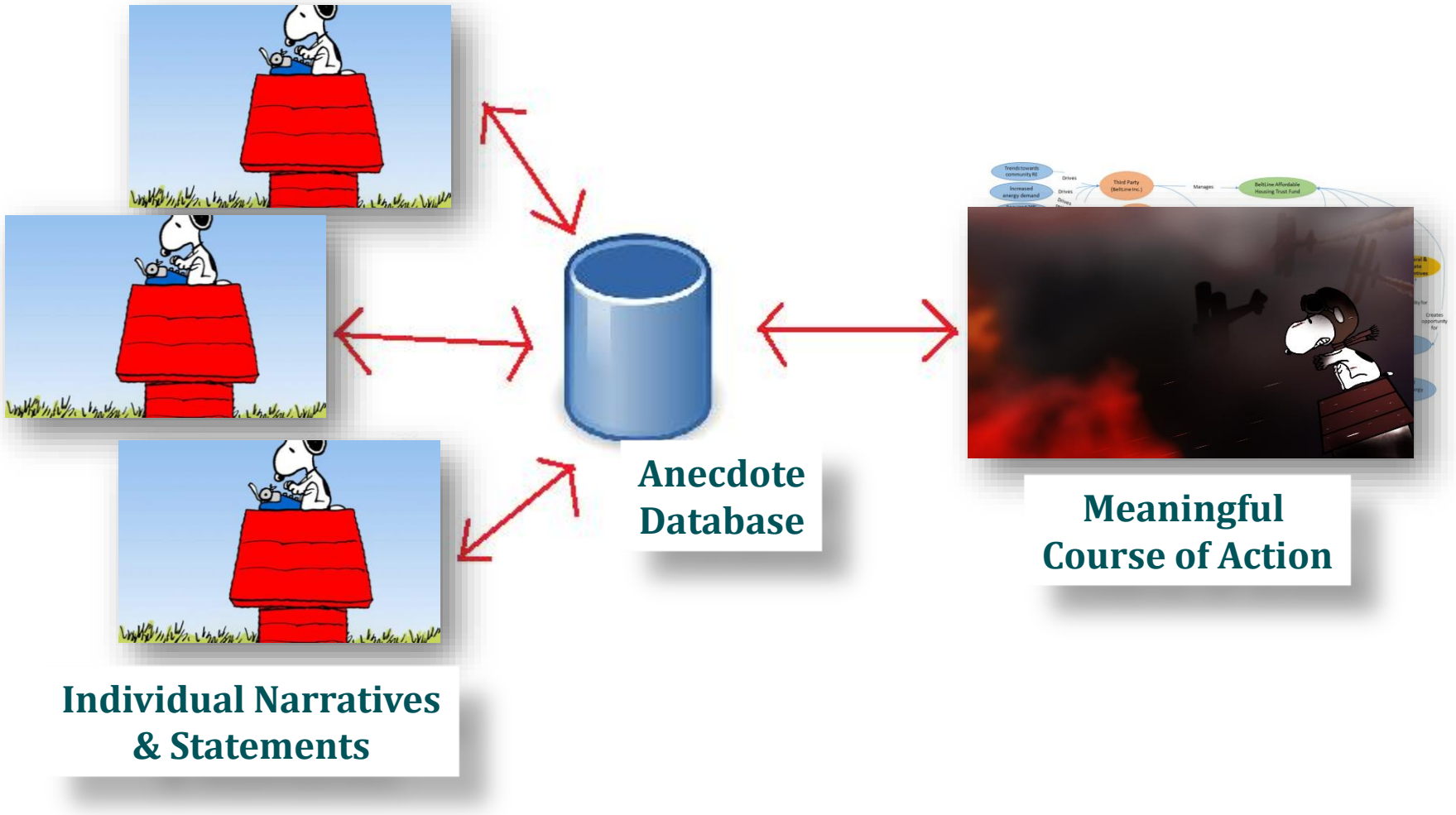
Collaboration & Communication Resources:
Connections among parts of the system that diffuse knowledge and enable learning

Knowledge Resources:
Information embedded in research, indigenous knowledge, intellectual property, etc.



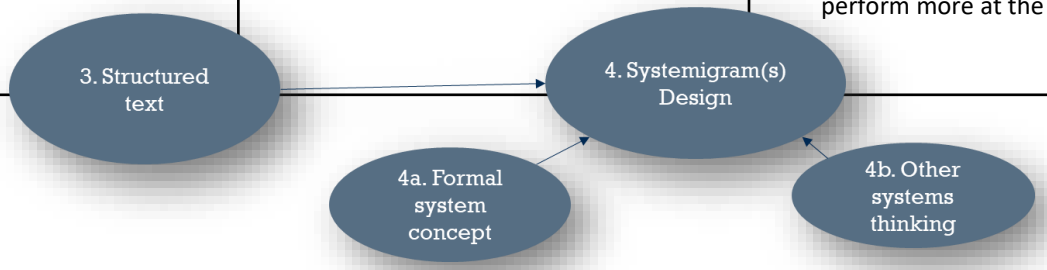
Storytelling and Narrative

storytelling and mapping tools to describe the future as a conceptual model



Context Analysis (Selected Phrases)

	Enabling Environment	Key Actors & Resources	Interactions/Activities	Outcomes/Outputs
Domain	• Operational Context – increasing complexity • DoD DE Strategy	• Manufacturing 4.0 drivers • Global innovation in DE	• Curate models across domains, fidelity, phases and the lifecycle	• **Goal 1: Formalize the development, integration and use of models to inform enterprise and program decision making** • Map the realm of the possible with warfighter needs
Institutions	• Develop, mature, and use IT infrastructures • Define and govern authoritative source of truth	• INCOSE and other professional organizations	• Digital program documents • Enterprise owns the ontology and data layer for analytical approaches • Libraries of reusable models • Pay once for data, reuse everywhere	• **Goal 2: Provide an enduring authoritative source of truth (AST)** • **Goal 4: Establish a supporting infrastructure and environment**
Processes	• Lexicon, taxonomies, ontologies • Paperless system and technical information	• Communities: Standards, guides • Communicators/ matchmakers • Model governance/version control mgmt. • Better informed Decision makers	• Digital twin that injects data back into the models • System data accessible from a single portal • Eliminate human process of finding and using data • Everything needed is on desktop, what's been done before is there to reuse	• **Goal 3: Incorporate technical innovations to improve the engineering practice** • opportunities that can be gained from deeper information in the AST • make the process more efficient and reduce rework • capture and maintain lessons learned
People	• Comfort with technology • Usability of DE methods & tools • Organizational and cultural resistance • Learning systems that adapt to individual abilities	• Leadership & messaging • Older vs younger workforce • Human capital - skills • A-Teams & B/C-Teams - performance	• Enhance collaboration • Humans can focus on creative work and machines can take care of mundane tasks • Understand incremental value of all trades, done dynamically	• **Goal 5: Transform Culture and Workforce** • easier to ingest new processes and incorporate acquisition expertise into the tools • make the B-team and C-team players perform more at the A-Team level



DE Transformation Systemigrams

Workforce and Culture

Much of the discussions around digital thread and digital engineering focuses on the technological and modeling aspects. While those are integral to the changing dynamics and processes, often overlooked is the human role and associated changes, and how it will shift and might change over time, as the broader system seeks to become more agile.

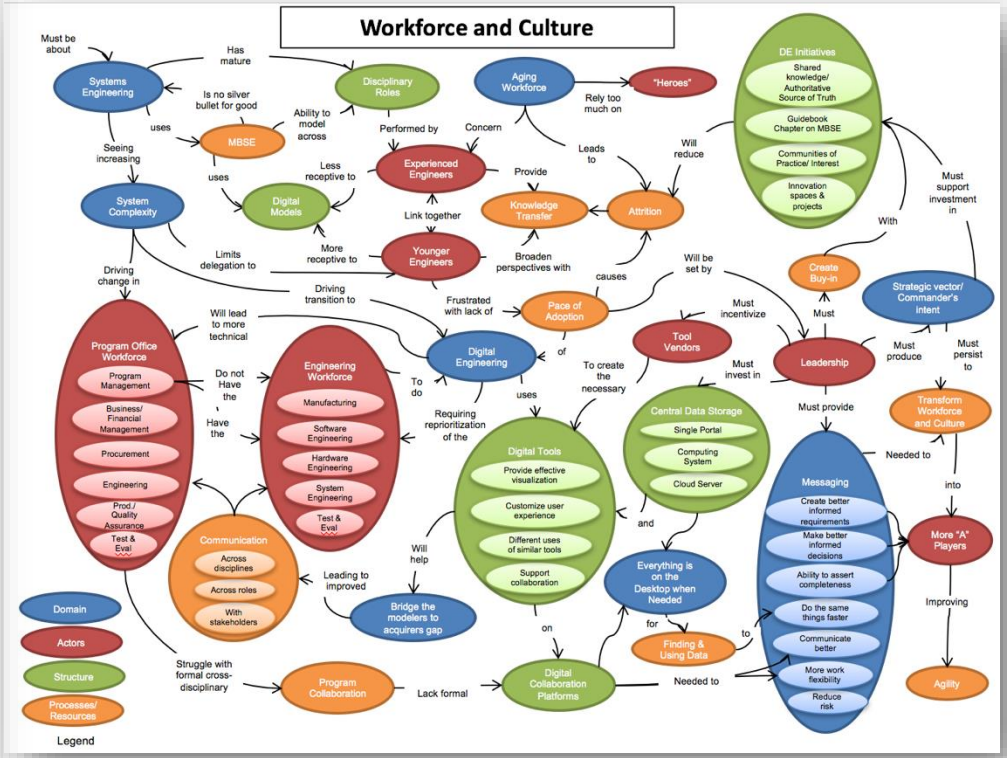
Most stakeholders and experts do agree there is a cultural change at play, along with needs for the workforce to adapt and change with the broader trends at play as well. There are divergences in perspective in regards to what this might look like, the change in the "old guard" to "new guard", whether or not there are workforce capabilities and the "talent" will look like.

DE is a cultural change in and of itself. There are the new tools which bring in digital natives and will be a merger of new technology and existing experience. As such, the workforce shift will be substantial. There will be big struggles to learn new ways. The goal is having the models to feed the decision processes, which requires training of modelers and a new breed of decision makers. However, it's a challenge to get a large group of people to change. Culture change is not done without resistance or done overnight. There is an extraordinary advantage to maintain the status quo and temptation to "do it like how we did last time". Culture change is organizationally dependent and unchangeable.

One of the bigger points of diversion amongst stakeholders is whether or not there is a workforce in place to grapple with the changes at play, and if so, whether there are capabilities to address the changes. On the one hand, DE is done today often times without the realization that is being applied. People who do models do it without thinking about it. However, there lacks the process and culture to bring together the emerging digital natives with grizzled veterans and their domain knowledge.

On the other hand, there is the belief that much of the workforce is an aged workforce that looks back at the way things were done rather than looking to the future. The younger group coming in also has shortfalls. The younger workforce is more skilled in a single discipline rather than a broad perspective. There needs to be an effort to better train the younger workforce to oversee multiple different domains to provide a more robust understanding of digital environment. However, bureaucracy and paperwork make it hard to train due to time constraints. Additionally, there is not enough money or time to train older workforce to train them how to use new tools as well.

This squeeze on resources also impacts the focus on SE, as discipline workforces are less and less SE focused and system implications. Labor is expensive and systems are expensive to implement. There are no expectations to think about larger system aspects from the onset. Hiring managers are worried about finding MBSE workers, but there should be more of an effort place finding systems engineers.



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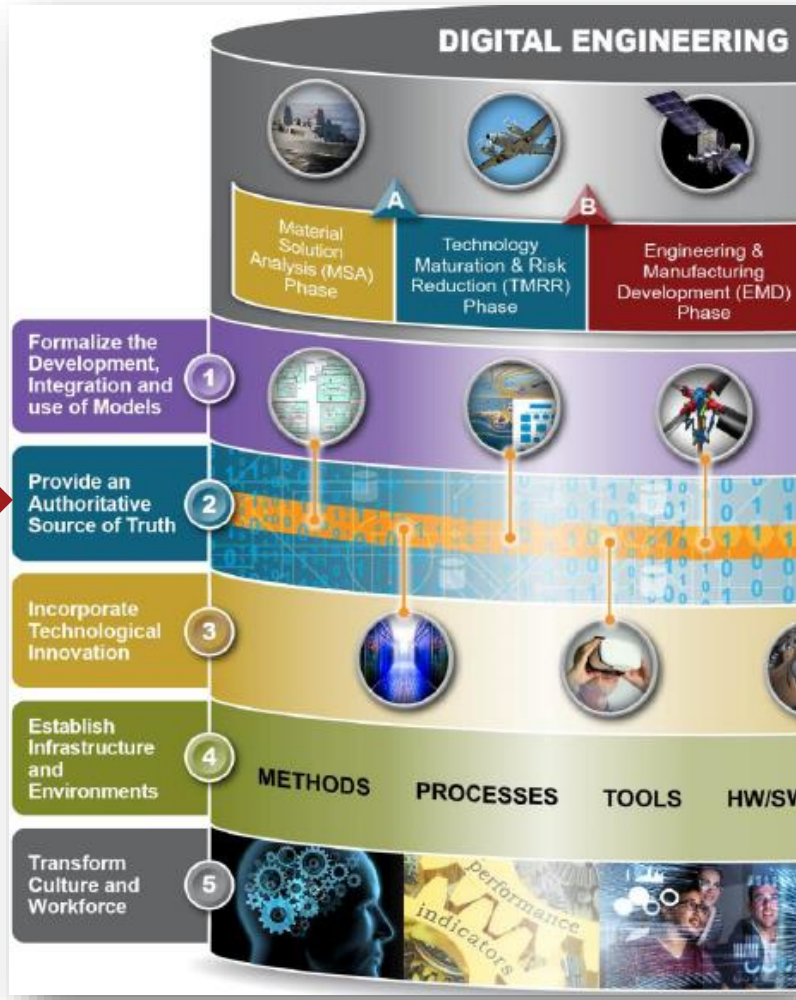

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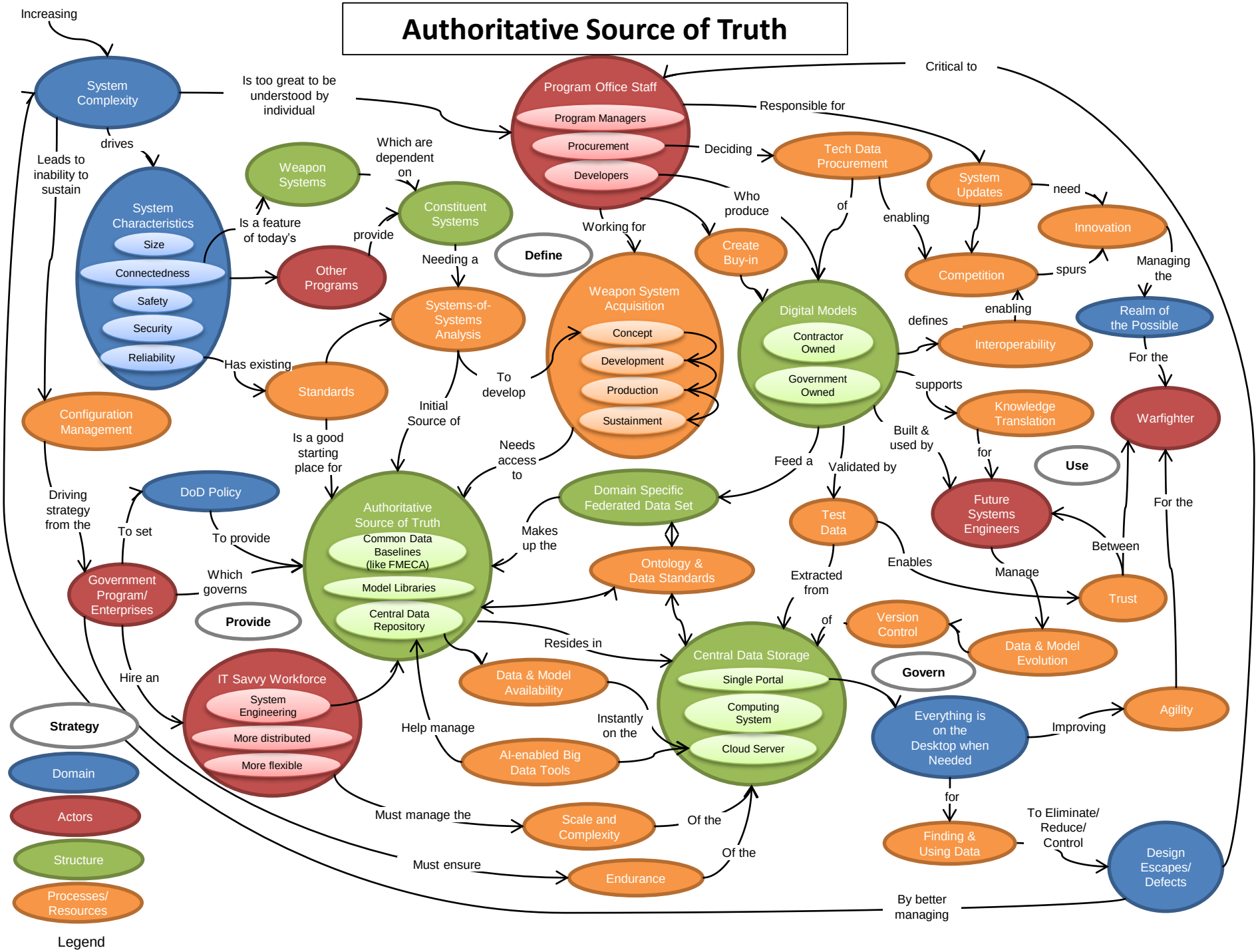

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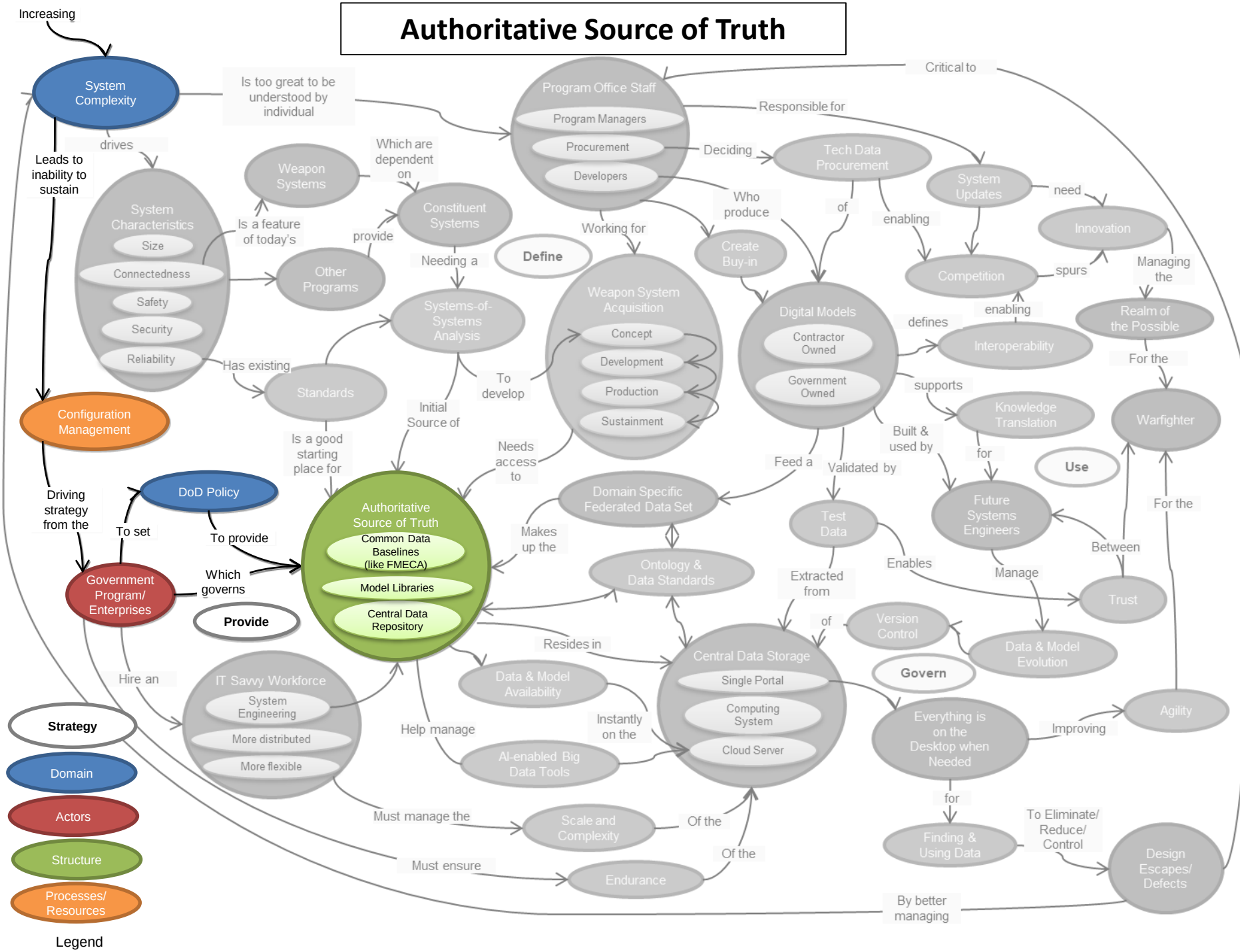

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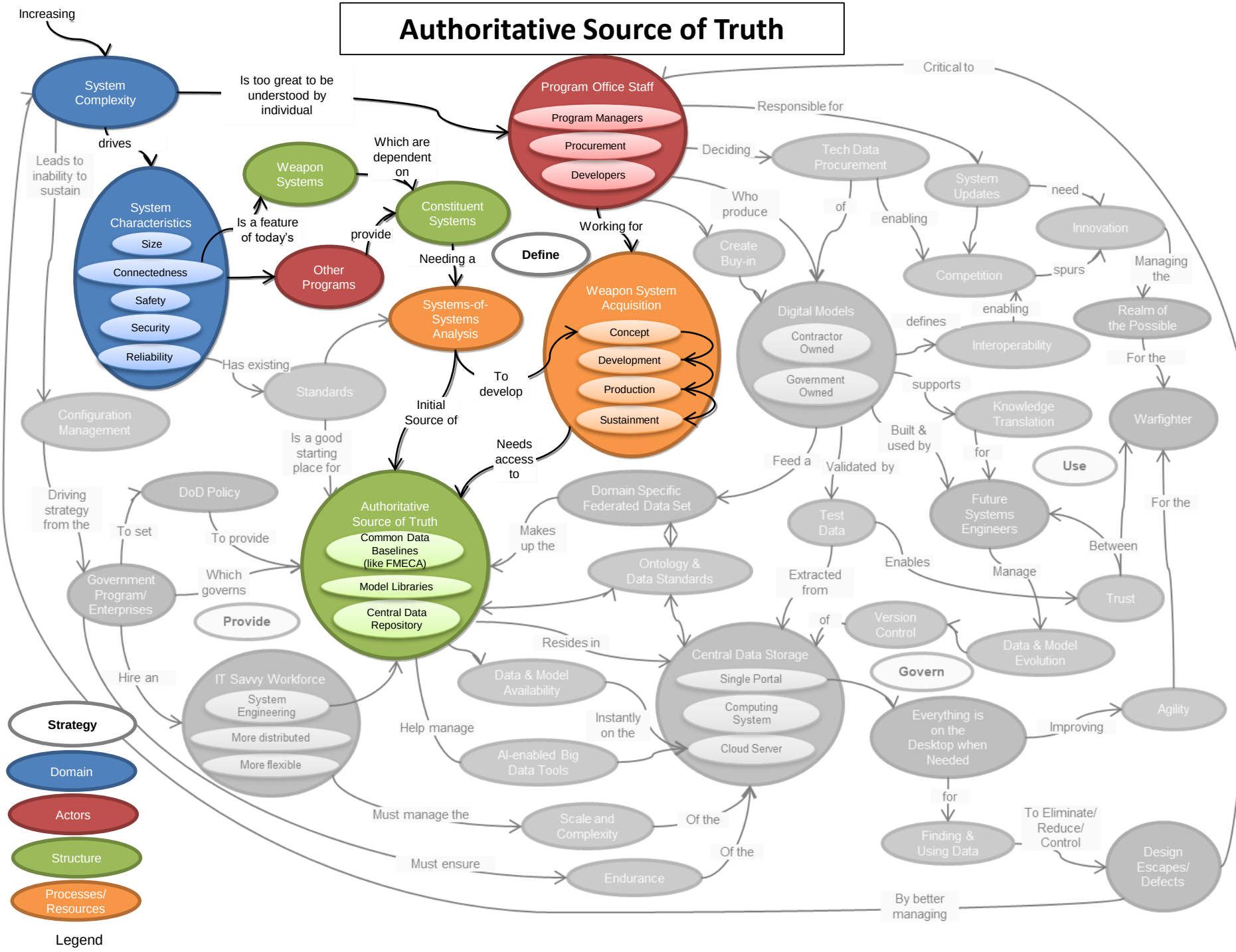

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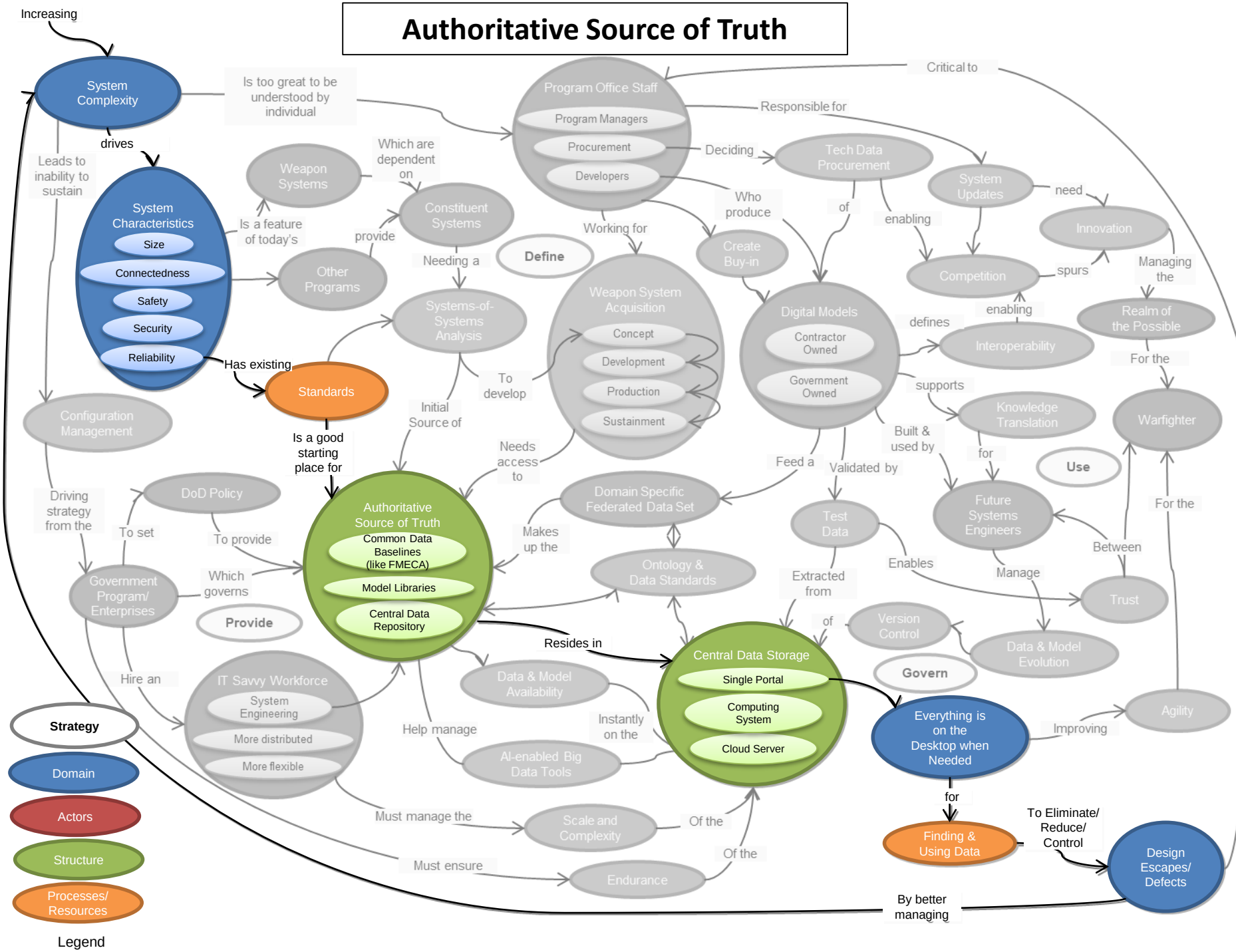

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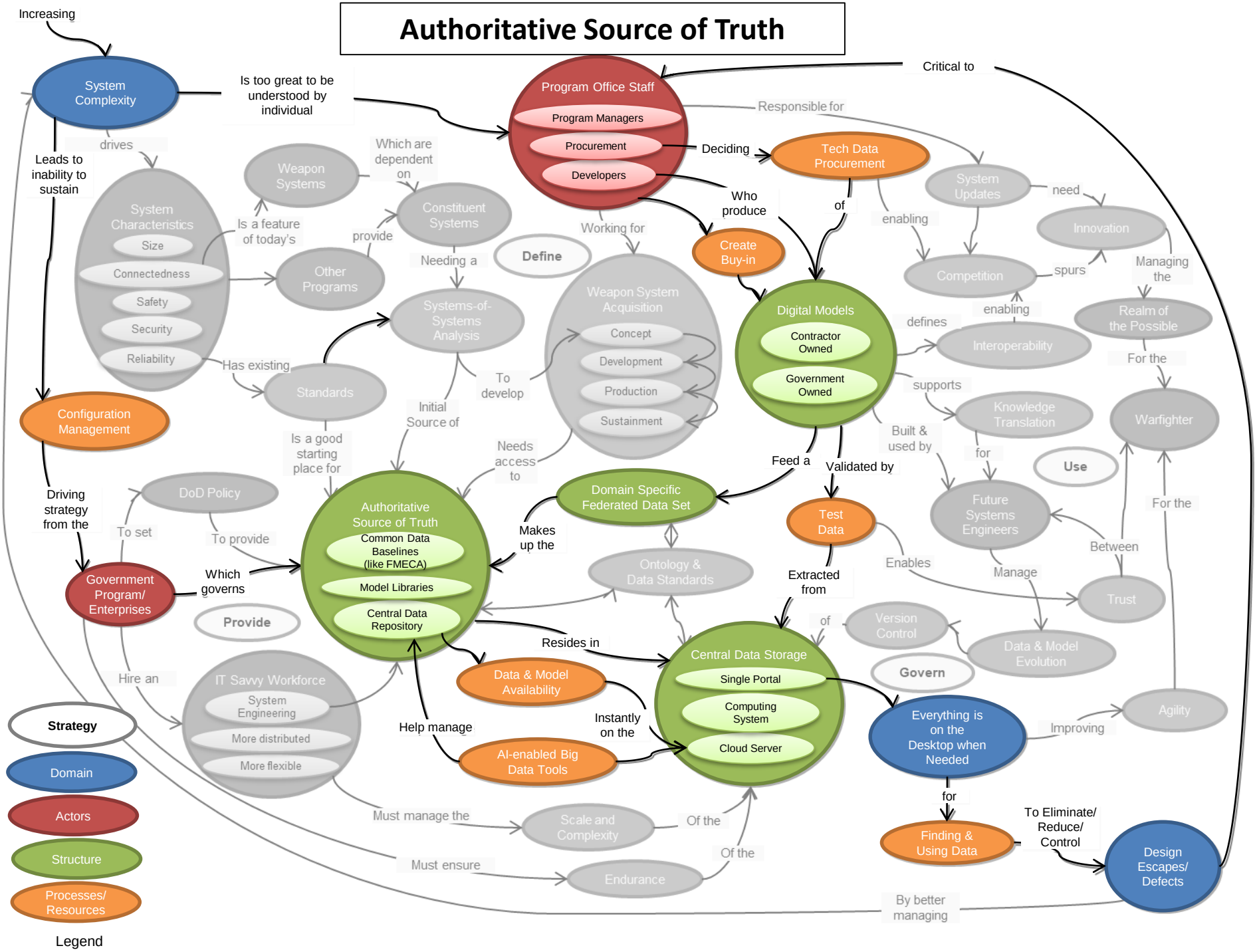

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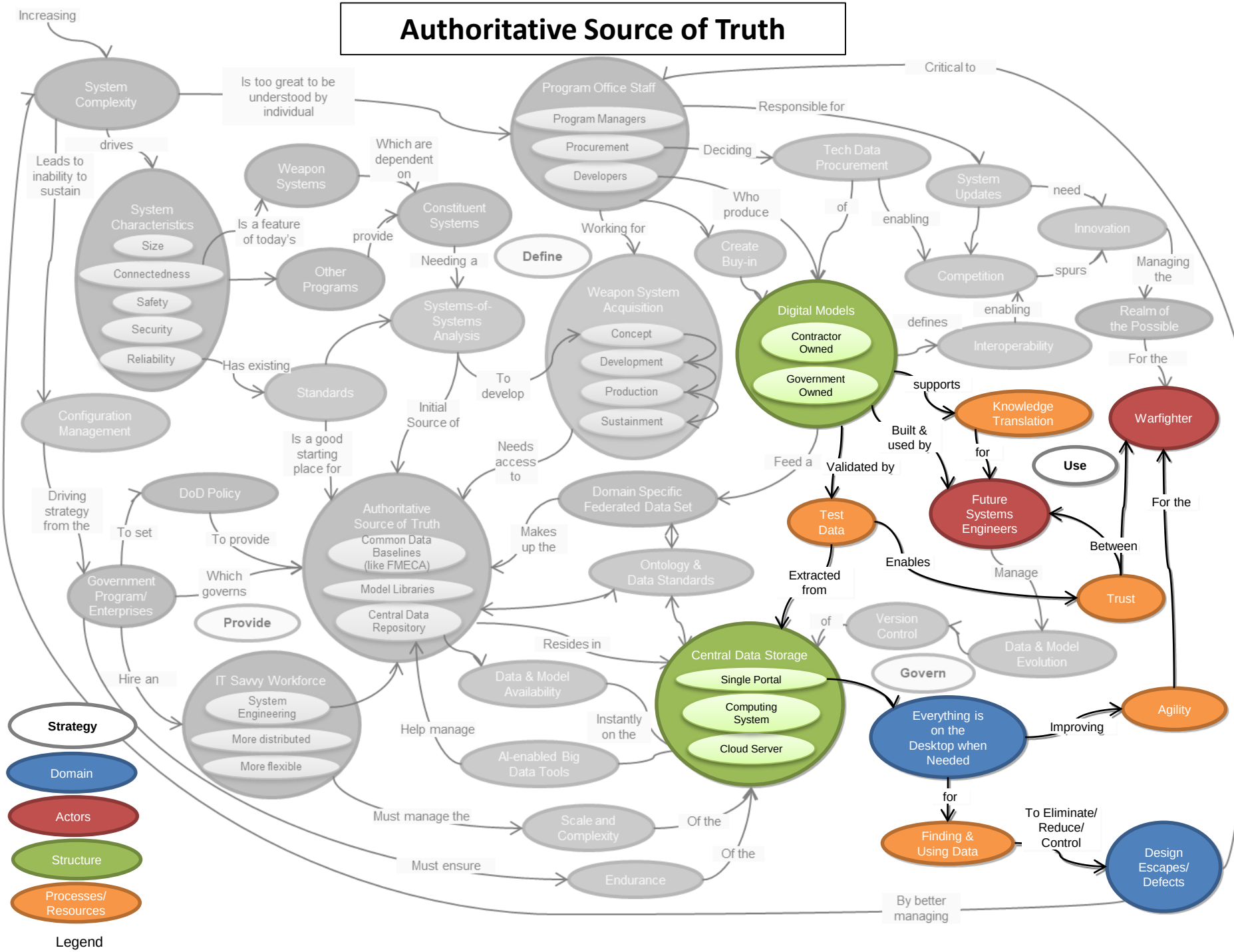

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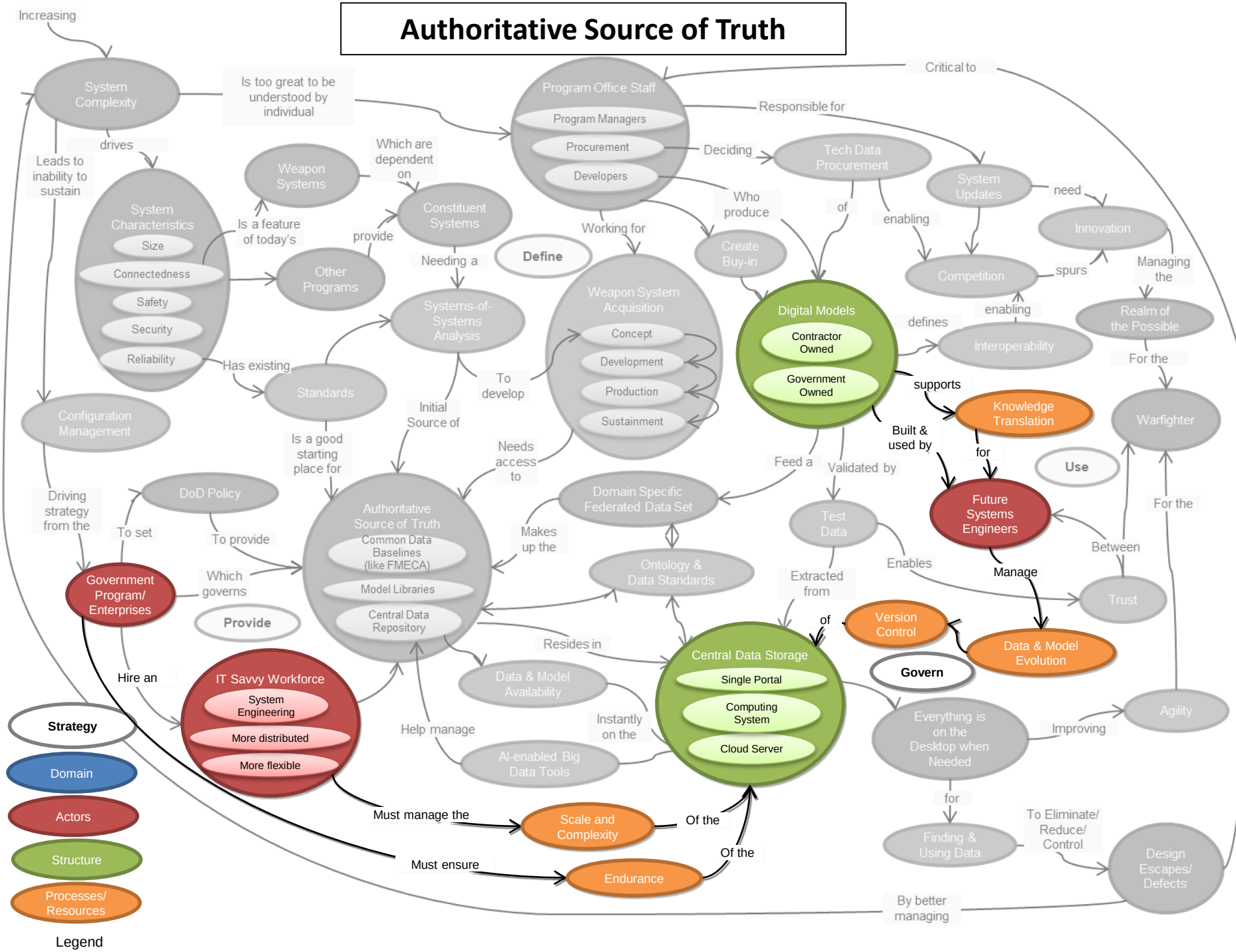

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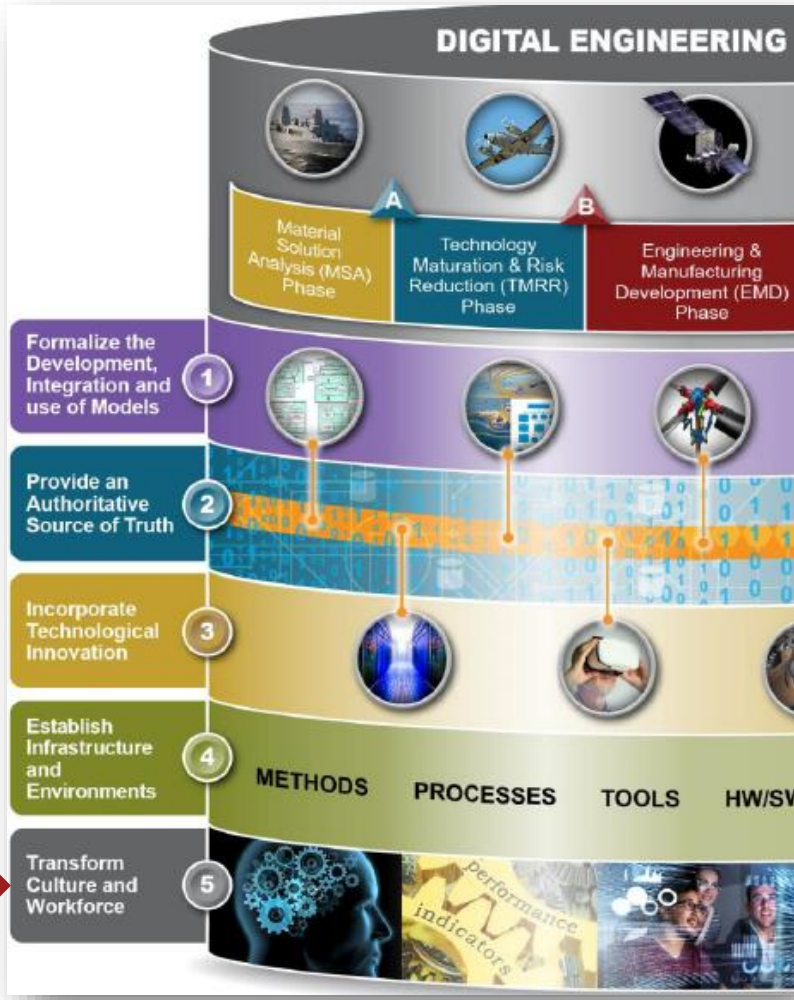

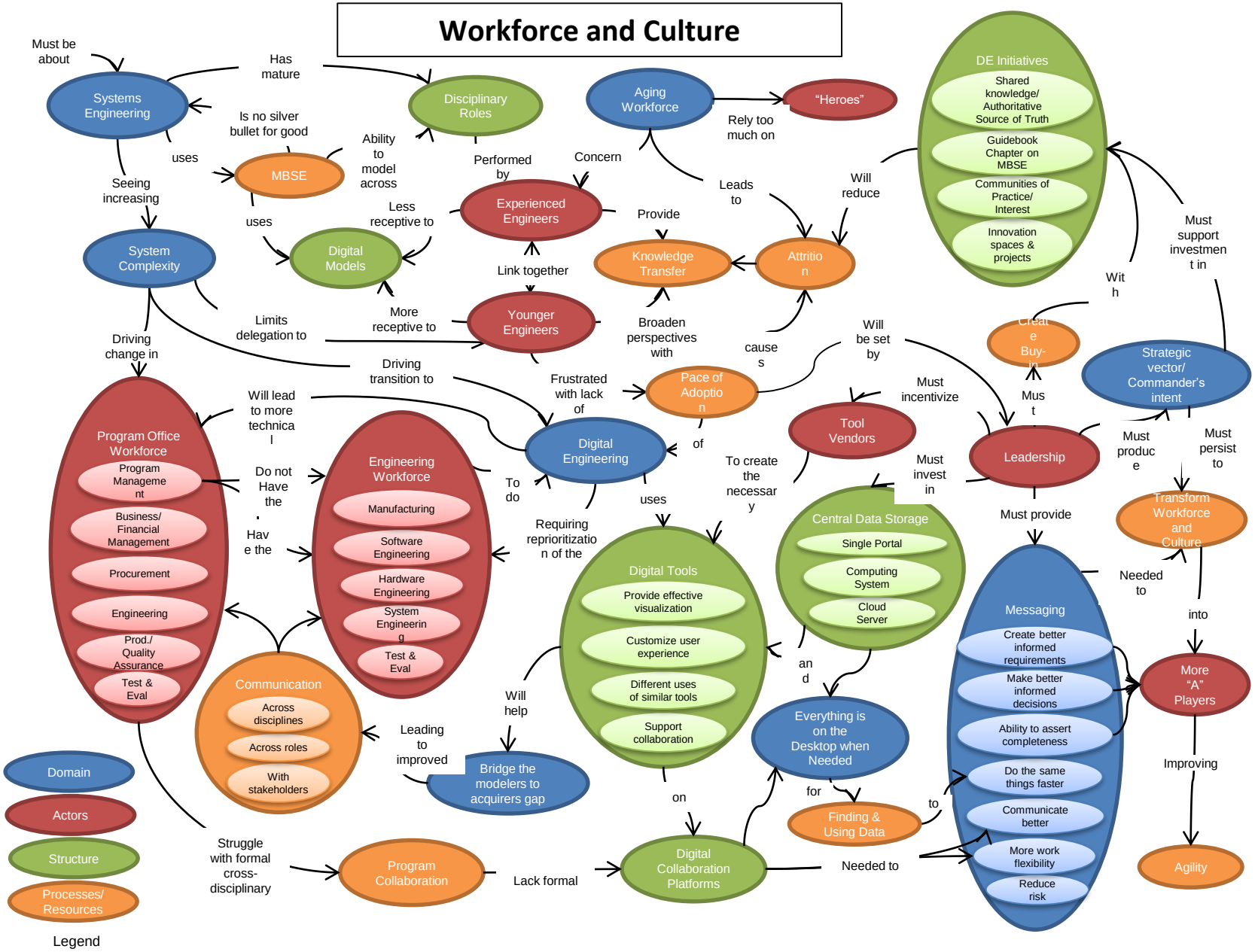
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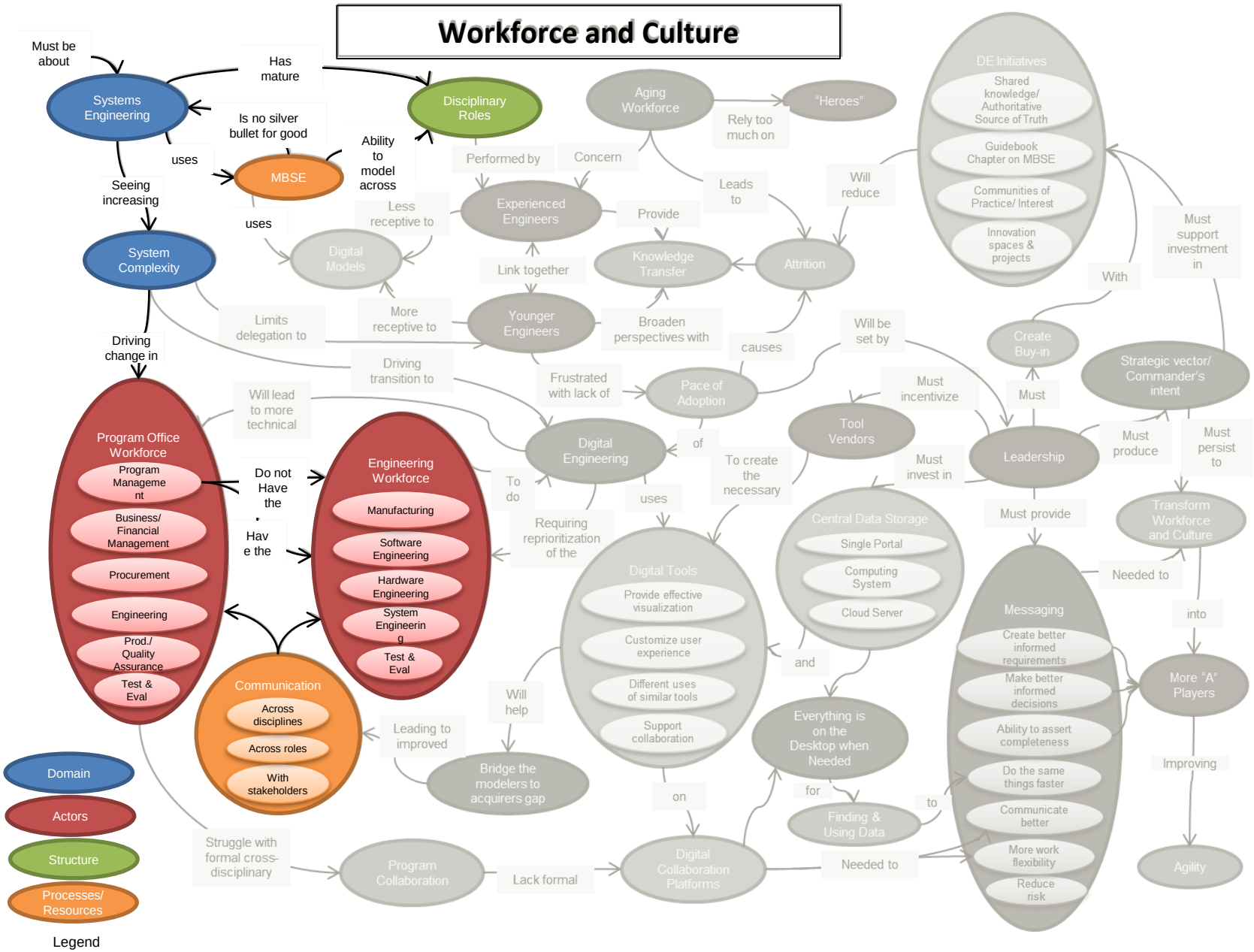
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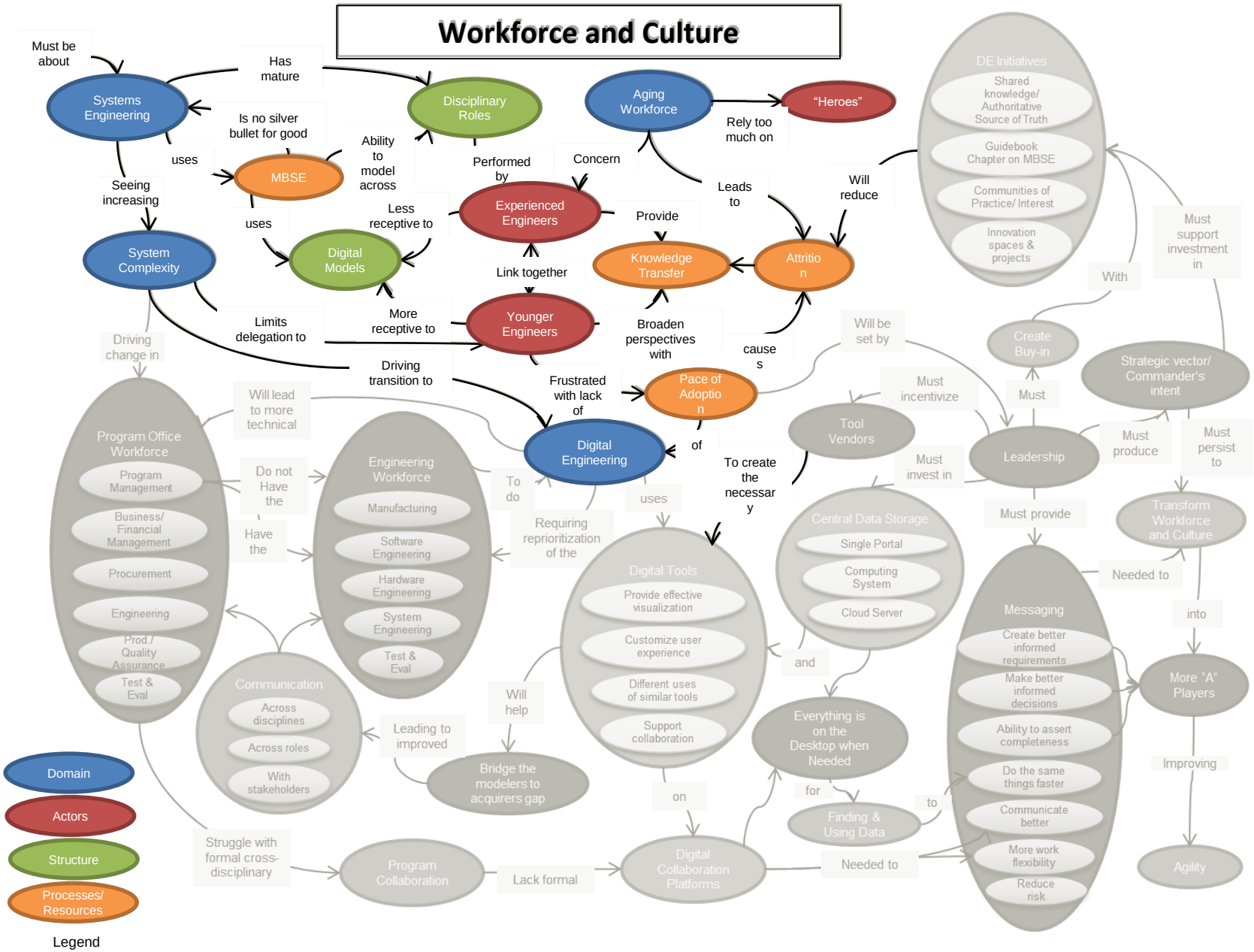
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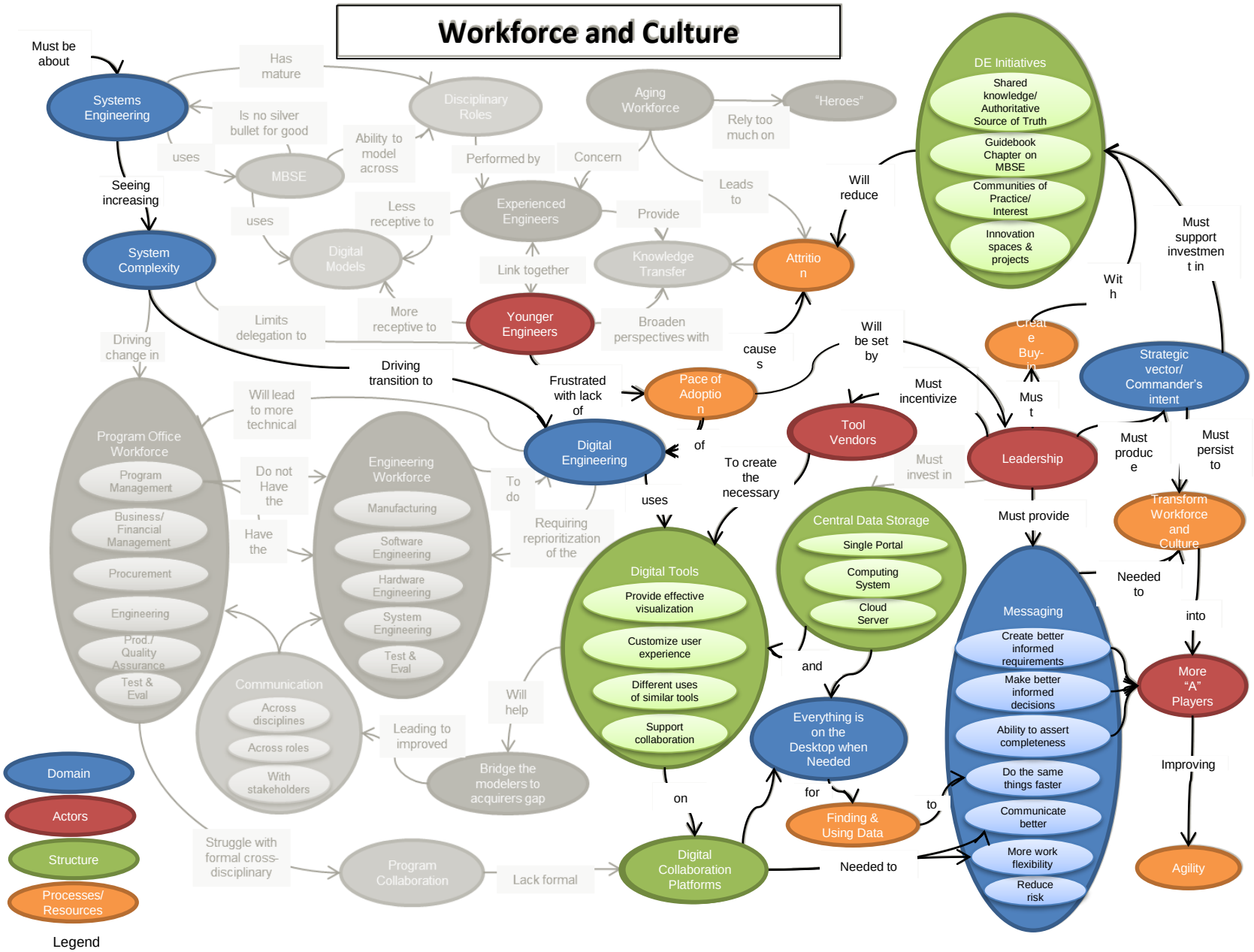
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Guidebook Chapter on MBSE
Communities of Practice/ Interest
Innovation spaces & projects
Must support investmen t in
Wit h
Link together
Younger Engineers
More receptive to
Broaden perspectives with
Limits delegation to
Driving change in
Driving transition to
cause s
Will be set by
Creat e Buy-in
Strategic vector/ Commander's intent
Frustrated with lack of
Pace of Adoptio n
Must incentivize
Mus t
Will lead to more technical
Digital Engineering
of
Tool Vendors
Must invest in
Leadership
Must produc e
Must persist to
Program Office Workforce
Program Management
Business/ Financial Management
Procurement
Engineering
Prod./ Quality Assurance
Test & Eval
Do not Have the
Have the
Engineering Workforce
Manufacturing
Software Engineering
Hardware Engineering
System Engineering
Test & Eval
To do
Requiring reprioritization of the
uses
To create the necessary
Digital Tools
Provide effective visualization
Customize user experience
Different uses of similar tools
Support collaboration
Central Data Storage
Single Portal
Computing System
Cloud Server
Must provide
Transform Workforce and Culture
Needed to
into
Messaging
Create better informed requirements
Make better informed decisions
Ability to assert completeness
Do the same things faster
Communicate better
More work flexibility
Reduce risk
More "A" Players
Improving
Communication
Across disciplines
Across roles
With stakeholders
Leading to improved
Will help
Bridge the modelers to acquirers gap
and
Everything is on the Desktop when Needed
for
Finding & Using Data
to
on
Digital Collaboration Platforms
Needed to
Agility
Struggle with formal cross-disciplinary
Program Collaboration
Lack formal
Domain
Actors
Structure
Processes/ Resources
Legend

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Workforce & Culture

- Most stakeholders and experts do agree there is a cultural change at play
- Divergence in perspective in regards to what this might look like
  - Change in the "old guard" to "new guard", whether or not there are workforce capabilities and the "talent" will look like
- Substantial workforce shift: new tools which bring in digital natives and will be a merger of new technology and existing experience
  - Are there capabilities and resources to address the changes?
  - Tensions between the old and new guard
- Evolution of Systems Engineering and System Modeling roles & methods
- Digital collaboration and access to truth data is a key enabler
- Commitment of leadership is essential
  - Investment, common messaging, safe places to experiment
- What innovations will drive the future DE desktop environment?

Agenda

- Introduction
- Methodology: Multi-level Sociotechnical Modeling & Enterprise Systems Analysis
- Context Background: DE Transformation
- Systemigram; Inform Enterprise and Program Decision Making
- Outcomes & Next Steps

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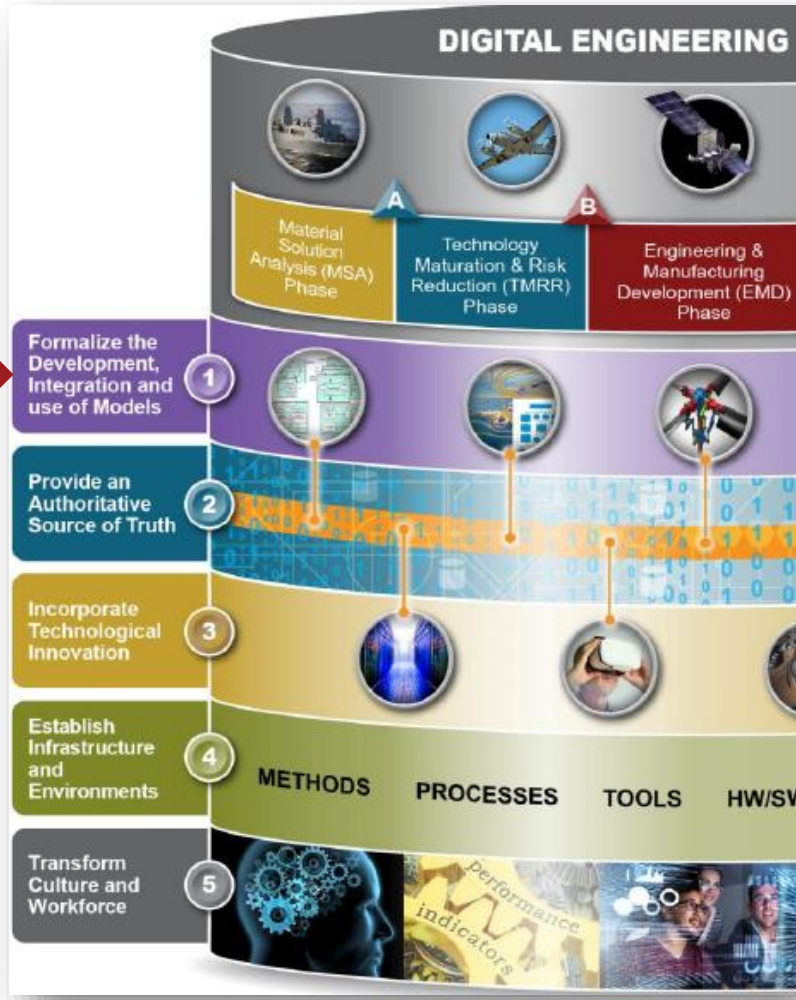
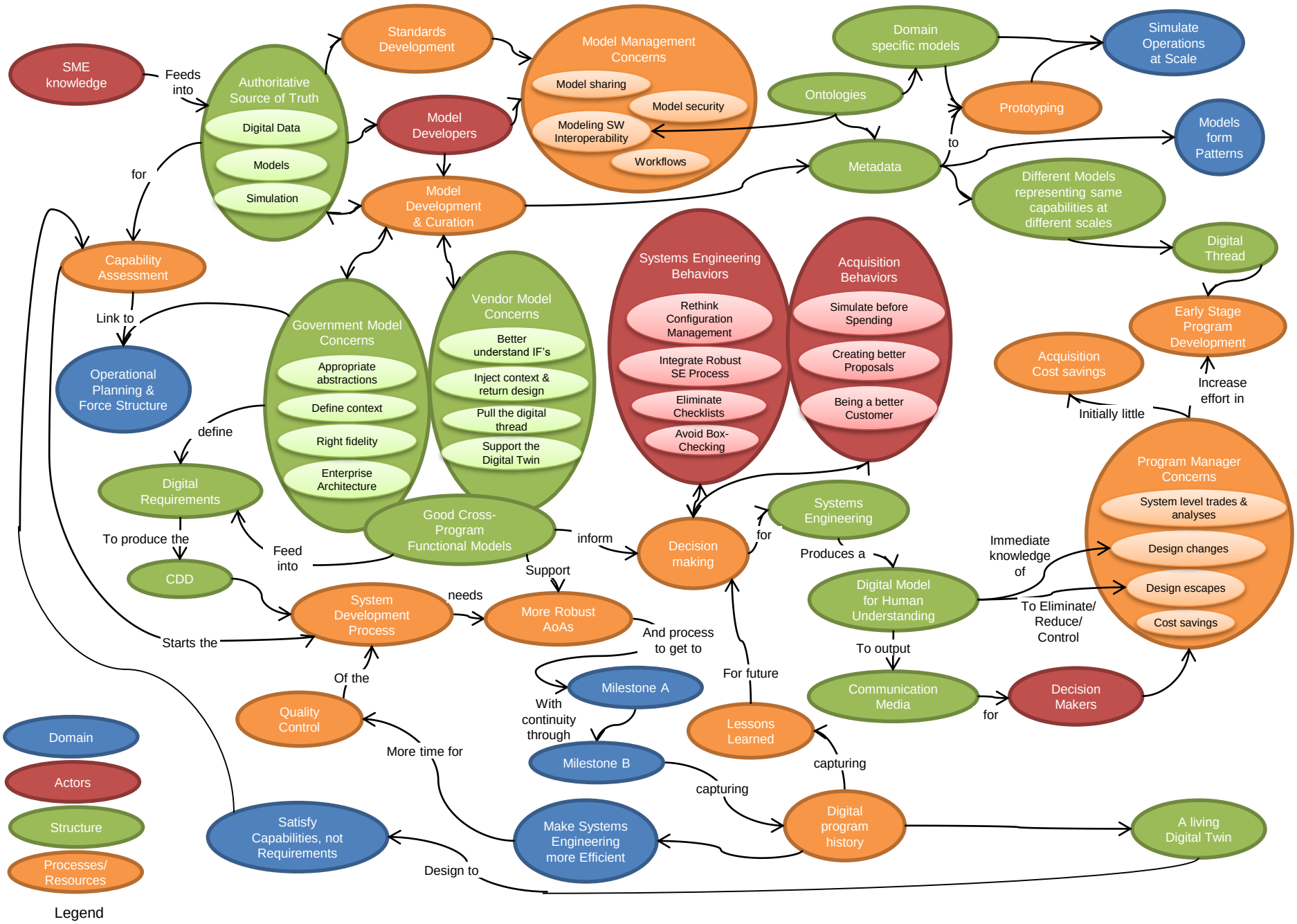
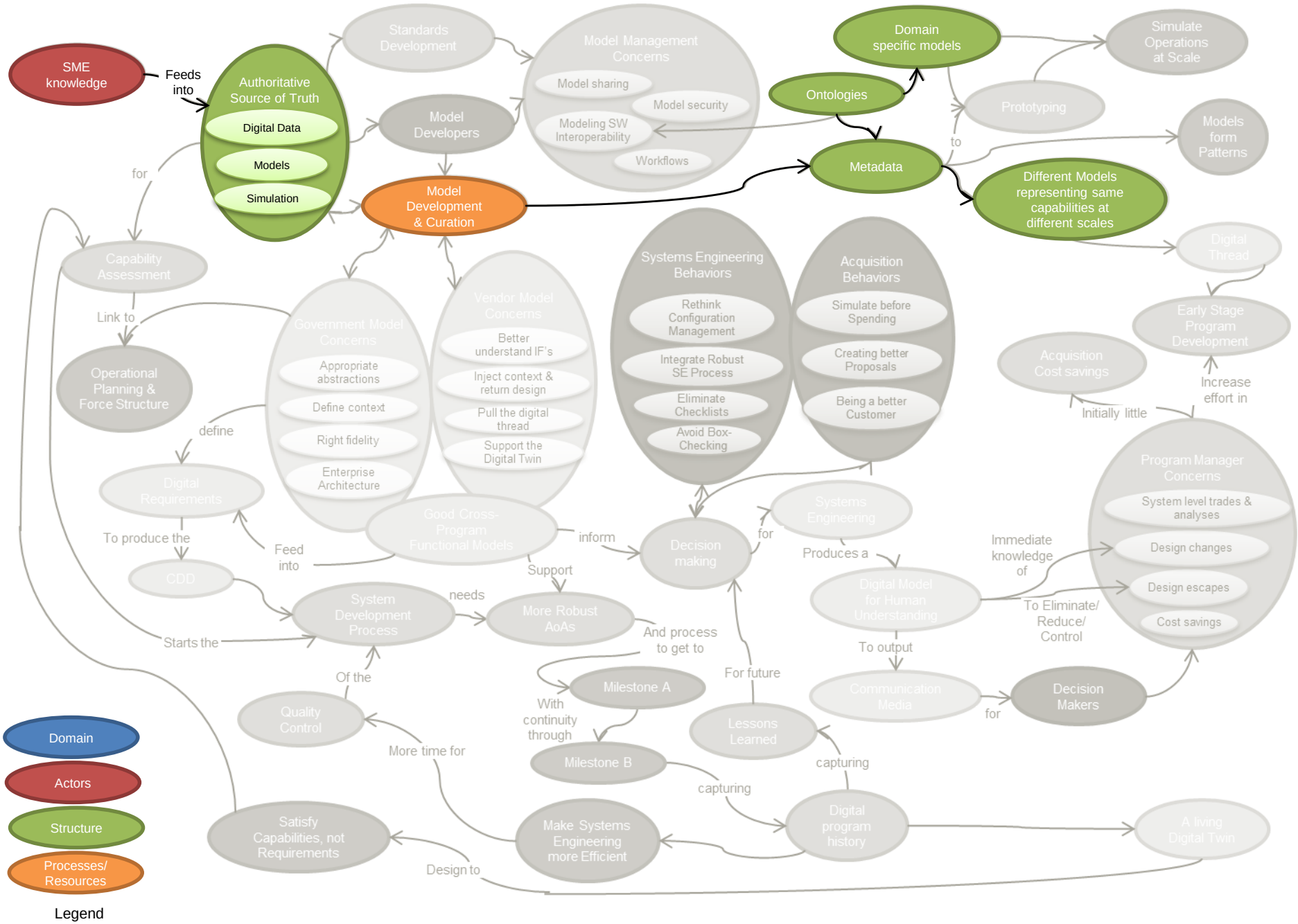
SERC Project RT-182 Digital Thread Enabled Acquisition



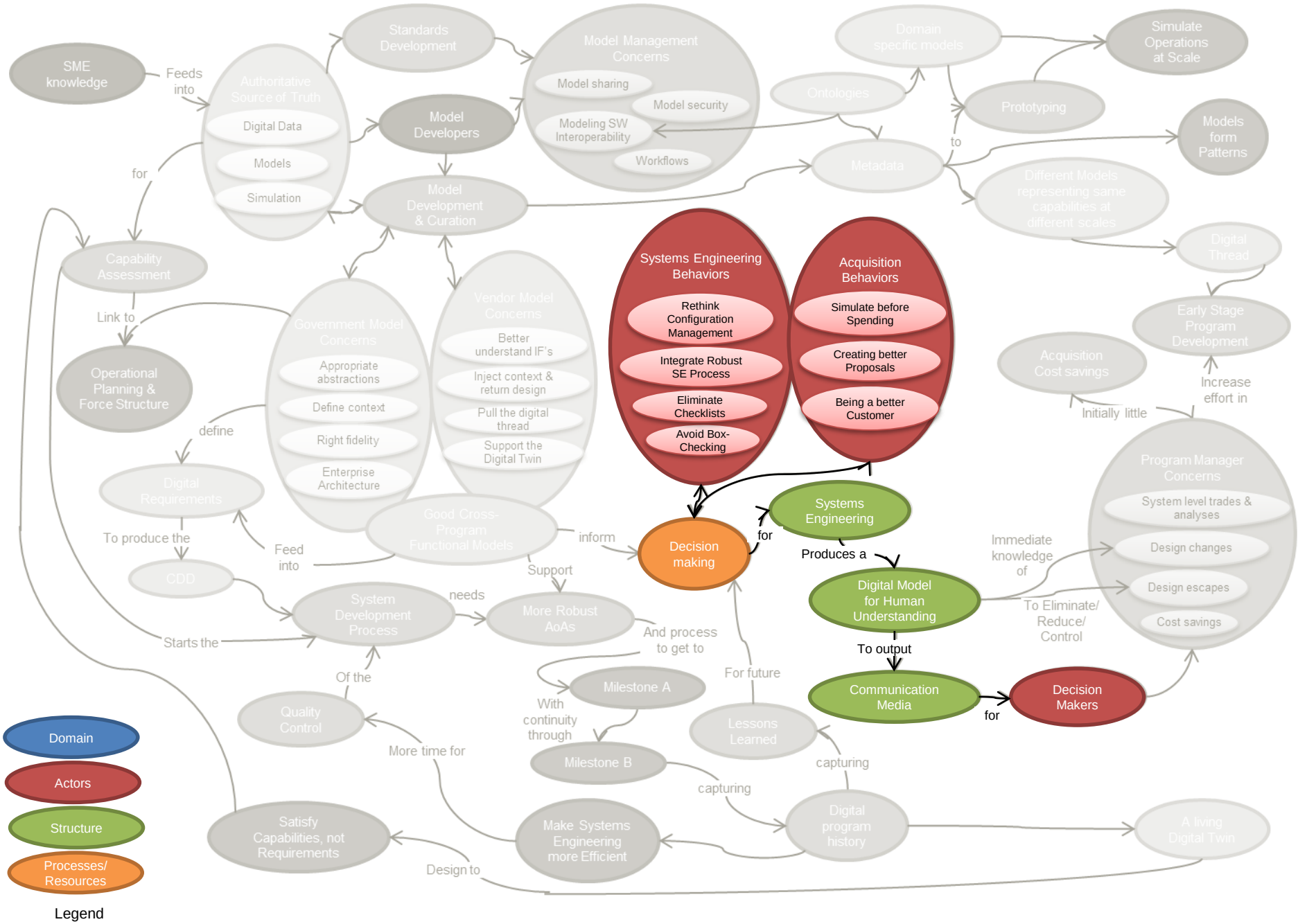
Inform Enterprise and Program Decision Making



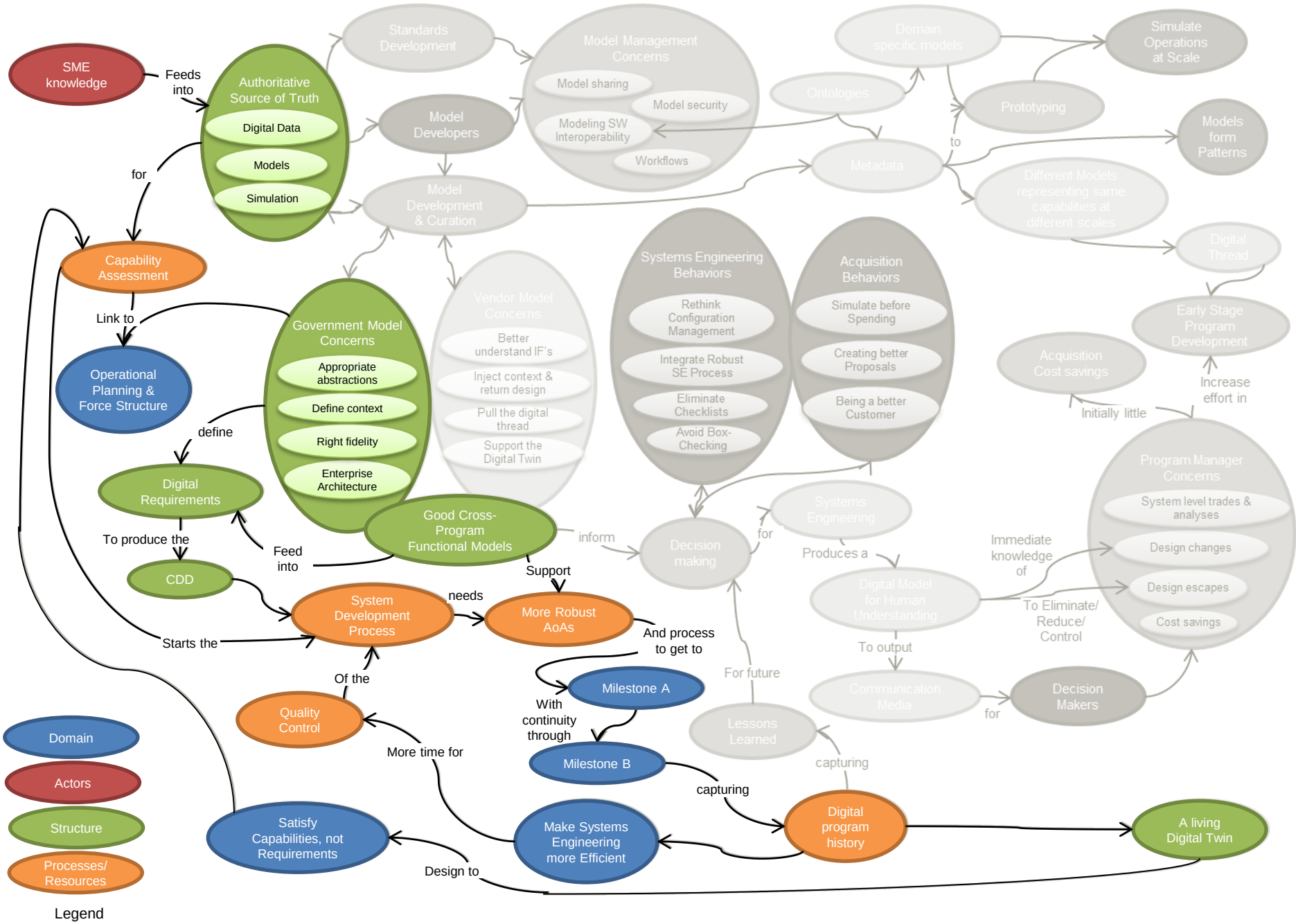
Inform Enterprise and Program Decision Making



Inform Enterprise and Program Decision Making



Inform Enterprise and Program Decision Making



Agenda

- Introduction
- Methodology: Multi-level Sociotechnical Modeling & Enterprise Systems Analysis
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- Systemigram; Other Insights
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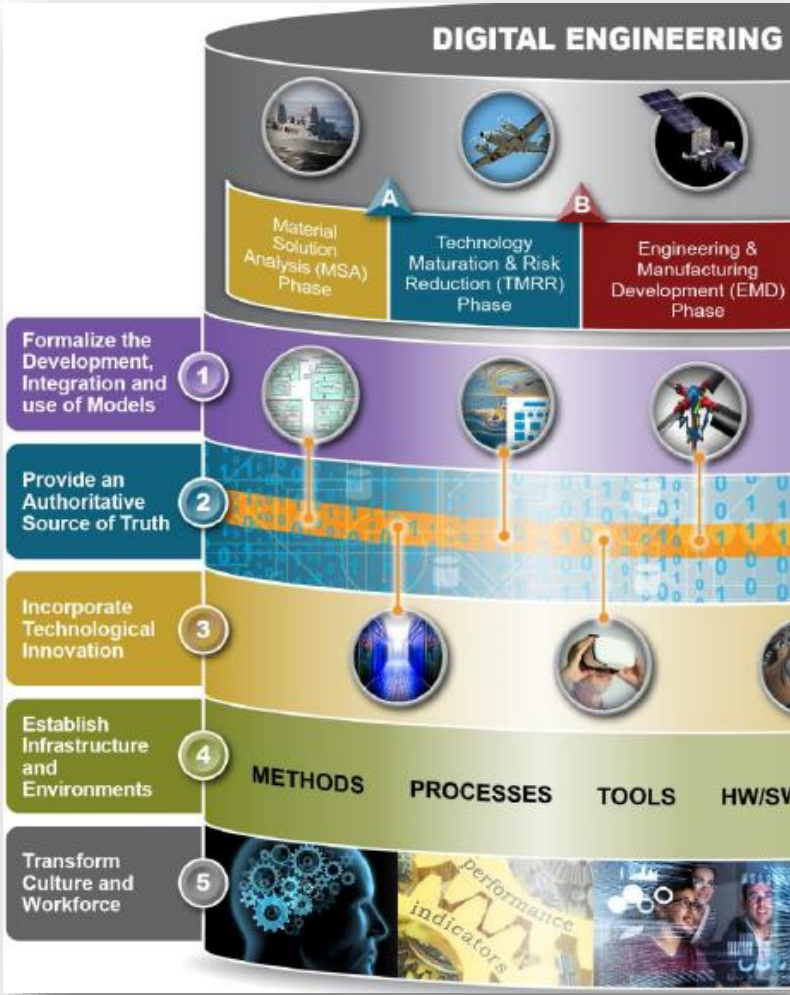
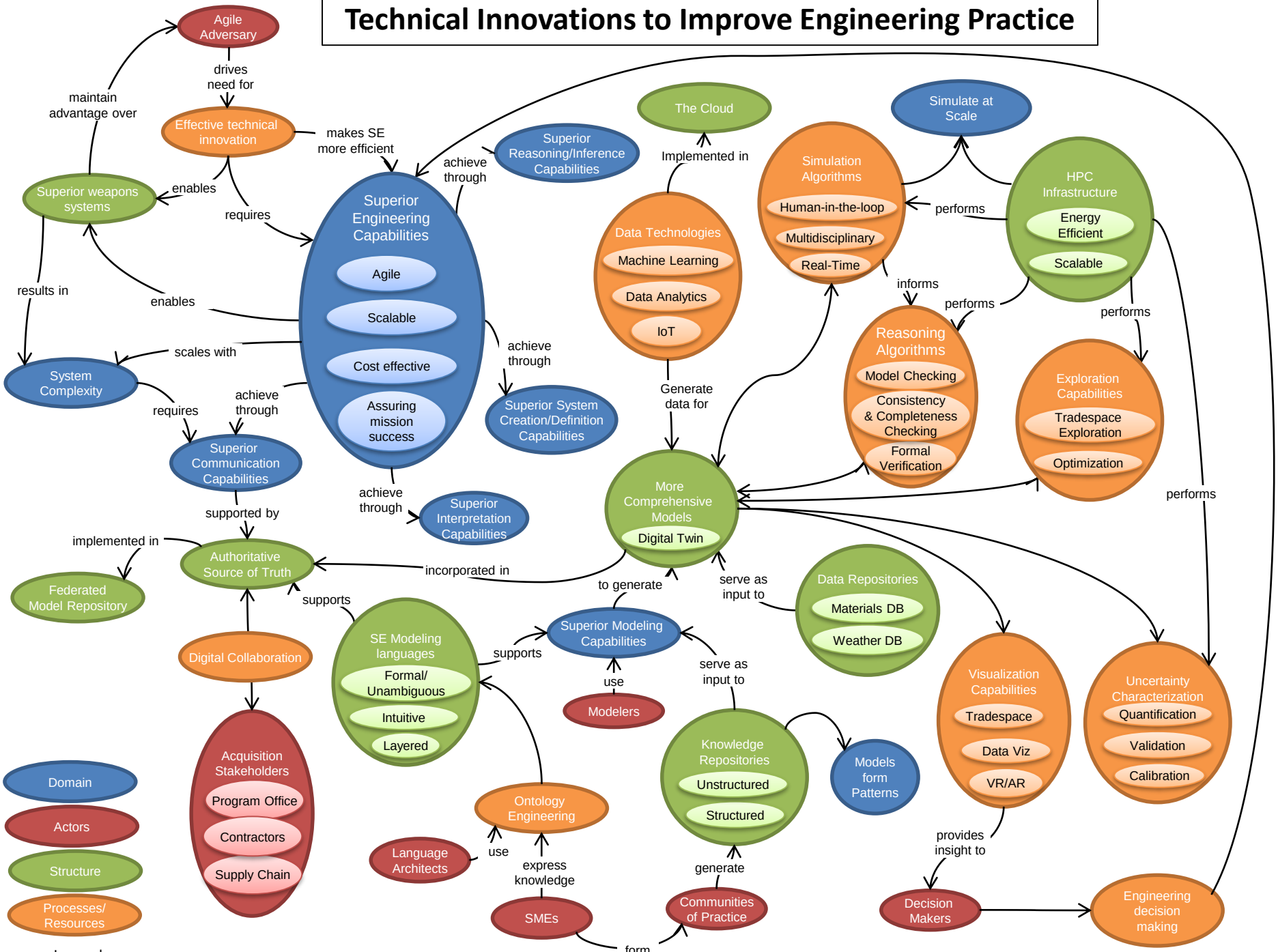
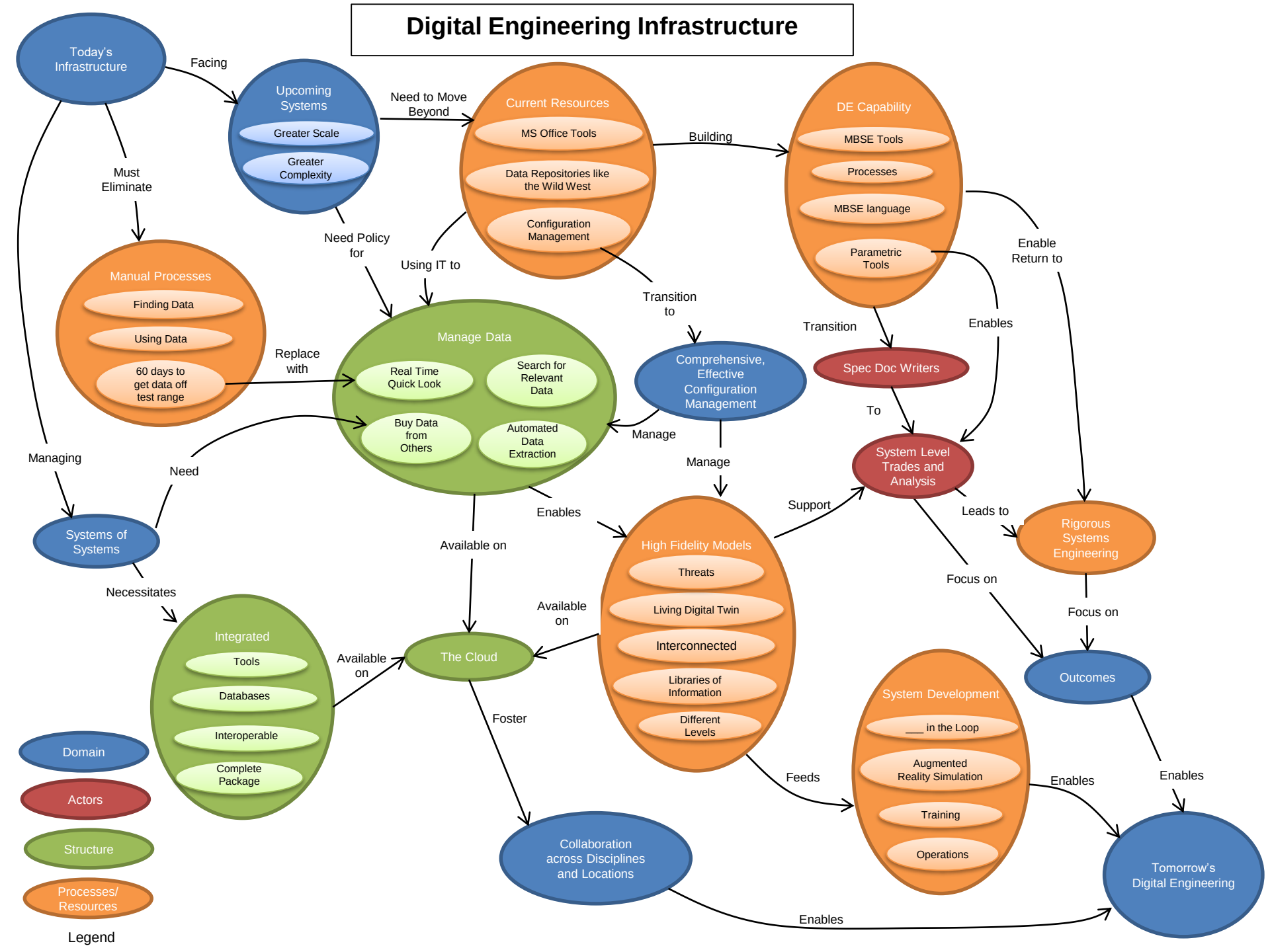
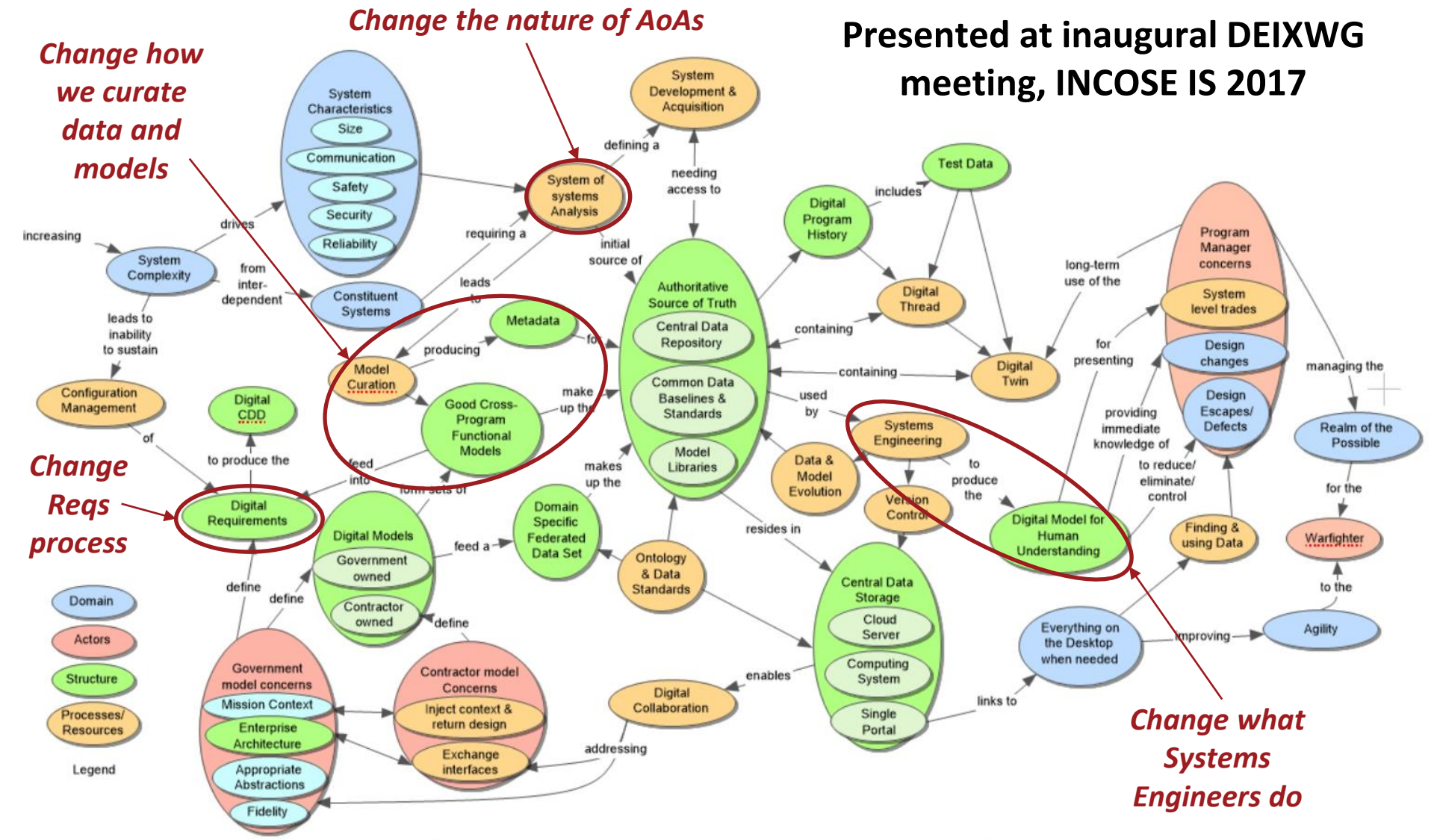


Technical Innovations to Improve Engineering Practice




Digital Engineering Infrastructure
Today's Infrastructure
Facing
Upcoming Systems
Greater Scale
Greater Complexity
Need to Move Beyond
Current Resources
MS Office Tools
Data Repositories like the Wild West
Configuration Management
Building
DE Capability
MBSE Tools
Processes
MBSE language
Parametric Tools
Must Eliminate
Manual Processes
Finding Data
Using Data
60 days to get data off test range
Need Policy for
Using IT to
Transition to
Enable Return to
Transition
Enables
Replace with
Manage Data
Real Time Quick Look
Search for Relevant Data
Buy Data from Others
Automated Data Extraction
Comprehensive, Effective Configuration Management
Spec Doc Writers
To
Manage
Manage
Managing
Need
System Level Trades and Analysis
Support
Leads to
Rigorous Systems Engineering
Systems of Systems
Enables
Available on
High Fidelity Models
Threats
Living Digital Twin
Interconnected
Libraries of Information
Different Levels
Focus on
Focus on
Necessitates
Integrated
Tools
Databases
Interoperable
Complete Package
Available on
Available on
The Cloud
Outcomes
Foster
System Development
___ in the Loop
Augmented Reality Simulation
Training
Operations
Feeds
Enables
Enables
Collaboration across Disciplines and Locations
Tomorrow's Digital Engineering
Enables
Domain
Actors
Structure
Processes/ Resources
Legend

Digital Information Exchange



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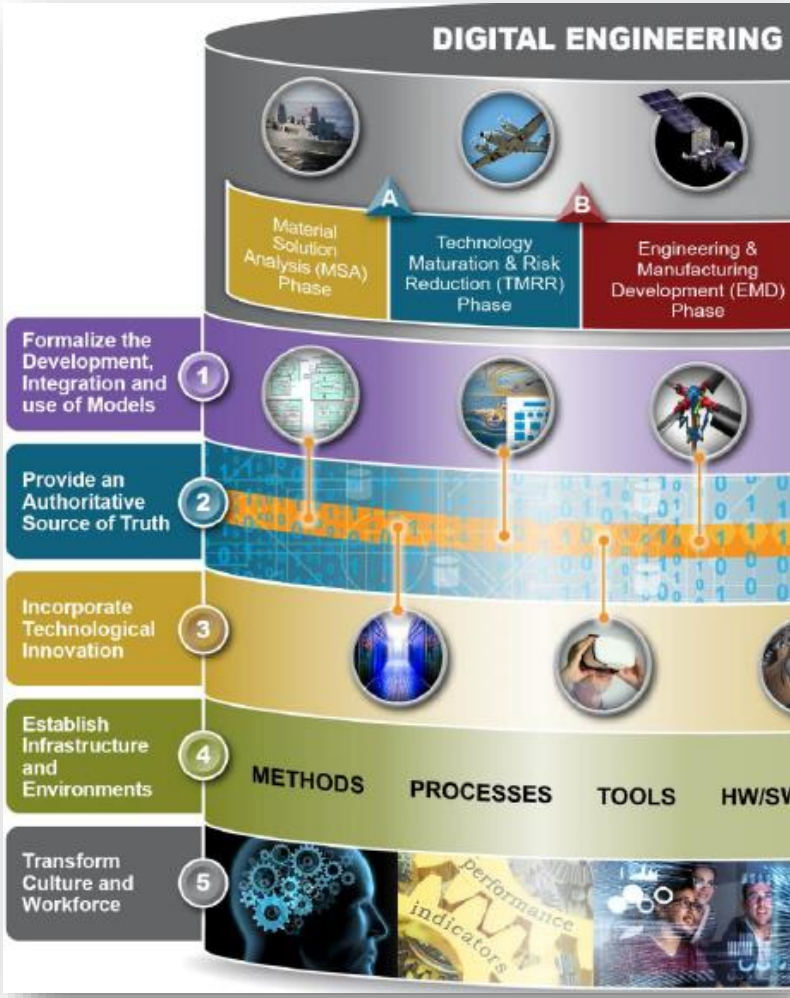
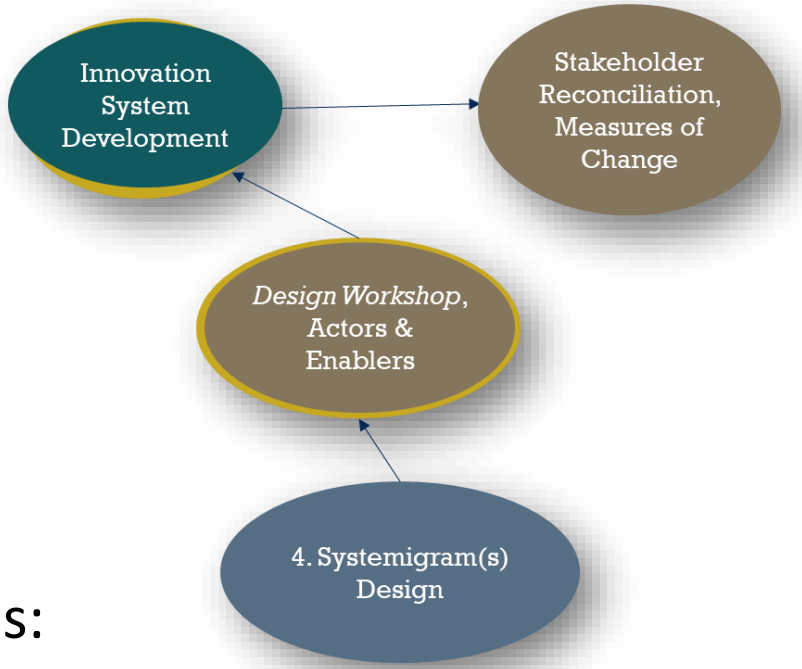


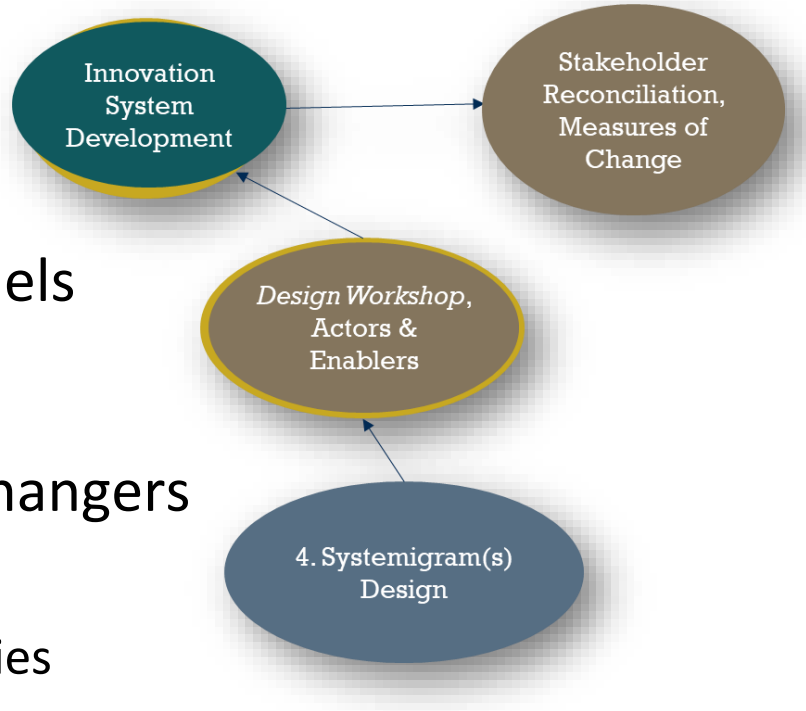
Outcomes and Next Steps

- Created holistic model of DoD Acquisition Enterprise change as DE is gradually adopted
- Good agreement across stakeholders on the nature of the strategy
- Descriptive modeling process reveals scope of change
- Testing insights in multiple forums using Systemigrams
- Base models informing other activities:
  - Digital Engineering Working Group (DEWG)
  - Digital Engineering Information Exchange Working Group (DEIXWG)



Next Phase – DE Metrics

- Theme: "A Program Office Guide to Successful DE Transition"
- Work with several DoD program offices, contractors, and tool providers
- Identify measures of success, and define multi-level measurement models
  - —Near- and long-term change indicators
- Identify potential innovation game-changers
  - —Define enablers and barriers to innovation
  - —Define cross-sector innovation opportunities



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Future Research Needs

- **Model Curation and Certitude.** Must develop a rigorous approach to verify, validate, and accredit the models that are incorporated into the Authoritative Source of Truth, particularly quality and range of valid use.
- **Metadata standards for the Authoritative Source of Truth.** Extend SET work on ontologies and metadata/metamodel libraries and tools.
- **Human Capital.** This will be a significant shift in the workplace, leading to an "IT/Data Savvy" workforce. Training programs must evolve with the strategy.
- **Bringing in the first and last phases. N**eed to engage and define how the capabilities assessment and development, operational, and test functions adopt and benefit from DE.
- **Evolution of Benefits of DE.** A sustained program that encourages exploring the art of the possible and understanding of the unique use cases that will evolve should be pursued.

Questions?

Thank you!