# Characterizing and Improving the Adoption Rate of Model-Based Systems Engineering through an Application of the Diffusion of Innovations Theory

Daniel R. Call

PhD Preliminary Exam

13 April 2023

WALTER SCOTT, JR.
COLLEGE OF ENGINEERING
COLORADO STATE UNIVERSITY

# Introduction

BYU
BRIGHAM YOUNG UNIVERSITY

B.S. Mechanical Engineering, 2009

U.S. AIR FORCE

Civilian Engineer, 2009- Present

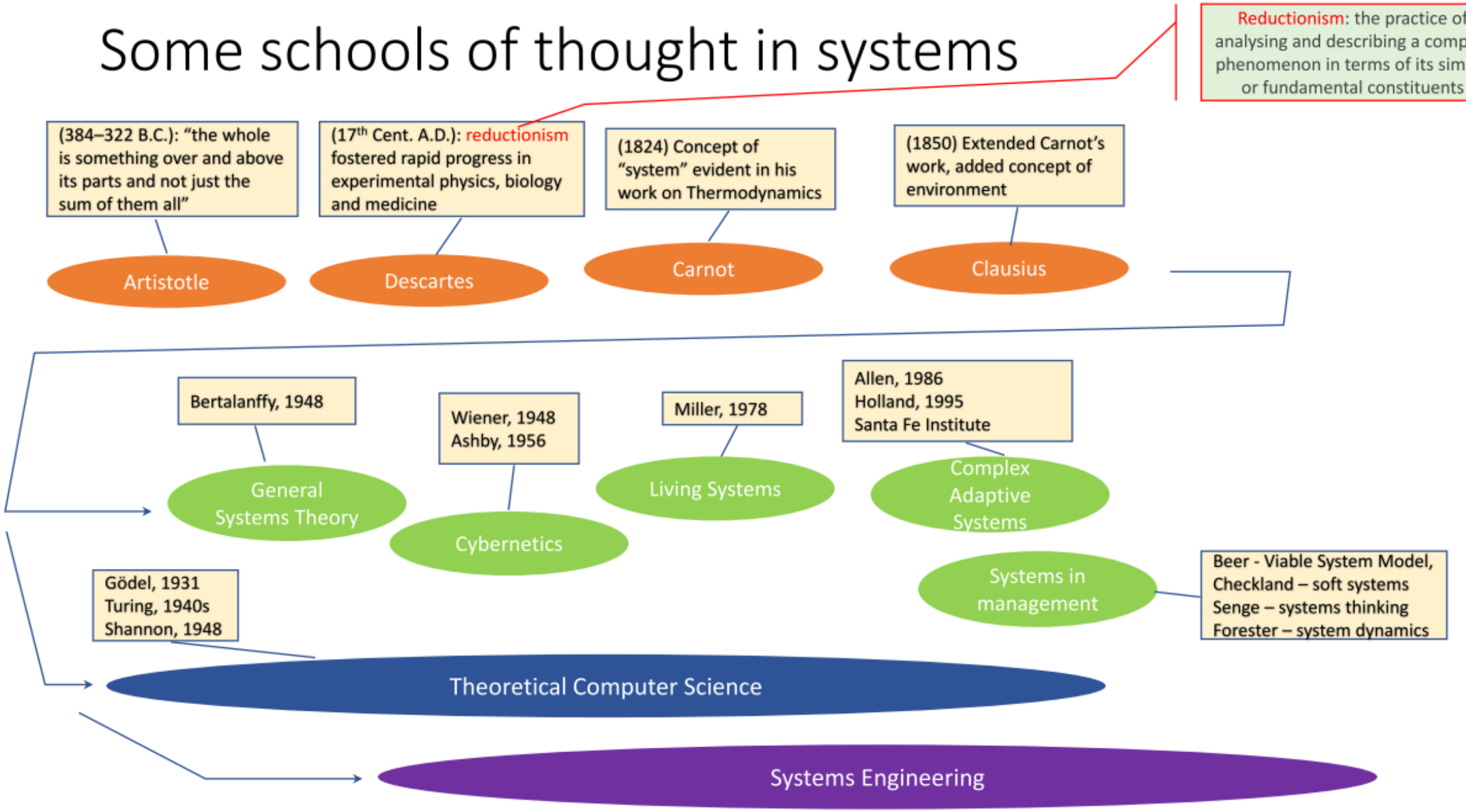
NPS
PRAESTANTIA PER SCIENTIAM
1909
NAVAL POSTGRADUATE SCHOOL

M.S. Systems Engineering, 2018

COLORADO STATE UNIVERSITY

Began PhD Systems Engineering Program Fall 2020

# Some schools of thought in systems






Sillitto, Hillary, Regina Griego, Eileen Arnold, Dov Dori, James Martin, Dorothy McKinney, Patrick Godfrey, Daniel Krob, and Scott Jackson. 2018. "What Do We Mean by 'System'? - System Beliefs and Worldviews in the INCOSE Community." *INCOSE International Symposium* 28 (1): 1190–1206. https://doi.org/10.1002/J.2334-5837.2018.00542.X.

# Why Systems Engineering?

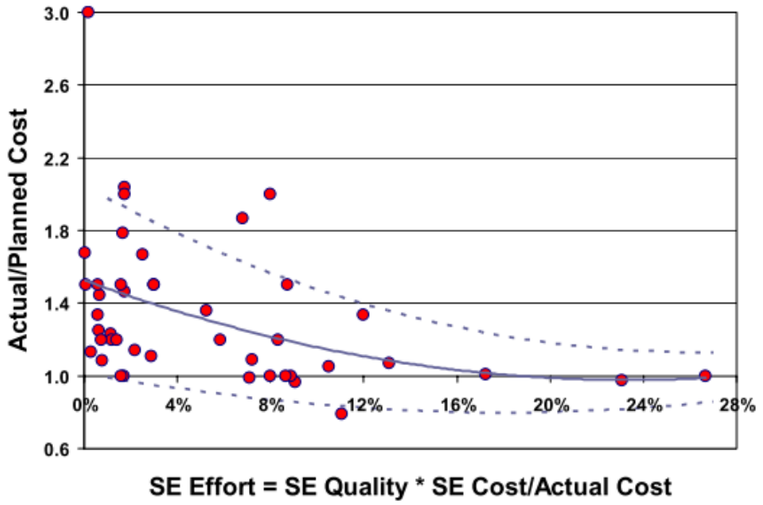
- “Modern systems engineering emerged during and immediately following World War II as weapons grew into weapons systems, due to the complexity in design, development and deployability” (Hoban 1993)
- The motivation of SE is to enable the realization, operation, maintenance, and disposal of systems (a collection of components and/or components and their relationships that provide a function that cannot be done by any of the constituent elements individually) that meets stakeholder needs and requirements by completing a series of defined technical and management processes throughout the system life cycle
- SE is a mature discipline that has evolved over decades of use and refinement

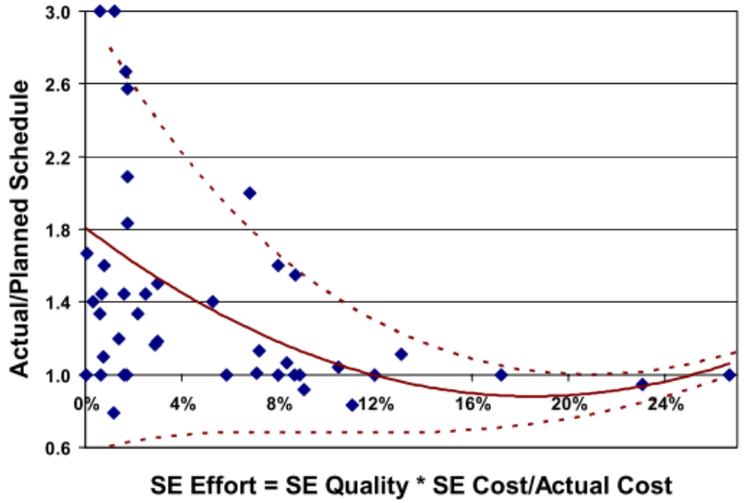
Hoban, Francis T., and William M. Lawbaugh. 1993. *Readings in Systems Engineering*. Vol. 6102. NASA Scientific and Technical Information Program.

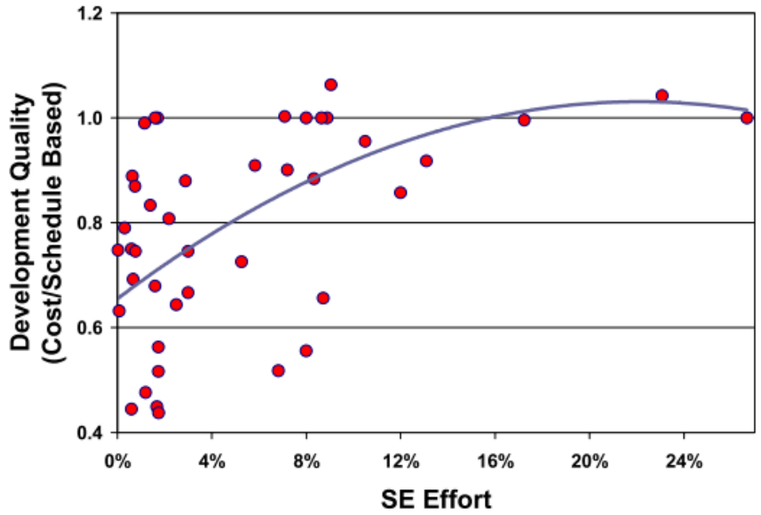


Emes, Michael, Alan Smith, and Douglas Cowper. 2005. “Confronting an Identity Crisis - How to ‘Brand’ Systems Engineering.” *Systems Engineering* 8 (2): 164–86. https://doi.org/10.1002/SYS.20028.

# The Value of Systems Engineering



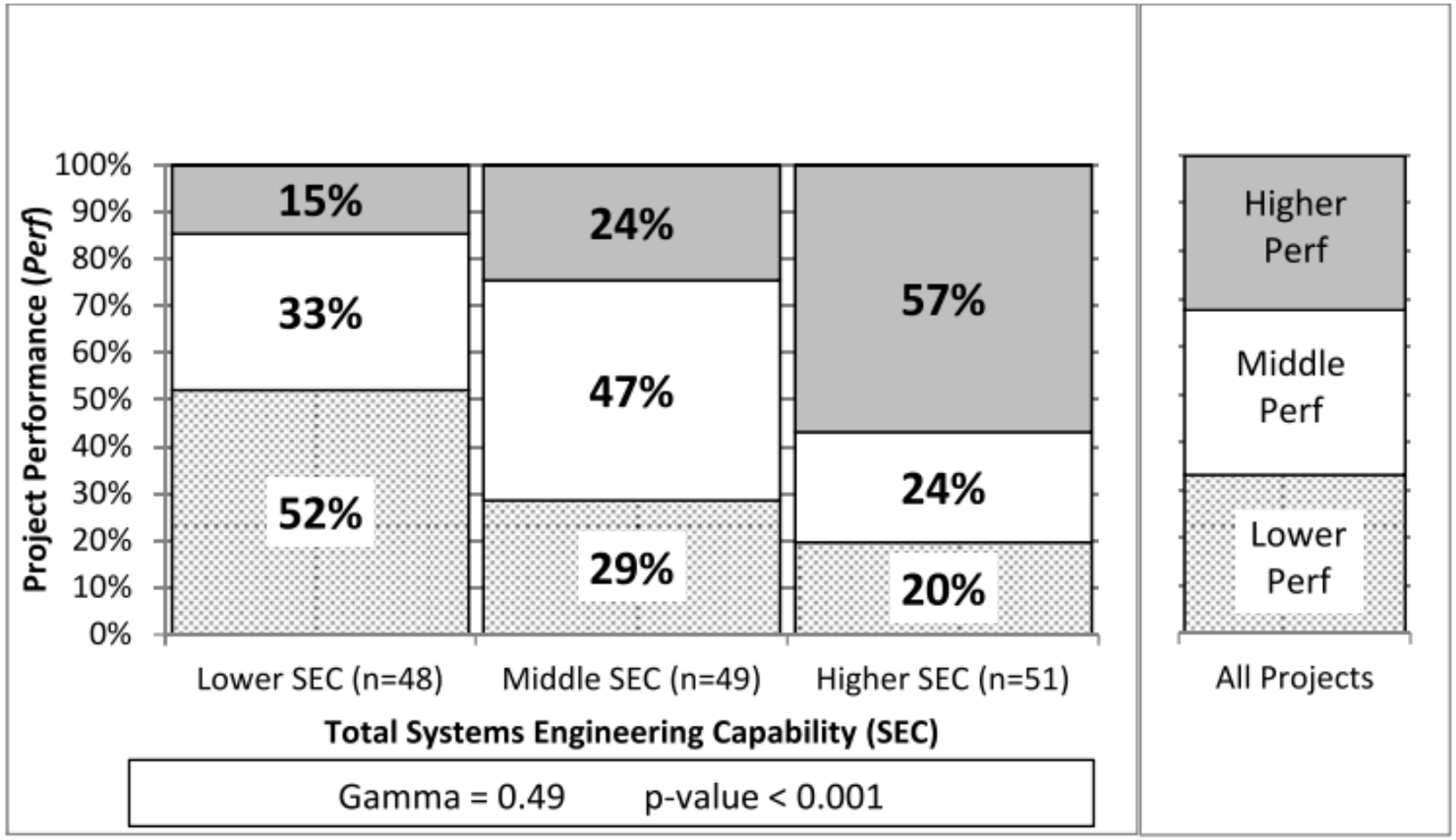




"Optimum SE effort is 15-20%"



Honour, Eric C. 2004. "Understanding the Value of Systems Engineering." *INCOSE International Symposium* 14 (1): 1207–22. https://doi.org/10.1002/j.2334-5837.2004.tb00567.x.

# The Value of Systems Engineering



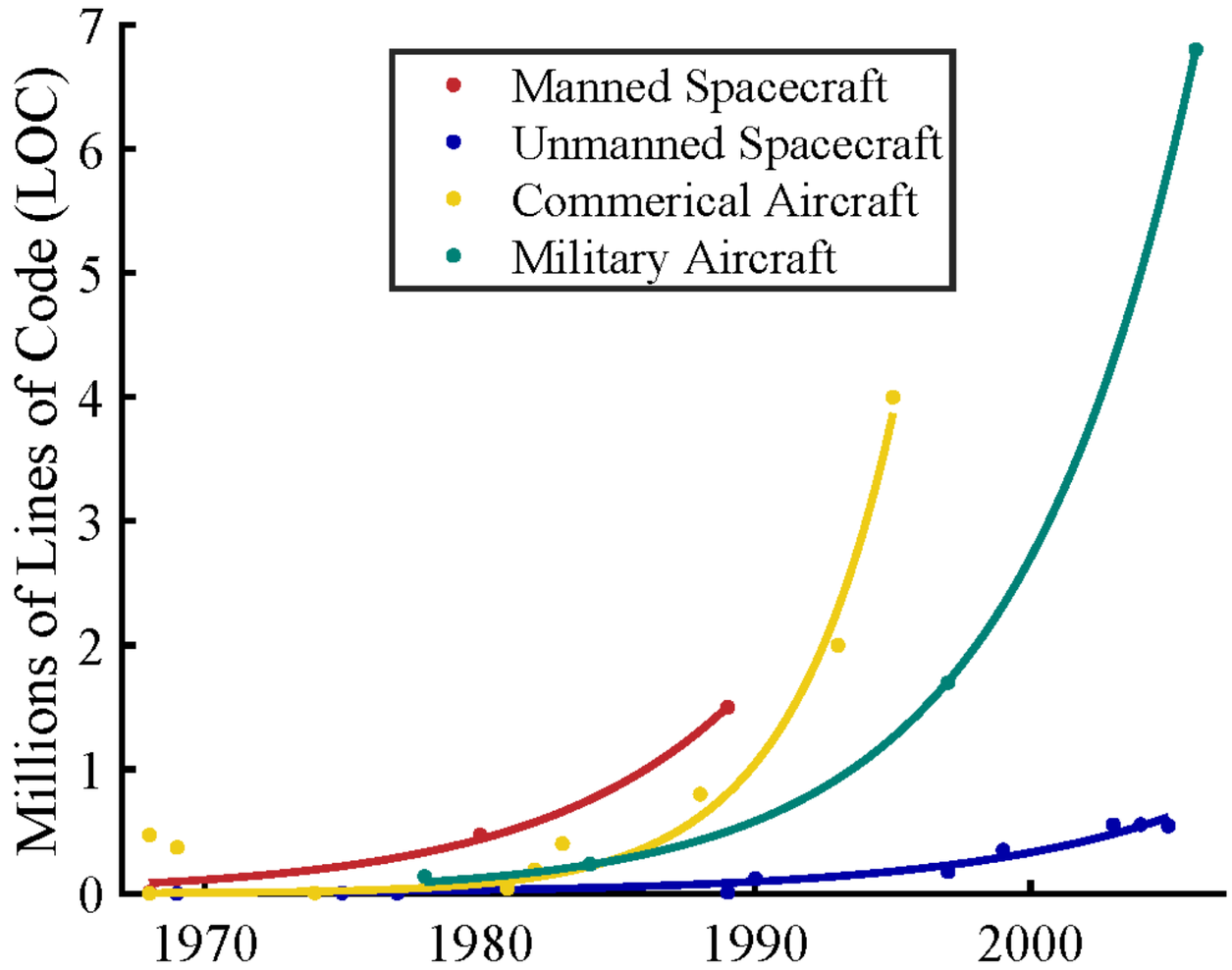



Elm, Joseph P, and Dennis R Goldenson. 2012. “The Business Case for Systems Engineering Study: Results of the Systems Engineering Effectiveness Survey.” Defense Technical Information Center. https://doi.org/10.21236/ada610517.

# Systems Engineering Challenges

- Increased complexity due to software-centric nature of modern systems

# Exponential Increase in Complexity






Call, Daniel R., and Daniel R. Herber. 2023. “A Case for Model-Based Systems Engineering in an Agile World and Principles for Growth.” In *(To Appear) INCOSE 2023 Annual International Symposium*. Honolulu, HI, USA.

# Systems Engineering Challenges

- Increased complexity due to software-centric nature of modern systems
- Continued systems failures in modern, complex systems are often a result of:
  - Insufficient communication between stakeholders
  - Outdated, incomplete, or inconsistent specifications and requirements
- Immature understanding of underlying systems science
  - What constitutes a good system?
  - Heuristic based vs. Scientific based
- Process overhead in agile world
  - “We are doing too much systems engineering when it isn't needed”
  - “We aren't doing the ‘right type’ of systems engineering”

Haskins, Cecilia. 2011. “A Historical Perspective of MBSE with a View to the Future.” *21st Annual International Symposium of the International Council on Systems Engineering, INCOSE 2011* 1: 488–504. https://doi.org/10.1002/j.2334-5837.2011.tb01220.x.

“Three General Systems Principles and Their Derivation: Insights from the Philosophy of Science Applied to Systems Concepts.” 2020. https://doi.org/10.1007/978-3-319-62217-0_46.

Kemp, Duncan, Richard Beasley, and Samantha Williams. 2015. “‘Suits You Sir! -- Choosing the Right Style of SE before Tailoring to Fit.’” *INCOSE International Symposium* 25 (1): 1245–62. https://doi.org/10.1002/J.2334-5837.2015.00127.X.

# Model-Based Systems Engineering (MBSE)

“The formalized application of modeling to support system requirements, design, analysis, verification, and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases”



Walden, David D., Garry J. Roedler, and Kevin Forsberg. 2014. “INCOSE Systems Engineering Handbook Version 4.” *INCOSE International Symposium* 24 (s1). https://doi.org/10.1002/j.2334-5837.2014.00042.x.

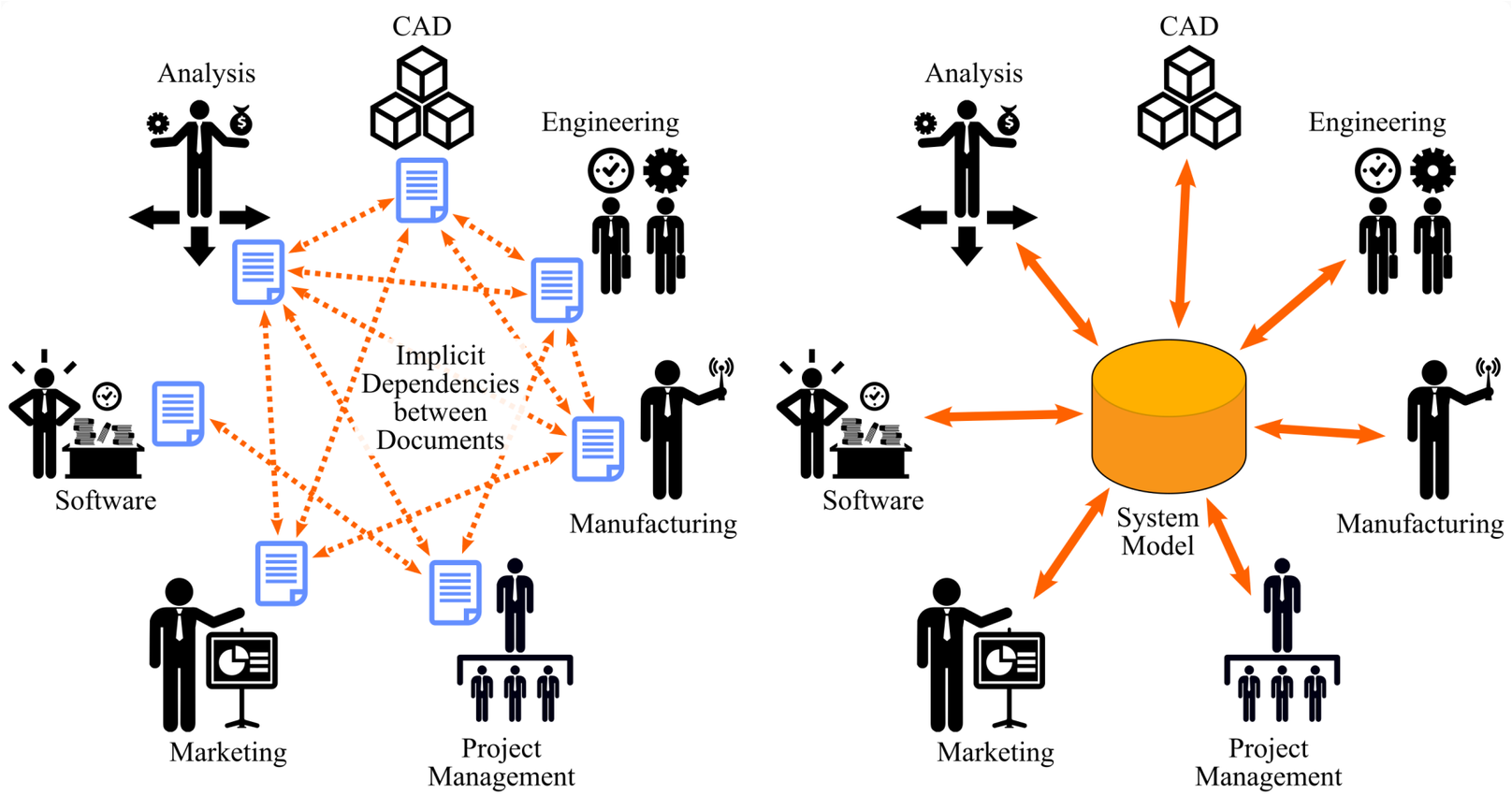
# Model-Based Systems Engineering (MBSE)

“the formalized application of modeling (static and dynamic) to support system design and analysis, throughout all phases of the system lifecycle, through the collection of modeling languages, structures, model-based processes, and presentation frameworks used to support the discipline of SE in a model-based or model-driven context”



Vaneman, Warren K. 2018. “Evolving Model-Based Systems Engineering Ontologies and Structures.” *INCOSE International Symposium* 28 (1): 1027–36. https://doi.org/10.1002/J.2334-5837.2018.00531.X.

# Model-Based Systems Engineering (MBSE)




(a) Traditional document-centric SE approach

(b) Model-based SE approach



Call, Daniel R., and Daniel R. Herber. 2022. “Applicability of the Diffusion of Innovation Theory to Accelerate Model-Based Systems Engineering Adoption.” *Systems Engineering* 25 (6): 574–83. https://doi.org/10.1002/SYS.21638.

# MBSE Benefits

- MBSE enhances the ability to capture, analyze, share, and manage the information associated with the complete specification of a product, resulting in the following benefits:
  - **Improved communications** facilitated by models that can be evaluated for consistency, completeness, correctness
  - **Improved ability to cope with complexity** in systems and to analyze change impacts
  - **Improved system quality**
  - **Improved knowledge capture and reuse** leading to reduced cycle time and lower maintenance costs
  - **Improve capacity to teach and learn SE**, to integrate new team members, to minimize loss of knowledge as team members leave, to establish shared mental models



Friedenthal, Sanford A., Regina Griego, and Mark Sampson. 2007. “INCOSE Model Based Systems Engineering (MBSE) Initiative.” *INCOSE 2007 Symposium* 17 (August): 2080. https://doi.org/10.1002/j.2334-5837.2007.tb02999.x.

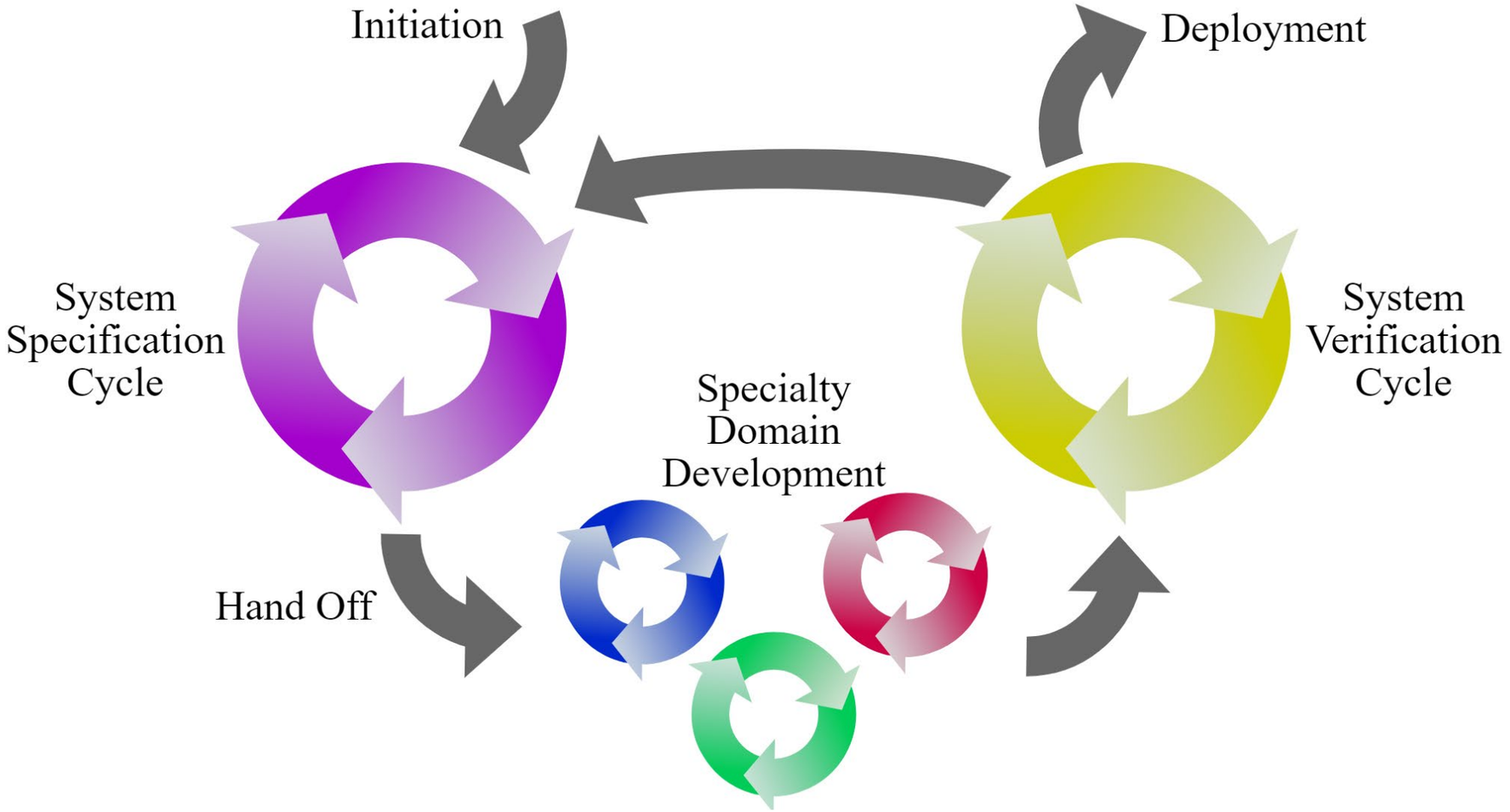
# Agile Systems Engineering (ASE)

- Some organizations are moving away from SE altogether because of the challenges of responding to rapid changes in operating environments, system requirements, and available technology
- The choice between SE rigor and agile methodology is a false dichotomy
- The concept of agile systems engineering is a natural and necessary progression for SE in a world where software is a dominant driver of modern systems
- ASE is a systems engineering approach that incorporates principles from the Agile Manifesto, a software development philosophy
  - Individuals and interactions over processes and tools
  - Working software over comprehensive documentation
  - Customer collaboration over contract negotiation
  - Responding to change over following a plan



Beck, Kent, Mike Beedle, Arie van Bennekum, Alistair Cockburn, Ward Cunningham, Martin Fowler, James Grenning, et al. 2001. “Manifesto for Agile Software Development.” *Manifesto for Agile Software Development*. http://www.agilemanifesto.org/.

# Agile Systems Engineering (ASE)






Call, Daniel R., and Daniel R. Herber. 2023. “A Case for Model-Based Systems Engineering in an Agile World and Principles for Growth.” In *(To Appear) INCOSE 2023 Annual International Symposium*. Honolulu, HI, USA.

# Agile SE and MBSE

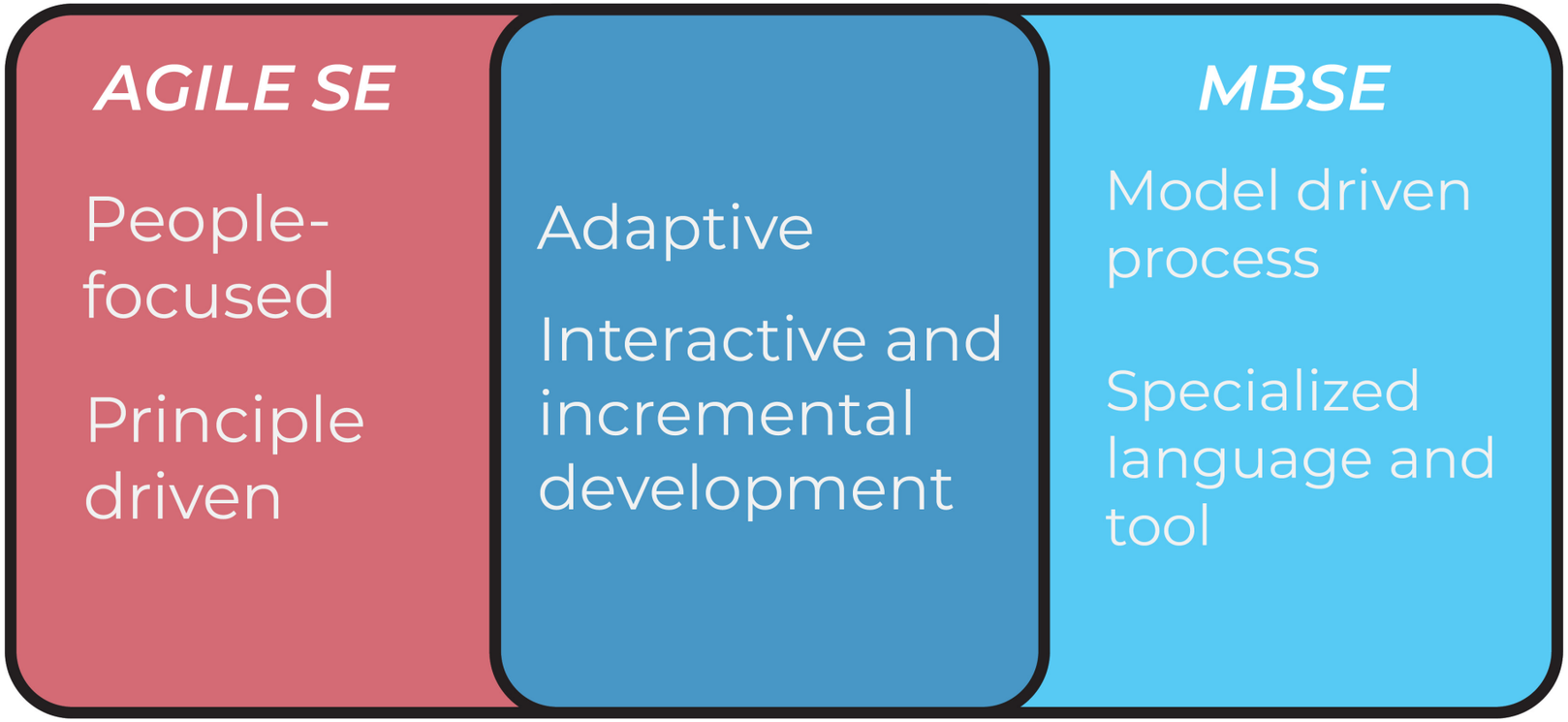
- The development and maintenance of document-based SE artifacts presents challenges in an ASE approach due to the pace and scope of required changes to those artifacts
- MBSE and ASE are very complementary and not only can but ***should*** coexist



Douglass, Bruce Powel. 2015. *Agile Systems Engineering*. Elsevier. https://doi.org/10.1016/C2014-0-02102-8.

# SYSTEMS ENGINEERING

Formal processes • Document-based artifacts






Call, Daniel R., and Daniel R. Herber. 2023. “A Case for Model-Based Systems Engineering in an Agile World and Principles for Growth.” In *(To Appear) INCOSE 2023 Annual International Symposium*. Honolulu, HI, USA.

# MBSE Adoption Status

- We are still referring to this approach as “model-based systems engineering” instead of simply “systems engineering”




Akundi, Aditya, Oscar Mondragon, Wilma Ankobiah, and Sergio Luna. 2022. “Perceptions and the Extent of Model-Based Systems Engineering (MBSE) Use-- An Industry Survey.” https://doi.org/10.1109/SysCon53536.2022.9773894.

# MBSE Adoption Challenges

- Technical
  - Lack of standardization and interoperability amongst tools
  - Challenges integrating tools in legacy environments
- Cultural
  - Overcoming the perception that MBSE is the latest fad
  - Stakeholders uncomfortable with new technologies
  - Uncomfortable learning curve
- Economic
  - Initial investment to purchase tools and train people
  - New technology presents unknown perceived and/or actual risks (cost, schedule, and performance)



Haskins, Cecilia. 2011. “A Historical Perspective of MBSE with a View to the Future.” 21st Annual International Symposium of the International Council on Systems Engineering, INCOSE 2011 1: 488–504. https://doi.org/10.1002/j.2334-5837.2011.tb01220.x.

# MBSE Adoption Challenges

- “Lack of related knowledge and skills”
- “Lack of perceived value of MBSE”
- “Resistance to change”
- “Lack of managerial support”



Motamedian, Bita. 2013. “MBSE Applicability Analysis.” *International Journal of Scientific & Engineering Research* 4 (2).

# MBSE Adoption Challenges


- Madni, Azad M., and Michael Sievers. 2018. “Model-Based Systems Engineering: Motivation, Current Status, and Research Opportunities.” *Systems Engineering*. https://doi.org/10.1002/sys.21438.
- Bonnet, Stéphane, Jean-Luc Voirin, Véronique Normand, and Daniel Exertier. 2015. “Implementing the MBSE Cultural Change: Organization, Coaching and Lessons Learned.” INCOSE International Symposium 25 (1): 508–23. https://doi.org/10.1002/j.2334-5837.2015.00078.x.
- Chami, Mohammad, and Jean-Michel Bruel. 2018. “A Survey on MBSE Adoption Challenges.”
- Henderson, Kaitlin A. 2022. “Exploring the Adoption Process of MBSE: A Closer Look at Contributing Organizational Structure Factors.”
- Bone, Mary, and Robert Cloutier. 2010. “The Current State of Model Based Systems Engineering: Results from the Omg™ Sysml Request for Information 2009.” In *Proceedings of the 8th Conference on Systems Engineering Research*.

# Current Systems Engineering Reality

- Systems engineering is important and provides value
- The practice of systems engineering is facing challenges associated with modern, complex systems
- There is ample evidence that MBSE and MBSE-supported ASE are well-suited to meet systems engineering challenges
- MBSE is not being widely adopted

# Now what?

"**Until** and **unless** we begin to delve into the social and cognitive aspects of how engineers work together and how system engineering is performed. . . possible contributions from fields far apart from engineering will continue to go unrecognized. . . The study of human interactions, cognitive psychology, social choice theory, and other disciplines **must be included** in the development of effective theories of system engineering" (emphasis added)

Griffin, Michael D. 2010 "How Do We Fix System Engineering?"

# Diffusion of Innovations Theory (DoIT)

- First edition of the *Diffusion of Innovations* published in 1962 by rural sociologist Everett Rogers– Fifth edition published in 2003
- Developed to understand why some innovations achieved rapid, widespread adoption while others were adopted more slowly, narrowly, or not at all
- **Innovation-** “an idea, practice, or object that is perceived as new by an individual or other unit of adoption
- **Diffusion-** “the process in which an innovation is communicated through certain channels over time among the members of a social system.”



Rogers, Everett M. 2003. *Diffusion of Innovations, 5th Edition*. Social Science / The Free Press. Free Press.

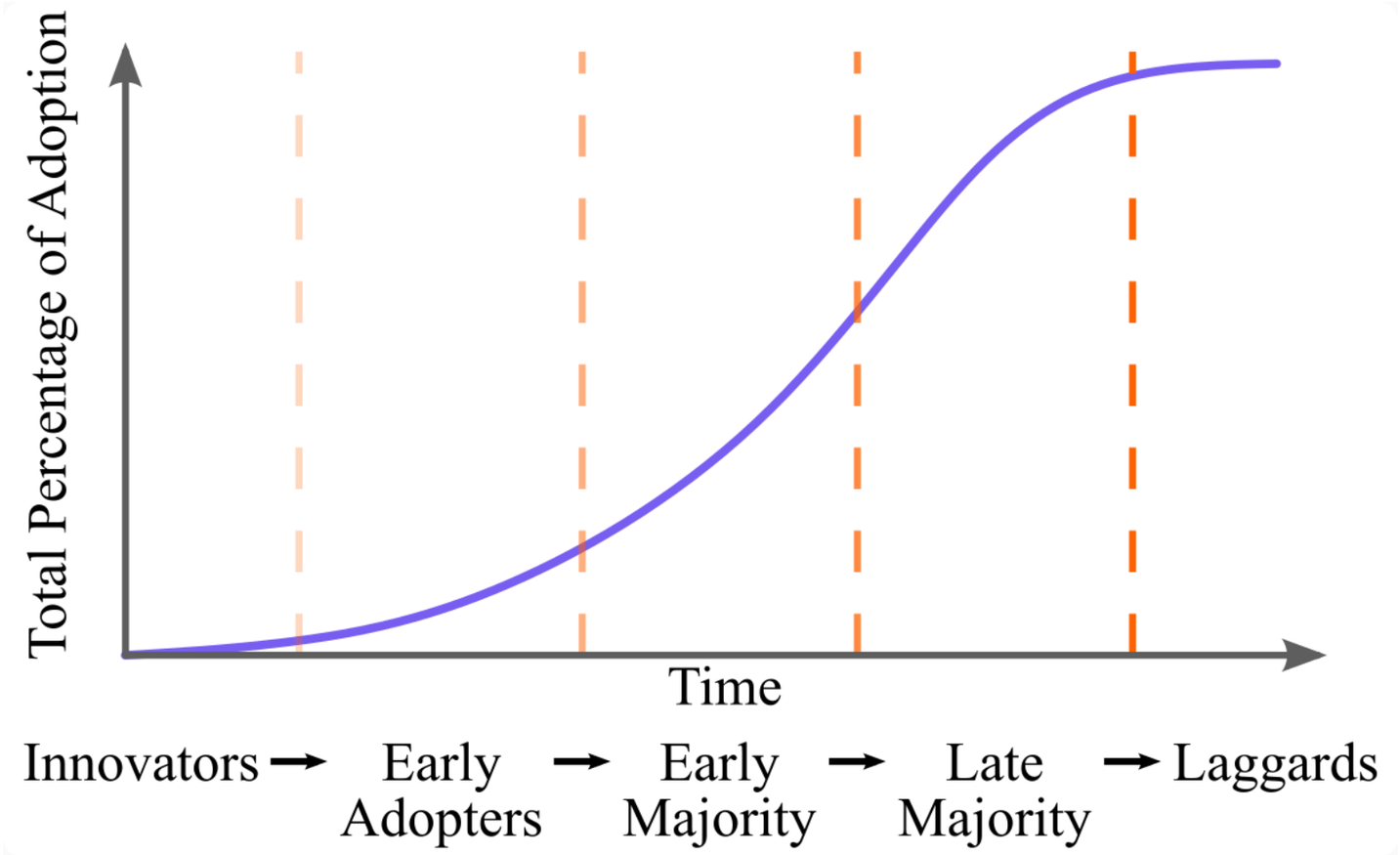
# Diffusion of Innovations Theory

- Water boiling in a Peruvian village (-)
- Controlling scurvy in the British Navy (-)
- Dvorak keyboard (-)
- Hybrid corn
- “Miracle Rice” in Bali (-)
- Modern math in Pittsburg
- Worldwide diffusion of kindergarten
- Prescription drugs
- Family planning
- STOP AIDS
- News of September 11 terrorist attacks
- Electric cars
- “Freedom Summer” recruitment
- Pure drinking water in Egyptian villages
- Preference for sons in India and China
- Smoking cessation programs
- Farm innovations in a Colombian village
- Fax
- Internet
- Snowmobiles in the Arctic



Rogers, Everett M. 2003. *Diffusion of Innovations, 5th Edition*. Social Science / The Free Press. Free Press.

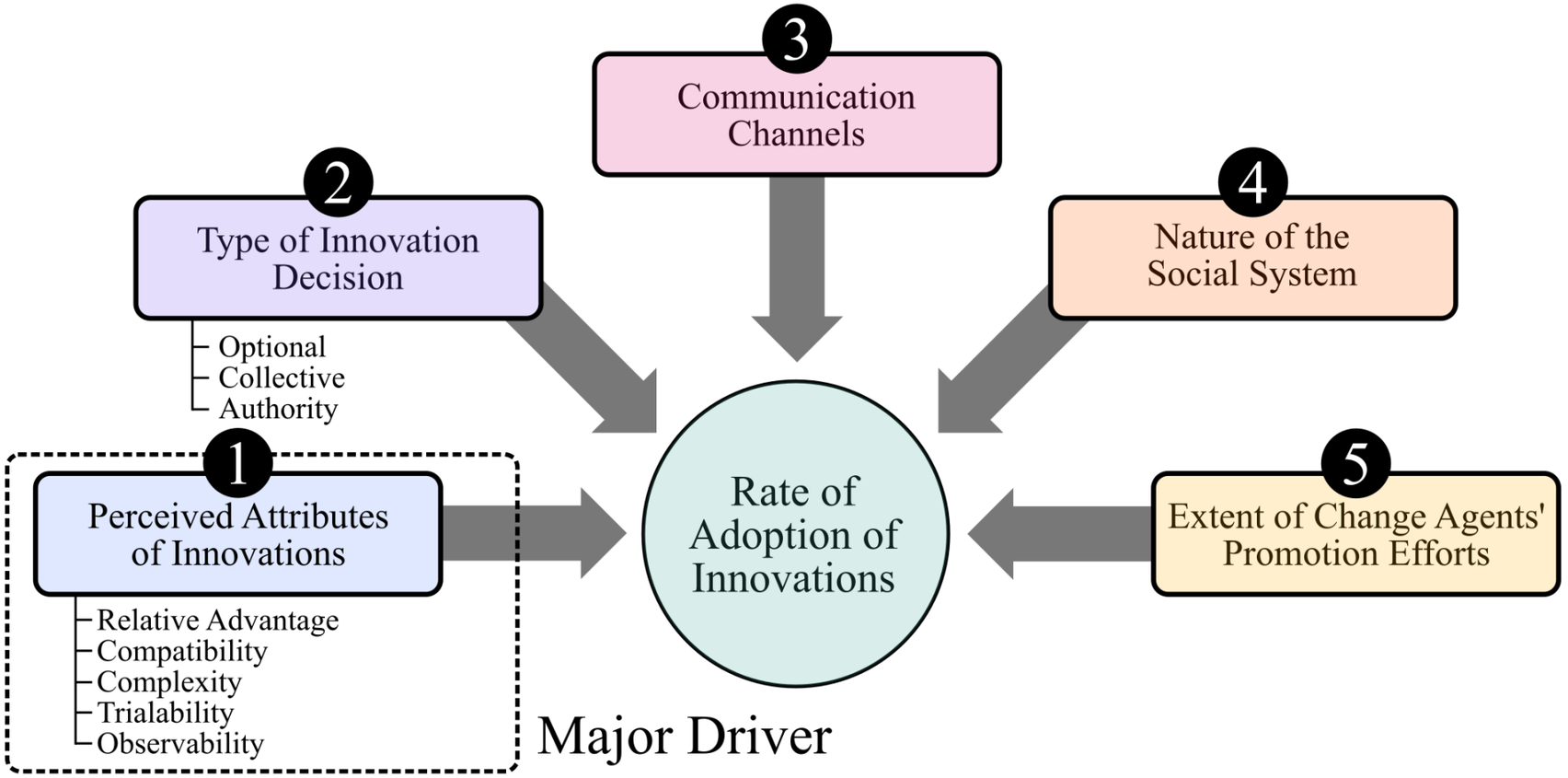
# Adoption S-Curve






Rogers, Everett M. 2003. *Diffusion of Innovations, 5th Edition*. Social Science / The Free Press. Free Press.

# Adoption Rate Variables






Rogers, Everett M. 2003. *Diffusion of Innovations, 5th Edition*. Social Science / The Free Press. Free Press.

# Perceived Attributes

| Attribute | Definition |
|---|---|
| Relative Advantage | The degree to which an innovation is perceived as being better than the idea it supersedes |
| Compatibility | The degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters |
| Complexity | The degree to which an innovation is perceived as relatively difficult to understand and use |
| Trialability | The degree to which an innovation may be experimented with on a limited basis |
| Observability | The degree to which the results of an innovation are visible to others |



Rogers, Everett M. 2003. *Diffusion of Innovations, 5th Edition*. Social Science / The Free Press. Free Press.

# “if [people] perceive situations as real, they are real in their consequences”

Thomas, W I, and Florian Znaniecki. 1927. *The {Polish} Peasant in {Europe} and {America}*. Vol. 73. https://doi.org/10.2307/538002.

# Research Question

How can the diffusion of innovation theory be applied to understand and improve the adoption rate of MBSE?

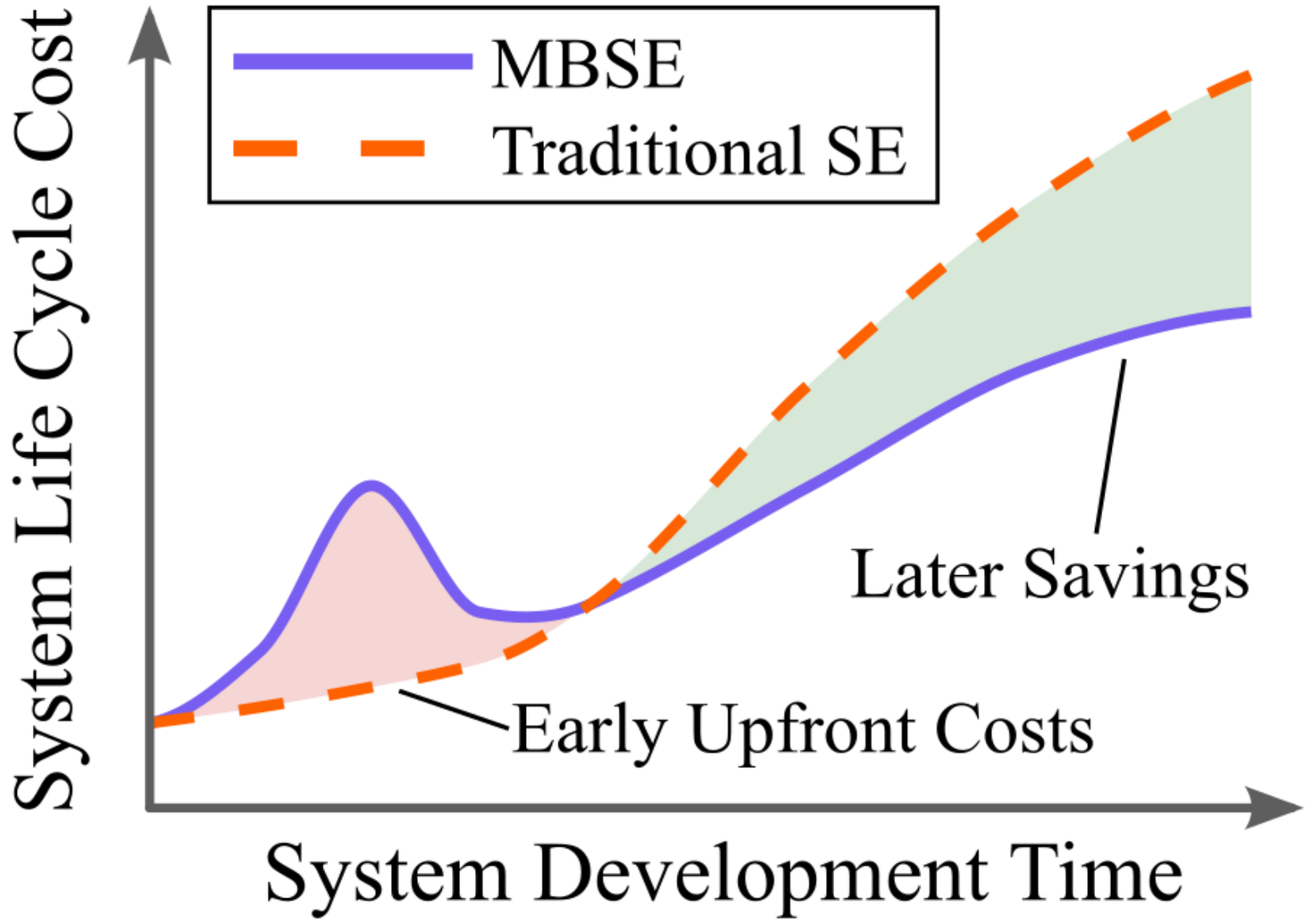
# Relative Advantage

“The degree to which an innovation is perceived as being better than the idea it supersedes”

**Current Perception**

- Early upfront cost hurts the perceived relative advantage

**Opportunities**


System Life Cycle Cost
MBSE
Traditional SE
Later Savings
Early Upfront Costs
System Development Time

# Relative Advantage

“The degree to which an innovation is perceived as being better than the idea it supersedes”

## Current Perception

- Early upfront cost hurts the perceived relative advantage
- Preventative innovation

## Opportunities

- Recognition of the upfront cost and improved understanding of lifecycle cost
- Further development of open-source solutions
- Improved design quality metrics

# Compatibility

"The degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters"

## Current Perception

- MBSE is new and different
- What need does MBSE meet?

## Opportunities

- Tailor MBSE methodology to existing systems engineering processes
- Focus on the needs that MBSE meets:
  - Enforce consistency
  - Error reduction
  - Authoritative source of truth

# Complexity

"The degree to which an innovation is perceived as relatively difficult to understand and use"

## Current Perception

- HIGH complexity
  - New language, tools, and processes

## Opportunities

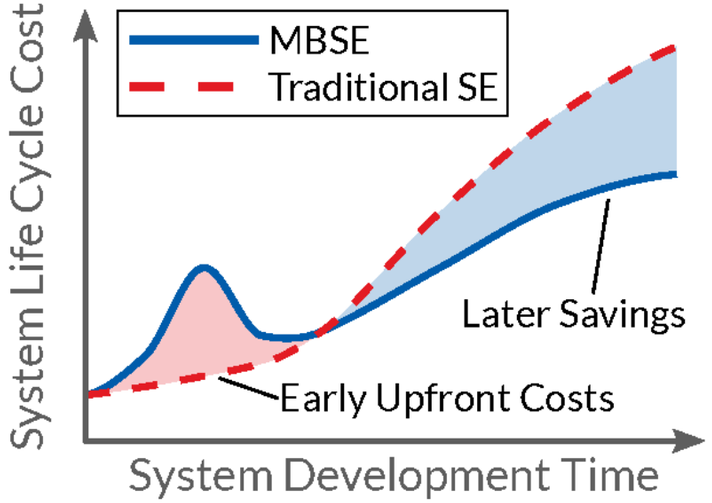
- Clear modeling purpose
- Established roles

# Trialability

"The degree to which an innovation may be experimented with on a limited basis"

## Current Perception

- All or nothing
- High cost of entry




## Opportunities

- Pilot projects
  - Limited modeling scope
- Further development of open-source solutions
- Utilize tool vendor trial licenses and training

# Observability

"The degree to which the results of an innovation are visible to others"

**Current Perception**

- Hard to see problems that are prevented

**Opportunities**

- Conduct design reviews and working groups directly from modeling tool
- Improve design quality metrics

# MBSE Adoption Success Story

- The NASA MBSE pathfinder projects and follow-on MBSE infusion and modernization initiative (MIAMI) are compelling examples of how elements of the theory of the diffusion of innovations can explain the rate of adoption of MBSE within an organization
  - **Relative Advantage-** Identified quantitative and qualitative benefits of MBSE from their earliest efforts
  - **Compatibility-** Integrated their MBSE efforts with existing SE and domain engineering processes
  - **Complexity-** Decreased by identifying specific purposes for each of the pathfinder projects and all the stakeholders knew how MBSE contributed to those purposes
  - **Trialability-** Each of these projects and initiatives represent limited trials of MBSE and each resulted in an expansion of the scope of MBSE work within the organization leading to plans for enterprise-wide implementation of MBSE
  - **Observability-** Increased observability by publishing the results of the effort



Holladay, Jon B., Jessica Knizhnik, Karen J. Weiland, Amanda Stein, Terry Sanders, and Paul Schwindt. 2019. “MBSE Infusion and Modernization Initiative (MIAMI): ‘Hot’ Benefits for Real NASA Applications.” In *IEEE Aerospace Conference Proceedings*. Vol. 2019-March. https://doi.org/10.1109/AERO.2019.8741795.

# Research Objectives

- **Research objective 1:** Complete a thorough literature review of extant publications relating to MBSE adoption and adoption challenges to identify trends that may be explained by the diffusion of innovations theory.
- **Research objective 2**: Conduct a survey of the SE community to assess the applicability of the diffusion of innovations theory by looking for a correlation between variables identified by the diffusion of innovations theory and MBSE use.
- **Research objective 3:** Develop specific recommendations, based on the diffusion of innovations theory, of ways that the practice of MBSE and the presentation of MBSE could be improved to accelerate its adoption.

# Research Objective 1

*Complete a thorough literature review of extant publications relating to MBSE adoption and adoption challenges to identify trends that may be explained by the diffusion of innovations theory.*

- Identify and document evidence-based benefits of MBSE
- Document specific claims about MBSE that relate to the perceived attributes of innovations as defined by the DoIT
- Evaluate published survey data after coding responses based on perceived attributes of innovations as defined by the DoIT
- Compile literature review into a comprehensive treatment of reasons for MBSE adoption and how the DoIT is well suited to improve the adoption rate of MBSE

# Research Objective 2

*Conduct a survey of the SE community to assess the applicability of the diffusion of innovations theory by looking for a correlation between variables identified by the diffusion of innovations theory and MBSE use.*

- As adoption rate is based on ***perceptions*** of MBSE, the most appropriate tool to assess those perceptions in a survey
- The major contributions of this research will be the data, analysis, and conclusions of a survey to determine the perceptions of MBSE of the SE community
- The goal of this survey is to validate and quantify the applicability of the diffusion of innovation theory to MBSE
- A paper will be written on the development, results, and analysis of MBSE perceptions survey

## Model-Based Systems Engineering (MBSE) Attribute Assessment

### Informed Consent

Dear Participant,
My name is Daniel Call, and I am a researcher from Colorado State University (CSU) in the Systems Engineering department. We are conducting a research study on perceptions of attributes of model-based systems engineering (MBSE). The title of our project is MBSE Attribute Perception Assessment. The Principal Investigator is Daniel Herber, also from the CSU Systems Engineering department, and I am the Co-Principal Investigator.

We would like you to take an anonymous online survey. Participation will take approximately 15 minutes. Your participation in this research is voluntary. If you decide to participate in the study, you may withdraw your consent and stop participation at any time without penalty. There are no known risks associated with this study.

We will not collect your name or personal identifiers. Anonymous data collected as a part of this survey may be used in future research studies or distributed to another investigator without additional consent. When we report and share the data to others, we will combine the data from all participants. While there are no direct benefits to you, we hope to gain more knowledge on the factors that affect the adoption rate of MBSE.

To indicate your consent to participate in this research and to continue to the survey, please click "Next Page" button below.

If you have any questions about the research, please contact Daniel Call at daniel.call@colostate.edu. If you have any questions about your rights as a volunteer in this research, contact the CSU IRB at: CSU_IRB@colostate.edu; 970-491-1553.

Thank you for your participation in this research-- your help is greatly appreciated!

| | |
|---|---|
| Daniel Call | Daniel Herber |
| Co-Principal Investigator | Principal Investigator |

# MBSE Attribute Assessment

- Survey hosted on Qualtrics Experience Management (XM) provided by CSU
- Institutional Review Board (IRB) determined EXEMPT from review (Protocol #4247)
- 6 warming up questions
- 18 questions about the five attributes of MBSE
- 11 questions on model-use based on INCOSE model-based capability matrix (MBCM)
- 7 demographic questions

# Warming Up Questions

- The first section of the survey is meant to orient the participants to a common of understanding of digital engineering (as defined by the DoD digital engineering strategy) and MBSE (as defined by INCOSE)
- The definitions of these terms are given, followed by questions about the participants familiarity with the terms and involvement in work related to these terms

Zimmerman, Philomena, Tracee Gilbert, and Frank Salvatore. 2019. “Digital Engineering Transformation across the Department of Defense.” *Journal of Defense Modeling and Simulation: Applications, Methodology* 16 (4): 2017. https://doi.org/10.1177/1548512917747050.

Walden, David D., Garry J. Roedler, and Kevin Forsberg. 2014. “INCOSE Systems Engineering Handbook Version 4.” *INCOSE International Symposium* 24 (s1). https://doi.org/10.1002/j.2334-5837.2014.00042.x.

# Perceived Attributes of Innovations

- 18 statements with a 5-point Likert scale for response
  - (Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree)
- Questions presented in a randomized order
- Some questions negatively coded (“Strongly Agree” results in lower score)
- Question breakdown
  - Relative advantage- 5
  - Compatibility- 3
  - Complexity- 5
  - Trialability- 3
  - Observability- 2

# Model-Use

- This section based on INCOSE model-based capability matrix (MBCM)
- MBCM has 42 total model-based capabilities sorted by eight different role-based areas (workforce/culture, SE processes/methodology, program/project processes methodology, model-based effectiveness, IT infrastructure, modeling tool construction, model use, and modeling policy)
- Columns represent the stage of that capability, ranging from Stage 0 (no capability) to Stage 4 (enterprise-wide capability).
- 11 total questions- two questions were included for each of the role-based areas except for model use which has one question and IT infrastructure and modeling policy which do not have any questions.
- Each question in this section was presented with a statement based on the stage 3 level of each model-based capability with a five-point Likert scale for the participant to indicate their agreement with the statement as it pertains to their organization



Hale, Joe, and Al Hoheb. 2020. “INCOSE Model-Based Capabilities Matrix and User’s Guide.”

# Organization Demographics

- Sector
- Life cycle stage
- Organization Size
- Formal systems engineering plan (model or document based)
- Digital engineering mandates
- Innovation and Experimentation
- Experience

# Survey Analysis

- Data can be analyzed in Qualtrics or downloaded for analysis in any statistics tool
- Likert scale data is ordinal, not interval
  - No way to quantify the difference between “Strongly Agree” and “Agree” and compare it to the difference between “Disagree” and “Strongly Disagree”
- Determine an appropriate analysis method and develop a data analysis plan
  - Ordered logistic regression?
  - Multinomial logistic regression?
- Select data analysis tool and write scripts
- Draw conclusions

# Research Objective 3

*Develop specific recommendations, based on the diffusion of innovations theory, of ways that the practice of MBSE and the presentation of MBSE could be improved to accelerate its adoption.*

- Earlier suggestions on improving MBSE adoption were based on anecdotal experiences and not grounded in reliable evidence
- With the benefit of a completed literature review and survey conclusions identifying which of the perceived attributes of MBSE have the greatest impact on MBSE use, if any, informed recommendations can be made to improve the perceptions and adoption rate of MBSE
- Beyond the survey data that provides the basis for these recommendations, development of these recommendations will likely require additional literature review and research to understand what work has already been done and to determine the most effective ways to implement them
- These recommendations must be thorough enough that they can be independently implemented, without being prescriptive in areas beyond the scope of the evidence from the data



Call, Daniel R., and Daniel R. Herber. 2022. “Applicability of the Diffusion of Innovation Theory to Accelerate Model-Based Systems Engineering Adoption.” *Systems Engineering* 25 (6): 574–83. https://doi.org/10.1002/SYS.21638.

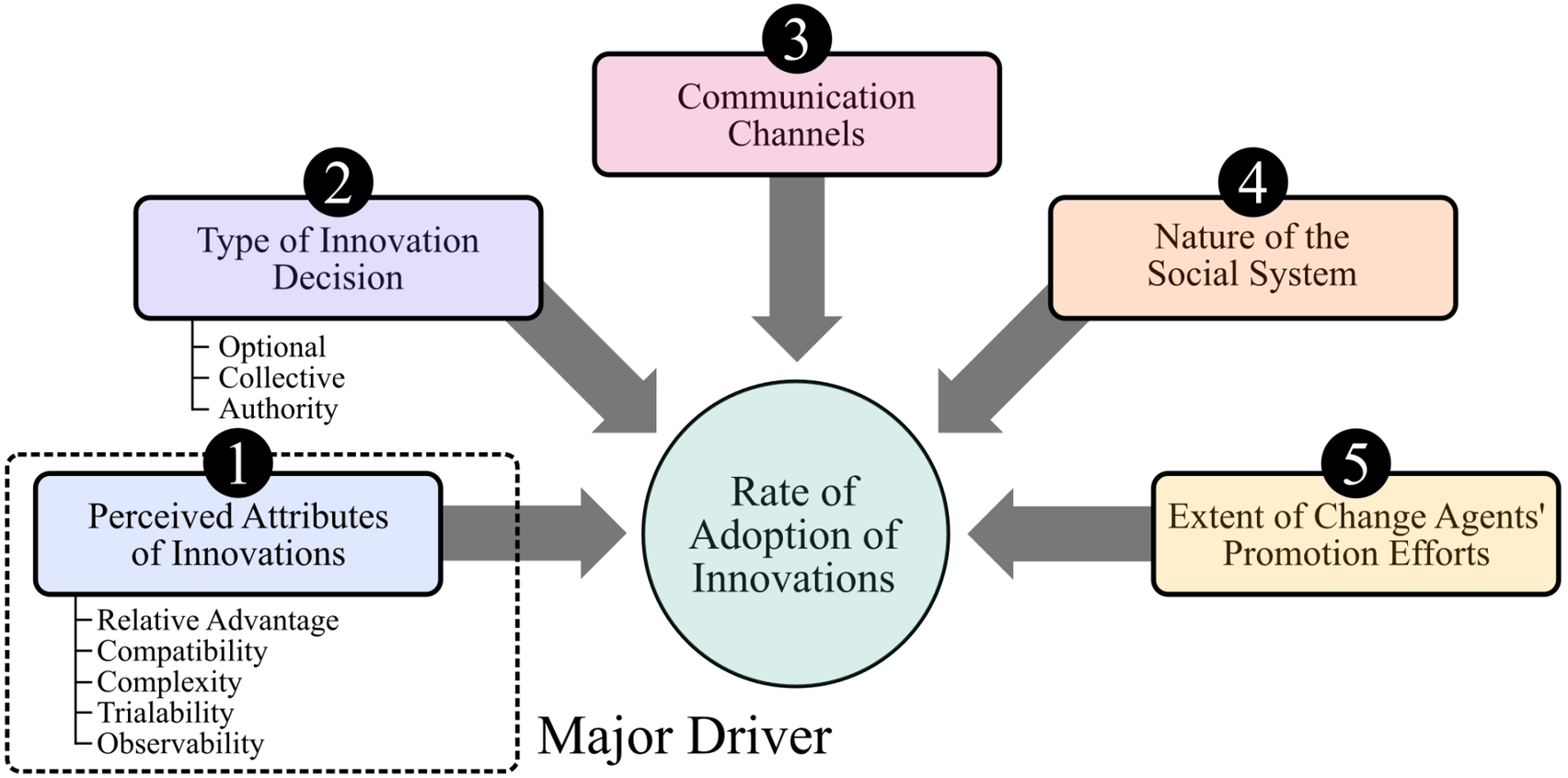
# Publications

- Call, Daniel R., and Daniel R. Herber. 2022. “Applicability of the Diffusion of Innovation Theory to Accelerate Model-Based Systems Engineering Adoption.” Systems Engineering 25 (6): 574–83. https://doi.org/10.1002/SYS.21638.
  - Call, Daniel. 2022. “IW2022 MBSE Lightning Rounds - When You Build It and They Do Not Come.” https://www.youtube.com/watch?v=iVLHR4mh4qc.
- Call, Daniel R., and Daniel R. Herber. 2023. “A Case for Model-Based Systems Engineering in an Agile World and Principles for Growth.” In (To Appear) INCOSE 2023 Annual International Symposium. Honolulu, HI, USA.
- Will prepare and submit a paper on the development, results, and analysis of MBSE perceptions survey

# Future Work

- Investigate applicability of the remaining variables identified by the DoIT

# Adoption Rate Variables



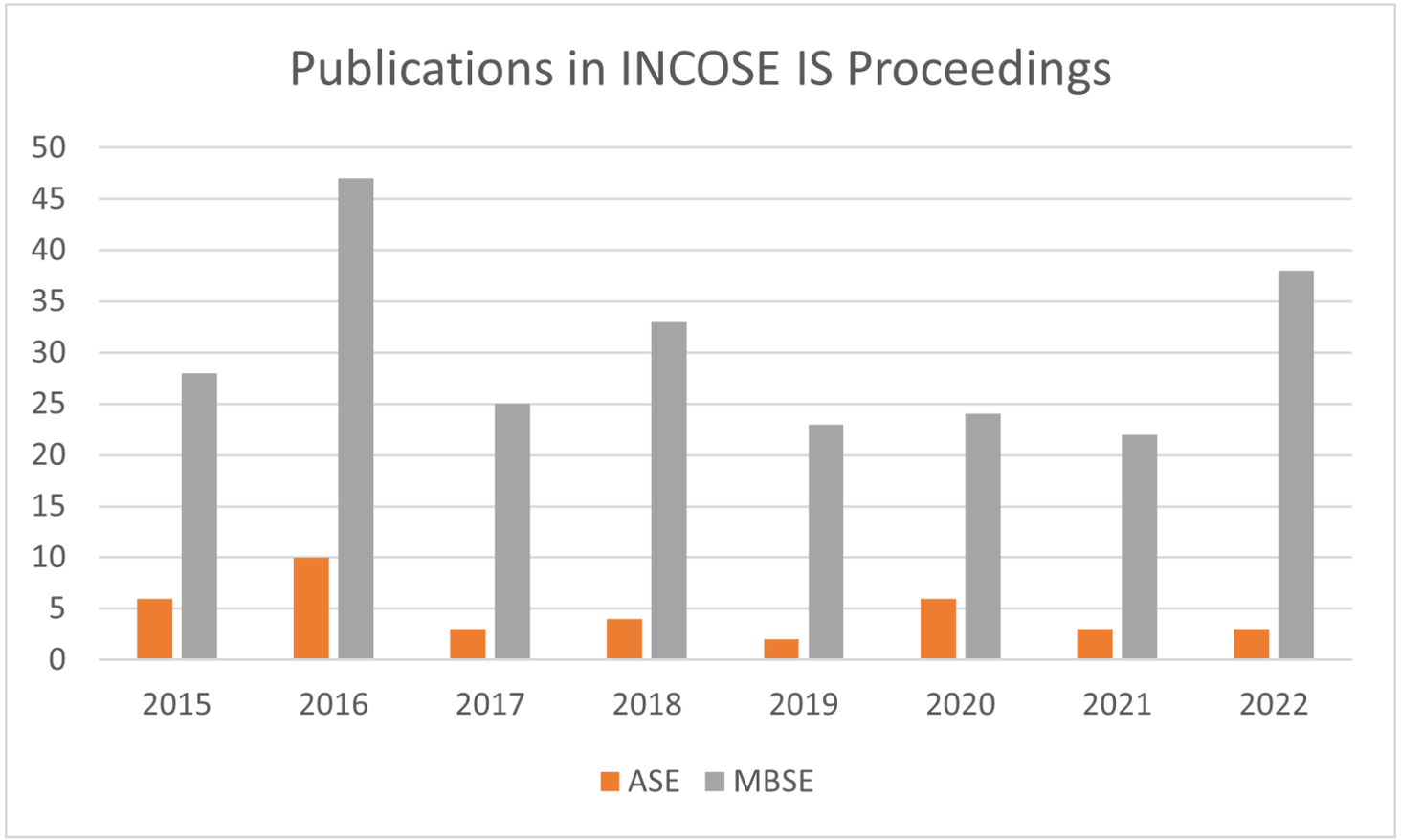



Rogers, Everett M. 2003. *Diffusion of Innovations, 5th Edition*. Social Science / The Free Press. Free Press.

# Future Work

- Investigate applicability of the remaining variables identified by the DoIT
- Further development of agile systems engineering principles and practices

# ASE vs. MBSE Publications



# Future Work

- Investigate applicability of the remaining variables identified by the DoIT
- Further development of agile systems engineering principles and practices
- Study of the underlying scientific principles of systems engineering to advance the scientific basis of the discipline

# Questions?

# Thank you

Colorado State University