Helix: Developing an Understanding of Organizational Systems Engineering Effectiveness

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Helix: Developing an Understanding of Organizational Systems Engineering Effectiveness

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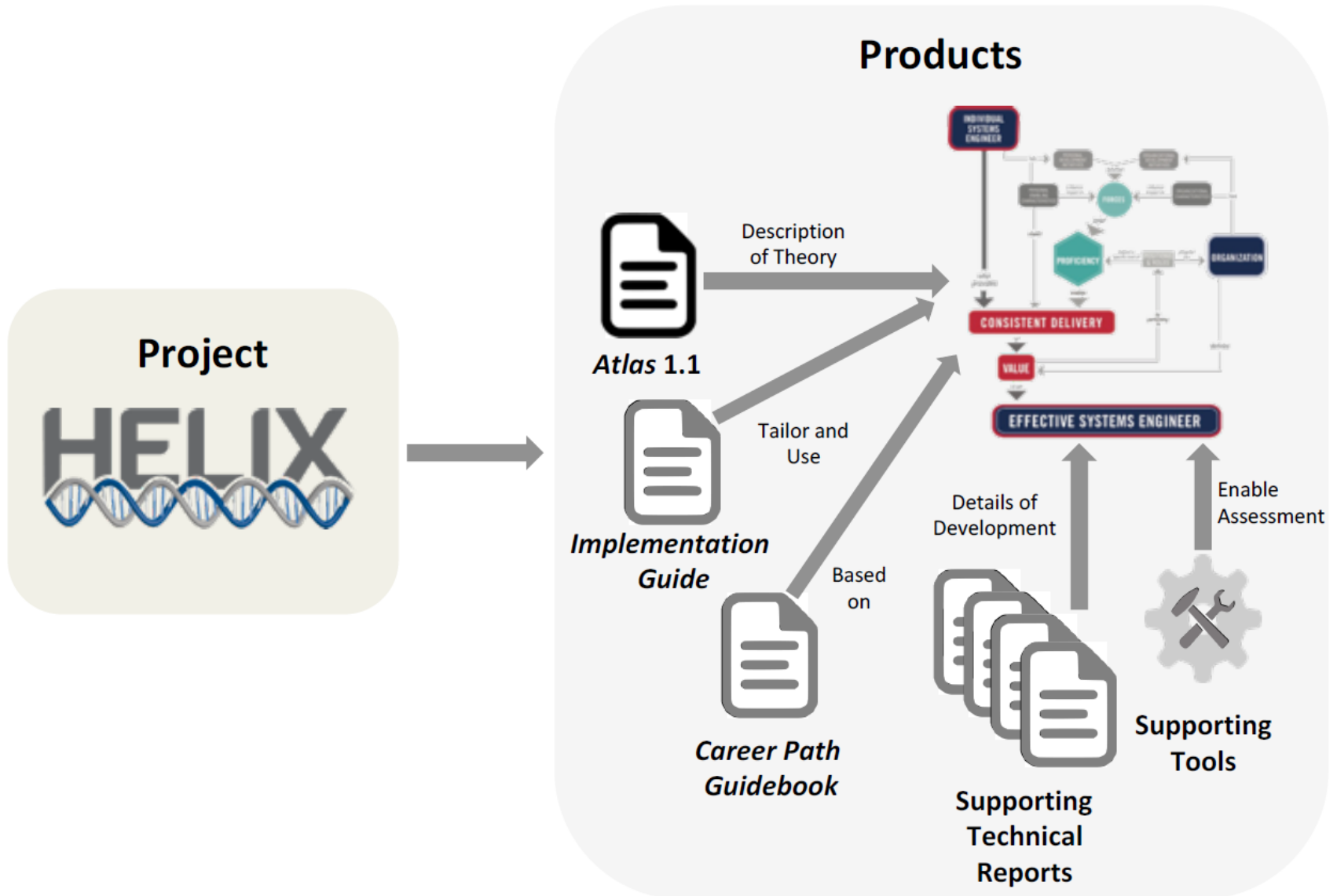**Mr. Bruno Salgado**

Stevens Institute of Technology

**2018 NDIA Systems Engineering Conference**

- Motivation

- Overview of the Helix Project

- Introduction

- Research Tasking and Objectives

- Research Methodology

- Data Collection

- Helix Dataset

- Proficiency Patterns

- Current State of Helix

- Future Directions

- An improved systems engineering capability is a recognized U.S. Department of Defense (DoD) science and technology priority.

- **The DoD is eager to understand:**

  - The capabilities of its existing SE workforce.

  - The capabilities of the existing defense industry workforce.

  - Any capability gaps that will impact the development of future systems.

  - How retirement of senior systems engineers will impact the overall workforce capabilities.

- The Helix team is currently investigating the connection between attributes of the work environment and effectiveness of the systems engineering workforce.

- Helix is a multi-year longitudinal study designed to build an understanding of the systems engineering workforce in the DoD and DIB. *(that scope is expanding)*

- Since 2012, the Helix project has investigated what makes systems engineers effective; this work culminated in *Atlas: The Theory of Effective Systems Engineers*.

- Current work incorporates the understanding of individual systems engineers defined in *Atlas*, but also incorporates more depth on organizational culture, governance, structure, and workforce composition on the systems engineering workforce effectiveness.
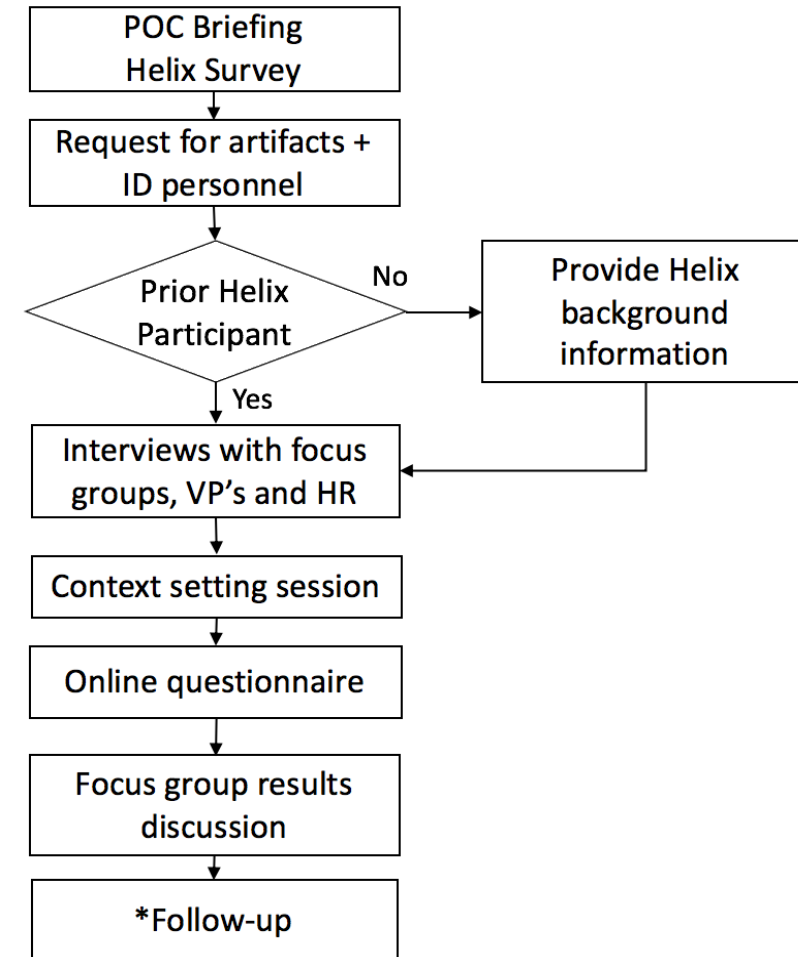

Helix

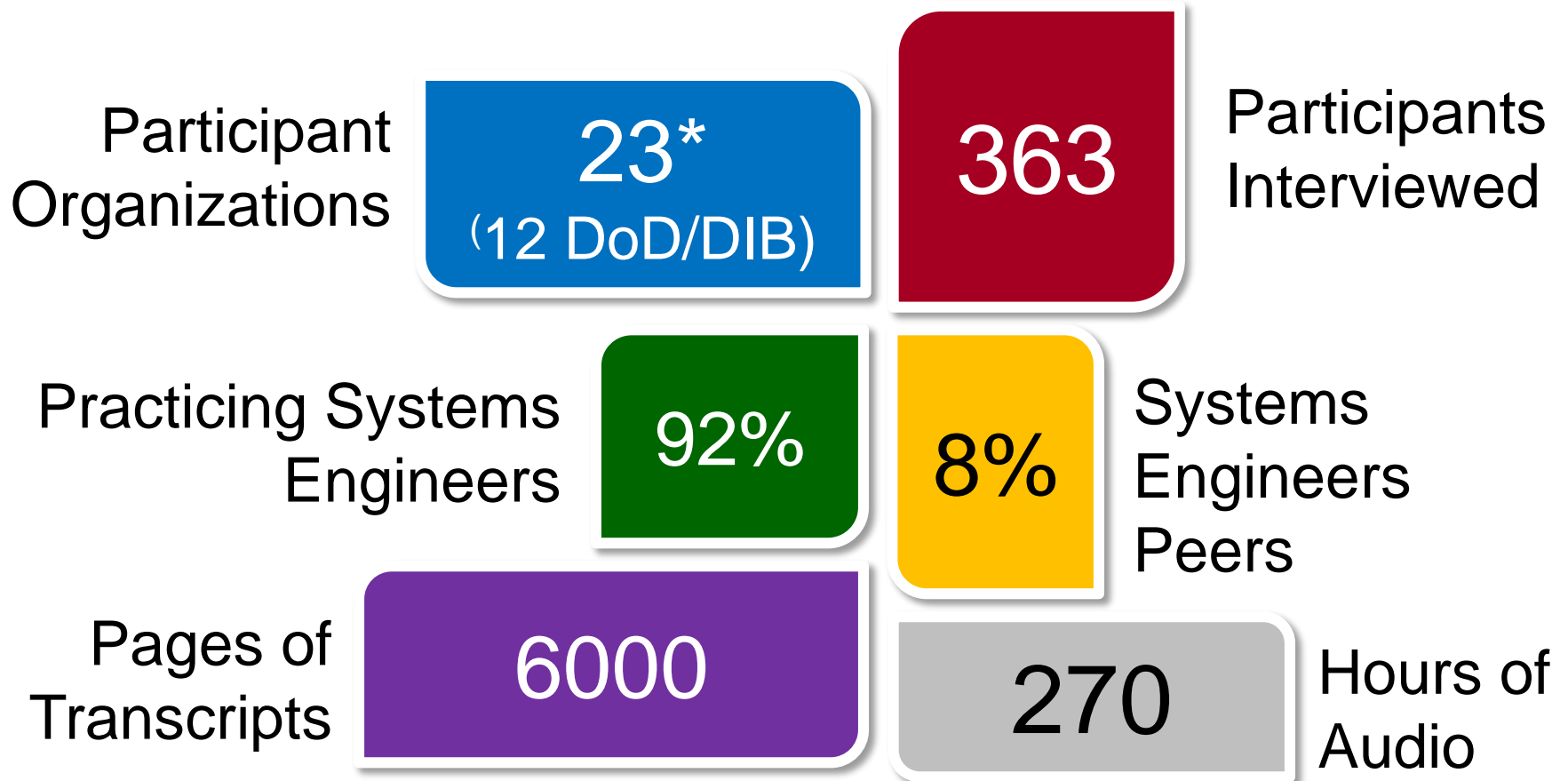| BEFORE	NOW
Focus:	*Focus:*
Individual	**Organization**
Characteristics	Characteristics
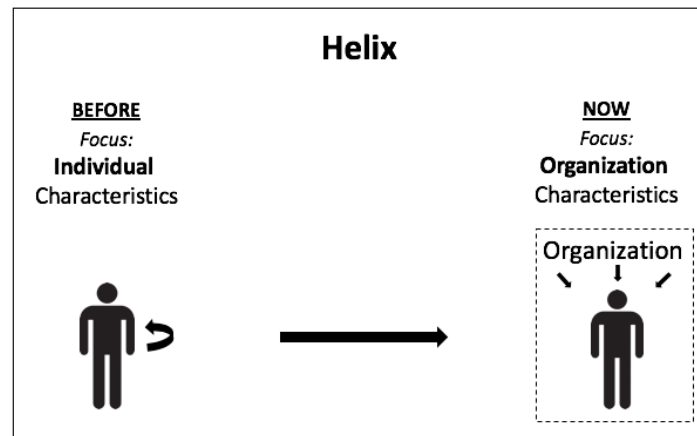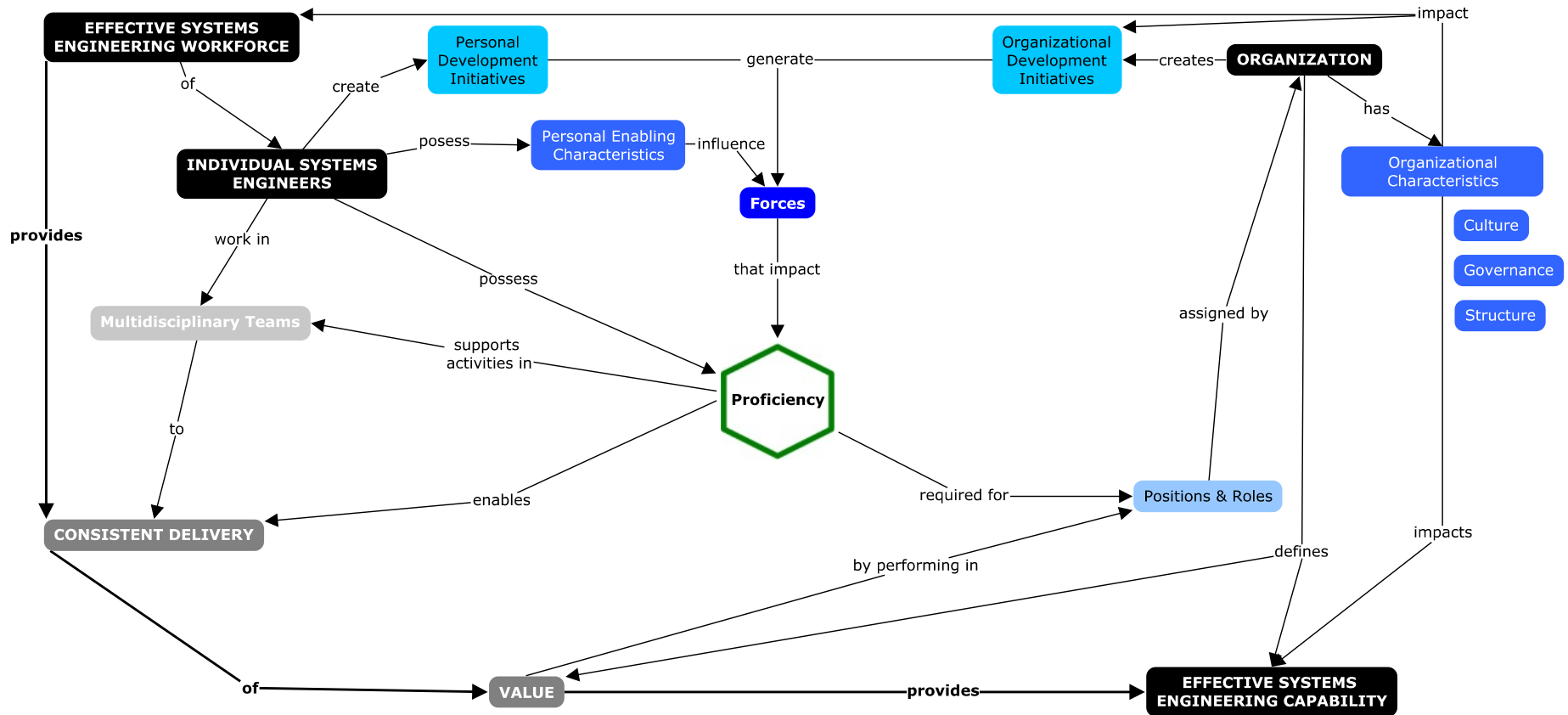
Organization

- This research task aims to provide key insights around three research questions:

  —**How can organizations improve the effectiveness of their systems engineering workforce?**

  —**How does the effectiveness of the systems engineering workforce impact the overall ability of an organization to successfully deploy increasingly complex systems and solutions (i.e., to have an effective systems engineering capability)?**

  —**What critical factors, in addition to workforce effectiveness, are required to enable systems engineering capability?**

In 2018, the Helix team has created a new methodology which:

- Builds off the learning for individual systems engineers, including improving data collection for proficiency and career path self assessments

- Delves into the culture, governance, and structure of the organizations, including:
  - **How are these intended to function?**
  - **How do they function in practice?**
  - **What is the alignment between these elements?**
  - **How do these aspects of the organization foster or inhibit systems engineering capability?**

POC Briefing Helix Survey
↓
Request for artifacts + ID personnel
↓
Prior Helix Participant —No→ Provide Helix background information
↓ Yes
Interviews with focus groups, VP's and HR
↓
Context setting session
↓
Online questionnaire
↓
Focus group results discussion
↓
*Follow-up

- Data collection has primarily been through semi-structured interviews with systems engineers.

- The new methodology utilizes a combination of in-person interviews, a web-based survey, and self-assessments to provide a holistic picture of the state of systems engineering practice within an organization.

- Reporting is done in an aggregated anonymous manner that does not reveal the identities of participating individuals or organizations.

SYSTEMS ENGINEERING RESEARCH CENTER

Participant Organizations — 23* (12 DoD/DIB)

363 — Participants Interviewed

Practicing Systems Engineers — 92%

8% — Systems Engineers Peers

Pages of Transcripts — 6000

270 — Hours of Audio

*7 additional organizations have agreed to participate, and prior participants will reengage

Demographics of Helix Participants
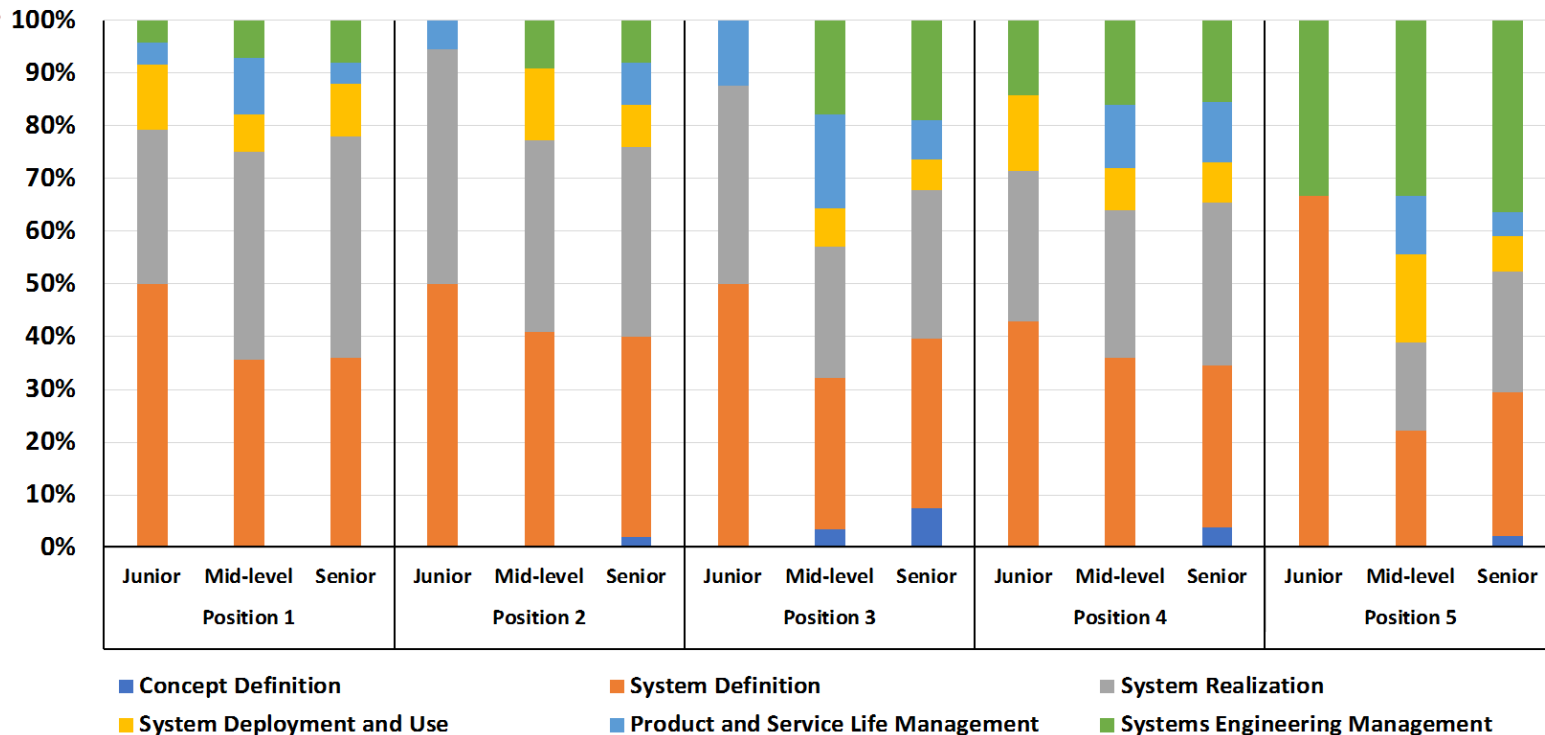
Seniority Demographics
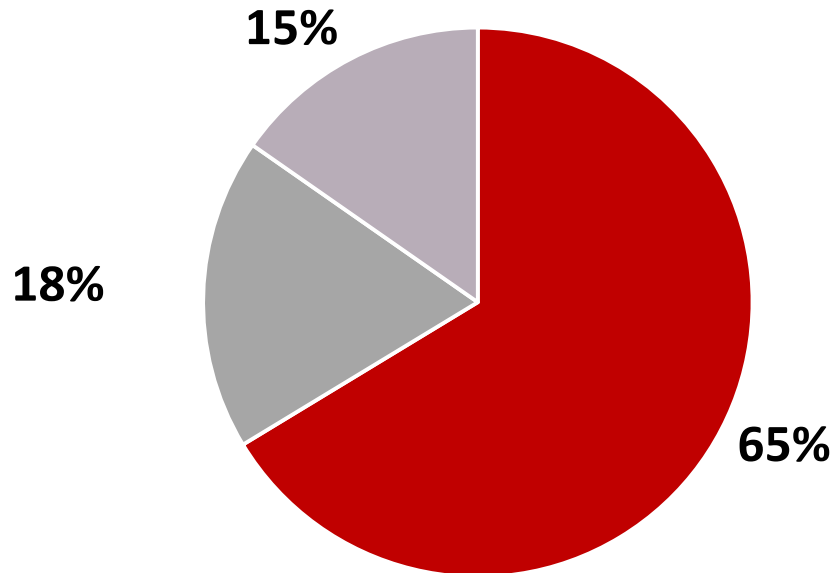
Why do we care about seniority?

It allows us to:

- Compare across individuals and groups at different parts of their careers

- Highlight differences in the way that senior systems engineers have developed and how junior and mid-level systems engineers are developing

Comparison of Lifecycle Stage by Seniority Level and Position

Legend categories:
- Systems Engineering Management
- Product Life and Service Life Management
- System Deployment and Use
- System Realization
- System Definition
- Concept Definition

Chart legend:
- Concept Definition
- System Definition
- System Realization
- System Deployment and Use
- Product and Service Life Management
- Systems Engineering Management

The Roles of Systems Engineers

Roles Focused on the System Being Developed:

- Concept Creator

- Requirements Owner

- Systems Architect

- System Integrator

- System Analyst

- Detailed Designer

- V&V Engineer

- Support Engineer
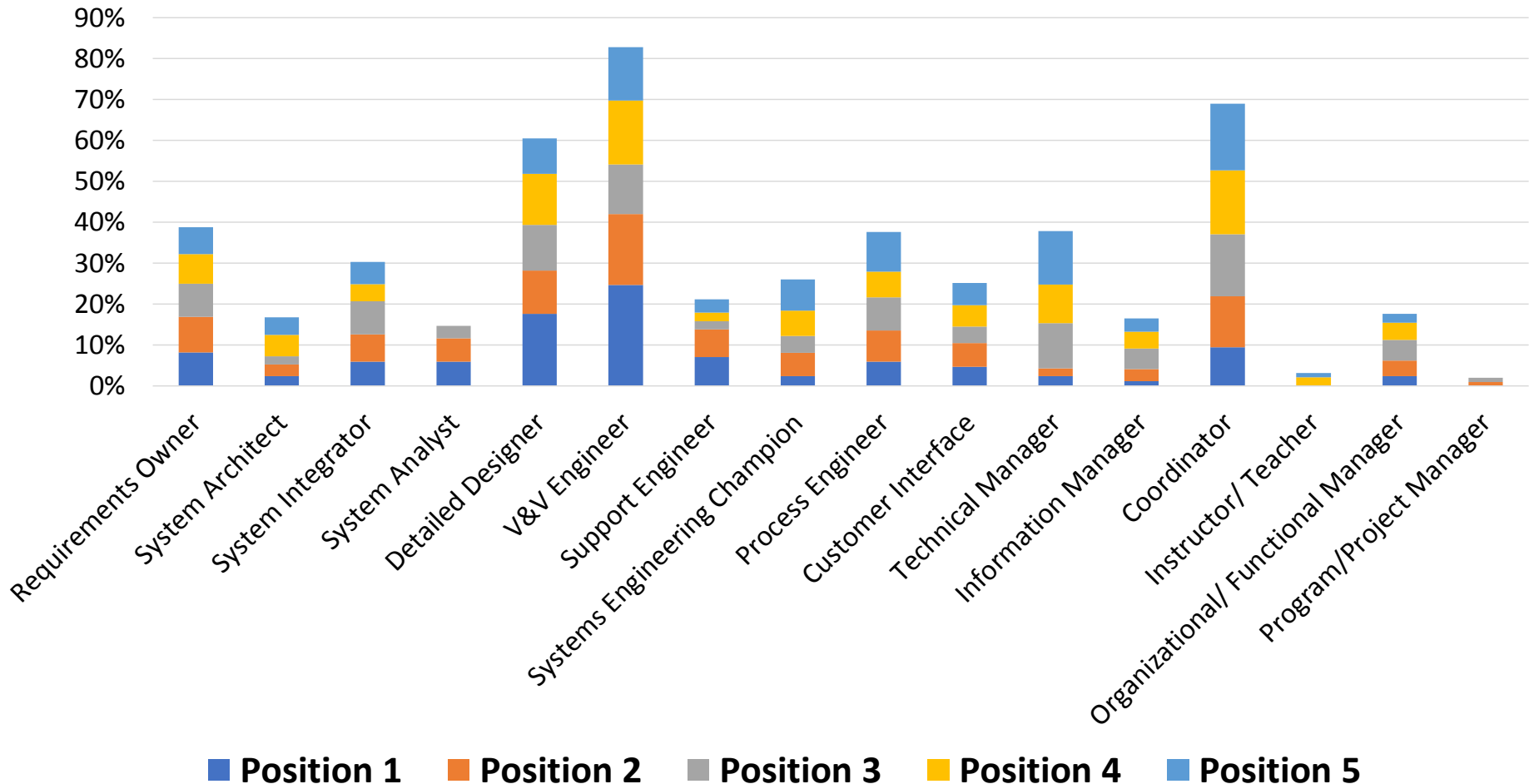
Roles Focused on SE Process and Organization:

- Systems Engineering Champion

- Process Engineer

Roles Focused on Teams That Build Systems:

- Customer Interface

- Technical Manager

- Information Manager

- Coordinator

- Instructor/Teacher

Senior SE- Comparison of Roles Performed across Positions

An Example of CSE's Roles

Position 1

System Analyst
Detailed Designer

Position 2

System Analyst

Position 3

Requirements Owner
System Architect

Position 4

System Architect
Detailed Designer
Support Engineer

Position 5

Requirements Owner
System Architect
Detailed Designer
V&V Engineer

Position 6

Requirements Owner
Detailed Designer
Technical Manager
Information Manager
Program/Project Manager

Position 7

Detailed Designer
Systems Engineering Champion
Process Engineer

Position 8

Information Manager
Org/Functional Manager

Position 9

Requirements Owner
Detailed Designer
Customer Interface
Coordinator
Org/Functional Manager

Position 10

System Architect
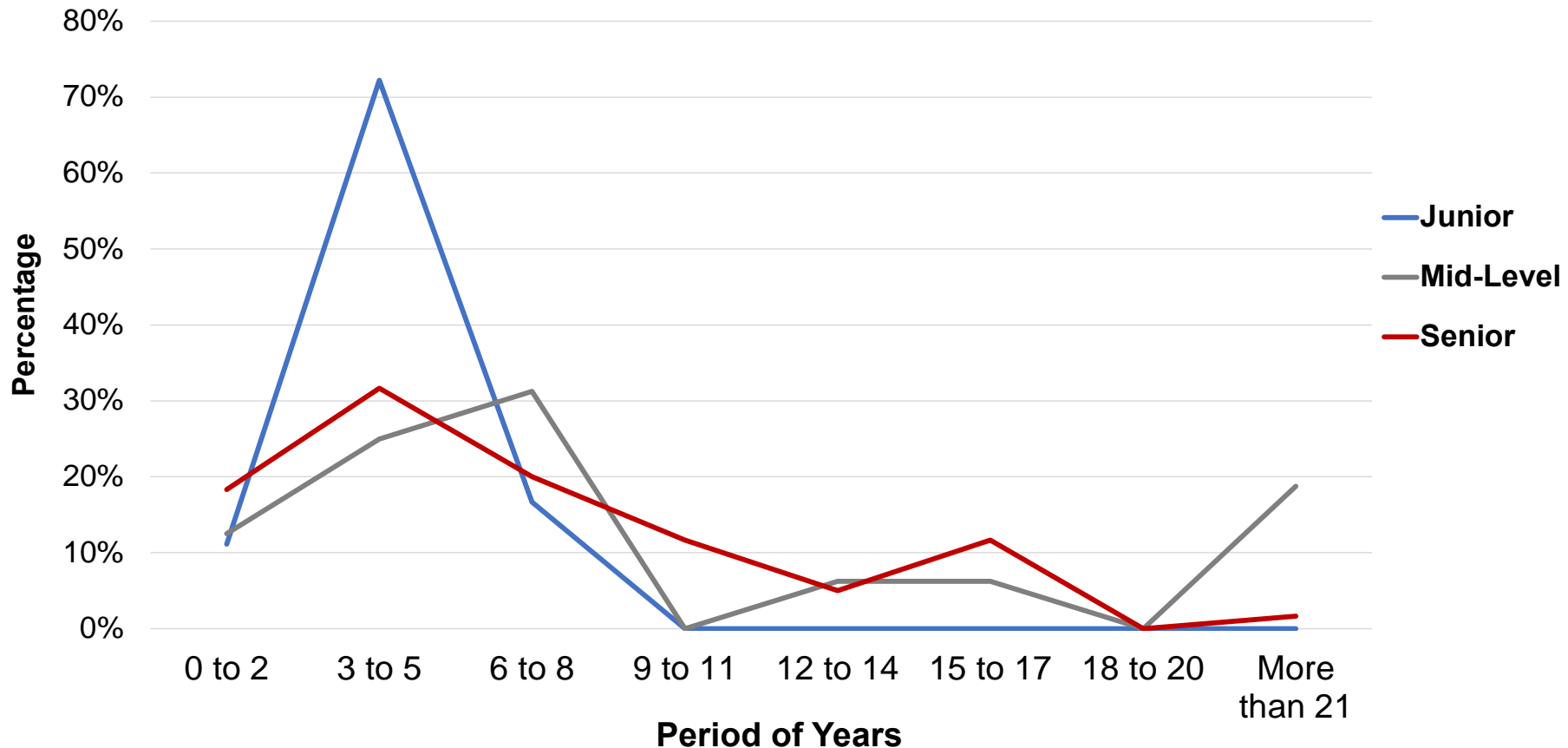System Integrator
Coordinator

Position 11

System Architect
V&V Engineer
Systems Engineering Champion
Process Engineer
Customer Interface
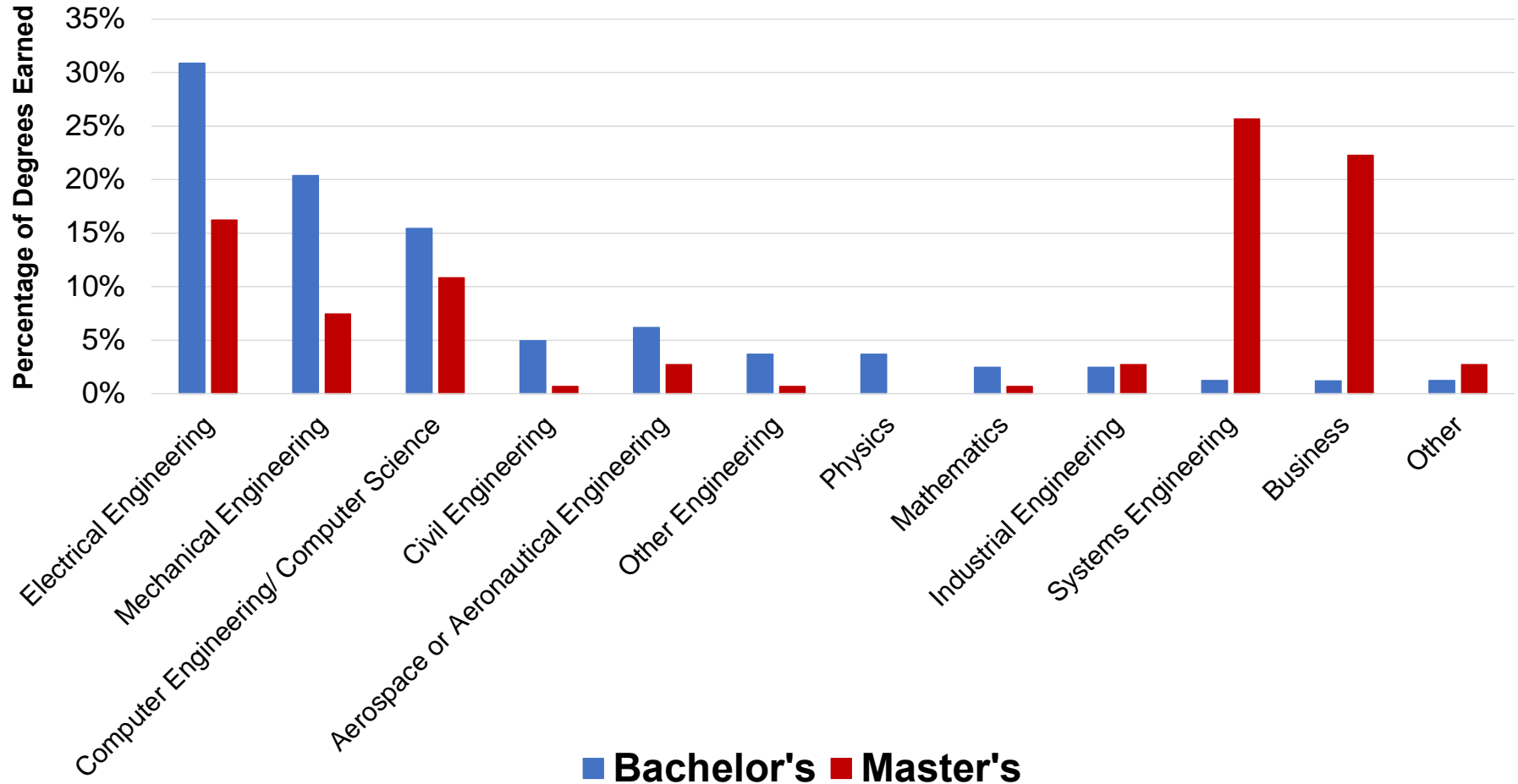Technical Manager
Information Manager
Coordinator

Position 12

Instructor/Teacher

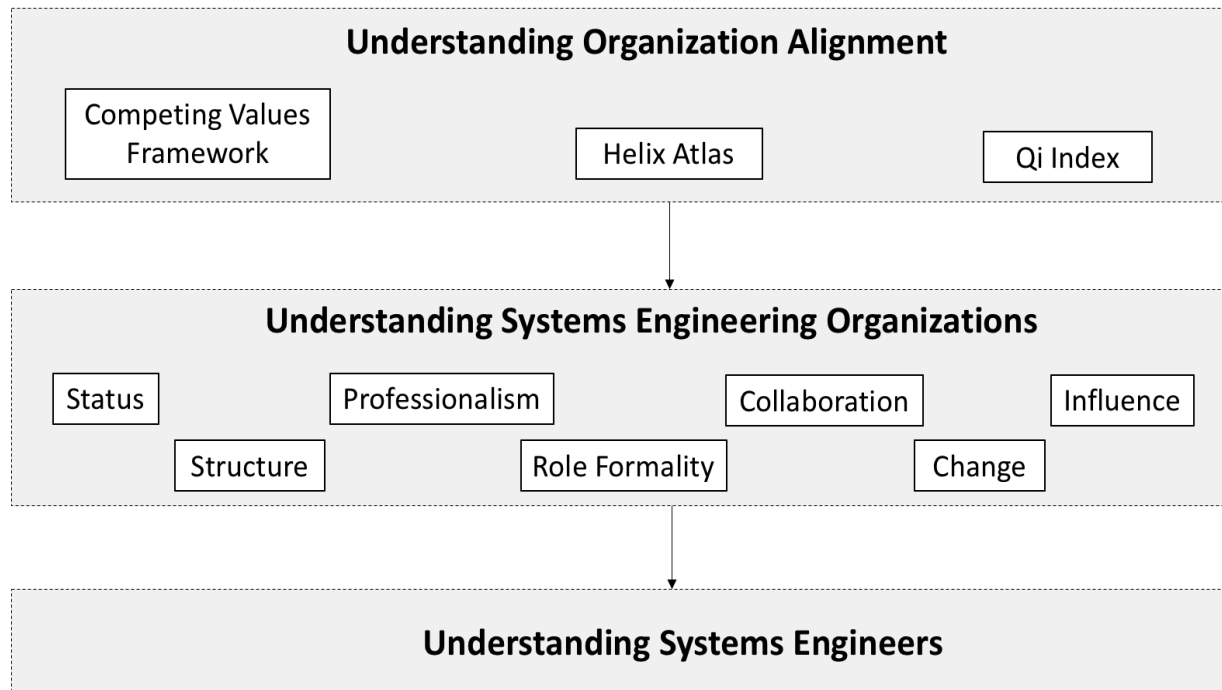## Time between Completion of Undergraduate and Graduate Education

Comparison of Degrees Earned: Bachelor's vs Master's

Current State of Helix
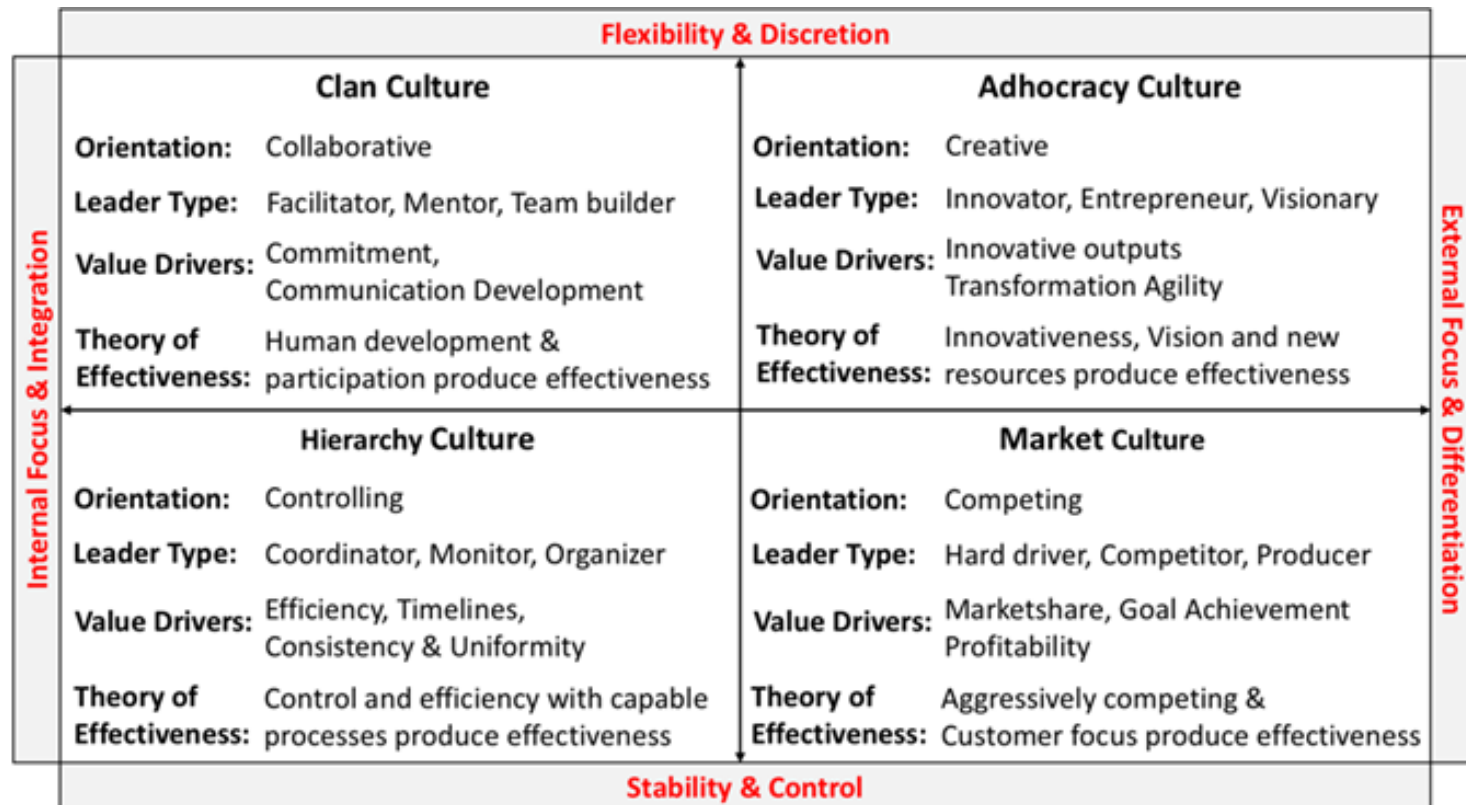
Updated Helix Methodology

- In 2018, the Helix team has created a new methodology which:

  - Builds off the learning for individual systems engineers, including improving data collection for proficiency and career path self assessments

  - Delves into the culture, governance, and structure of the organizations, including:

    - **How are these intended to function?**

    - **How do they function in practice?**

    - **What is the alignment between these elements?**

    - **How do these aspects of the organization foster or inhibit systems engineering capability?**

- The new methodology utilizes a combination of in-person interviews, a web-based survey, and self assessments to provide a holistic picture of the state of systems engineering practice within an organization.

- The new methodology includes a web-based survey, which is a combination of *Atlas 1.1* with two well-established culture assessment tools called the Competing Values Framework and the Quality of Interaction Index (Qi Index) to understand the alignment of systems engineering organizations.

Understanding Organization Alignment

| Competing Values Framework | Helix Atlas | Qi Index |

Understanding Systems Engineering Organizations

| Status | Professionalism | Collaboration | Influence |

| Structure | Role Formality | Change |

Understanding Systems Engineers

The Competing Values Framework

- The Competing Values Framework (CVF) developed by Kim S. Cameron and Robert E. Quinn (2011) as measured by the "Organizational Culture Assessment Instrument" (OCAI), which has been used by hundreds of organizations over 25 years to understand and describe main cultural attributes that relate to organizational success.

Flexibility & Discretion

Internal Focus & Integration

Clan Culture

Orientation:	Collaborative
Leader Type:	Facilitator, Mentor, Team builder
Value Drivers:	Commitment, Communication Development
Theory of Effectiveness:	Human development & participation produce effectiveness

Adhocracy Culture

Orientation:	Creative
Leader Type:	Innovator, Entrepreneur, Visionary
Value Drivers:	Innovative outputs Transformation Agility
Theory of Effectiveness:	Innovativeness, Vision and new resources produce effectiveness

Hierarchy Culture

Orientation:	Controlling
Leader Type:	Coordinator, Monitor, Organizer
Value Drivers:	Efficiency, Timelines, Consistency & Uniformity
Theory of Effectiveness:	Control and efficiency with capable processes produce effectiveness

Market Culture

Orientation:	Competing
Leader Type:	Hard driver, Competitor, Producer
Value Drivers:	Marketshare, Goal Achievement Profitability
Theory of Effectiveness:	Aggressively competing & Customer focus produce effectiveness

External Focus & Differentiation

Stability & Control

Competing Values Framework adapted from Cameron and Quinn (2011)

The Competing Values Framework

- The Helix team is using the CVF to see how the organizational cultures impact the organization's ability to deliver systems engineering capabilities.

- The culture types are measure by a six-item survey (the OCAI), where each member of the culture divides 100 points among four alternative descriptions for the six items, depending on how similar the description is to their organization, as shown in the example below (Cameron & Quinn, 2011, pp. 30).

- The six items include dominant characteristics, leadership, management of employees, organizational glue, strategic emphasis, and criteria of success.

Example of questions adapted from the CVF survey (Cameron & Quinn, 2011, pp. 30)

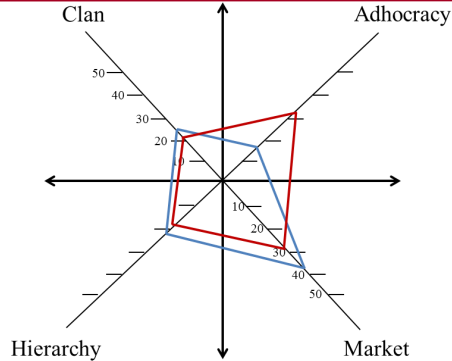| Dominant Characteristics	Now	Future
A. The organization is a very personal place. It is like an extended family. People seem to share a lot of themselves.		
B. The organization is a very dynamic and entrepreneurial place. People are willing to stick their necks out and take risks.		
C. The organization is very results oriented. A major concern is with getting the job done. People are vey competitive and achievement oriented.		
D. The organization is a very controlled and structured place. Formal procedures generally govern what people do.		
TOTAL		
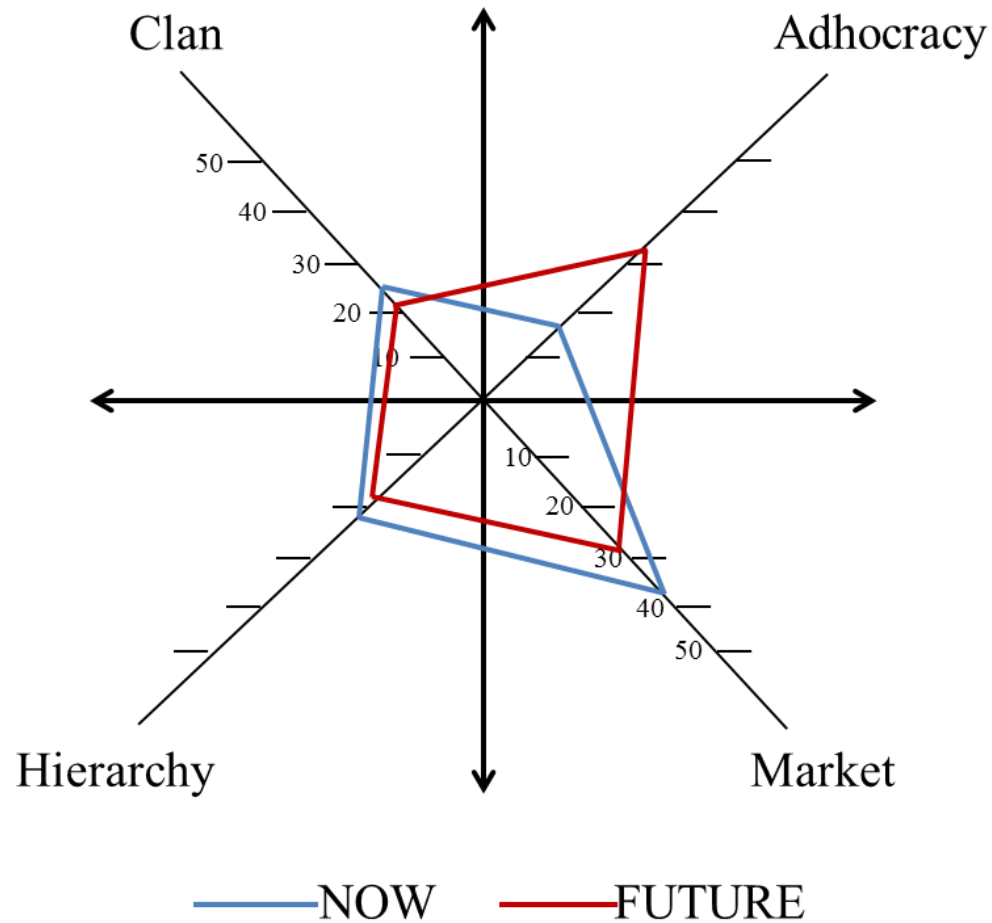
Quality of Interaction Index (Qi Index)

- Alison Reynolds developed the Qi Index, a relational and behavioral approach, to improve an organization's ability to adapt to opportunities and threats.

- Over a number of years of research and practice, the Qi Index assessment has helped organizations identify specific team behaviors that may impact the overall performance of the team.

- A new methodology is presented which is a combination of *Atlas 1.1* with two well-established culture assessment tools called the Competing Values Framework and the Quality of Interaction Index (Qi Index) to understand:
  — The types of cultures and their influence on systems engineering;
  — The relationships between governance approaches, culture, and systems engineering approaches; and
  — The links between the previous work on individual systems engineers (*Atlas*) and these organizational characteristics.

- Additional data collection with the web-based survey, site interviews, self assessments, and follow-up interviews with Helix participants.

- Continue data analysis to find organizational patterns from the organizational profiles, CVF analysis, Qi Index analysis, and the self assessments.

- Expand the modeling and simulation efforts to include natural language processing, text mining, agent-based, and system dynamics.

- Enhance the user interface of the self assessment tool.

CVF – Current and Future

NOW — FUTURE

Workforce Capability

Current
Target

Systems Processes

Governance Model

Teaming – Current and Future

Control Panel

Toggles that allow organizations to explore how organizational changes could impact SE capability

Systems Engineering CAPABILITY

Performance

Cost   Time
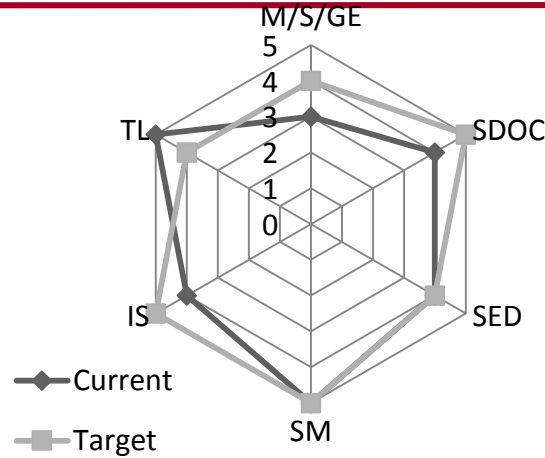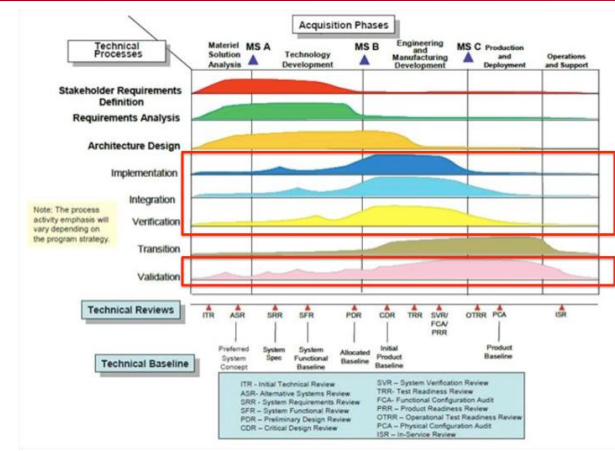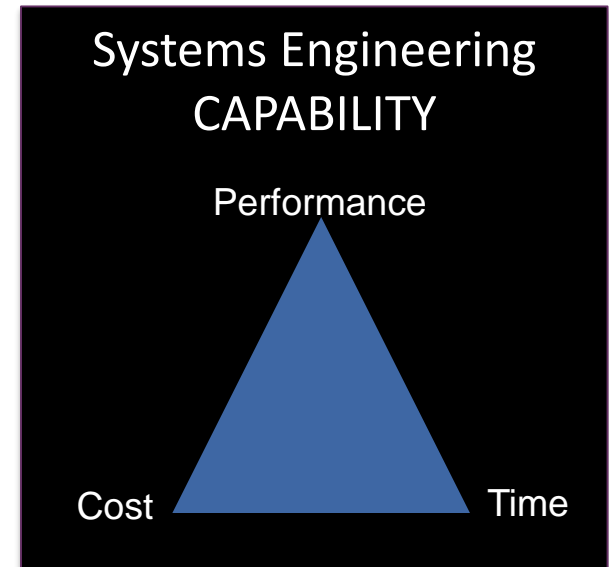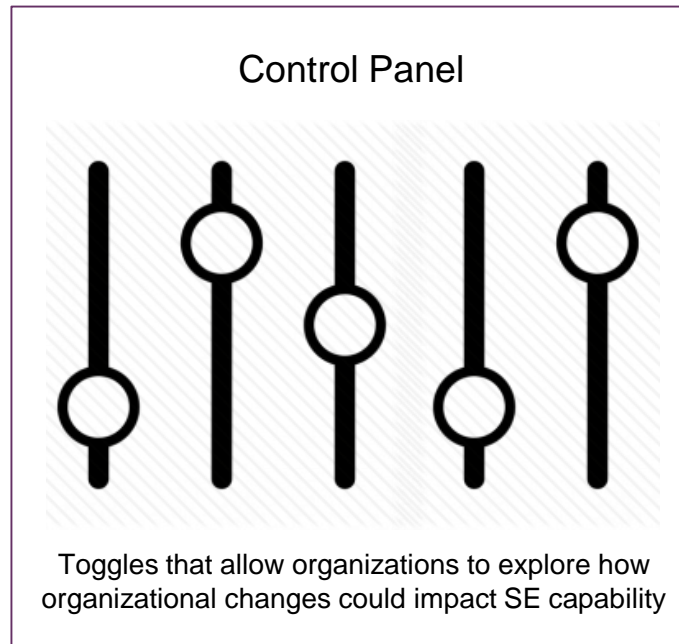
HELIX

CALL FOR PARTICIPATION

SINCE 2012, THE HELIX PROJECT HAS INVESTIGATED WHAT MAKES SYSTEMS ENGINEERS EFFECTIVE; THIS WORK CULMINATED IN ATLAS: THE THEORY OF EFFECTIVE SYSTEMS ENGINEERS. IN 2016, THE HELIX TEAM EXPANDED THE RESEARCH TO LOOK MORE CLOSELY AT THE ORGANIZATIONAL FACTORS THAT INFLUENCE SYSTEMS ENGINEERING AS A DISCIPLINE AND THE DELIVERY OF EFFECTIVE SYSTEMS ENGINEERING CAPABILITY. 364 INDIVIDUALS FROM 23 ORGANIZATIONS HAVE PARTICIPATED TO DATE.

HOW CAN I PARTICIPATE IN HELIX?

Atlas provides a framework for examining the overarching systems engineering capabilities of an organization, including: workforce proficiency, organizational culture, structure, and governance, teaming, and how these integrate to deliver effective systems engineering capability.

There are many ways to participate:

- Online survey (*just scan QR Code below)*

- Proficiency and career path self assessments
- Organizational site visits
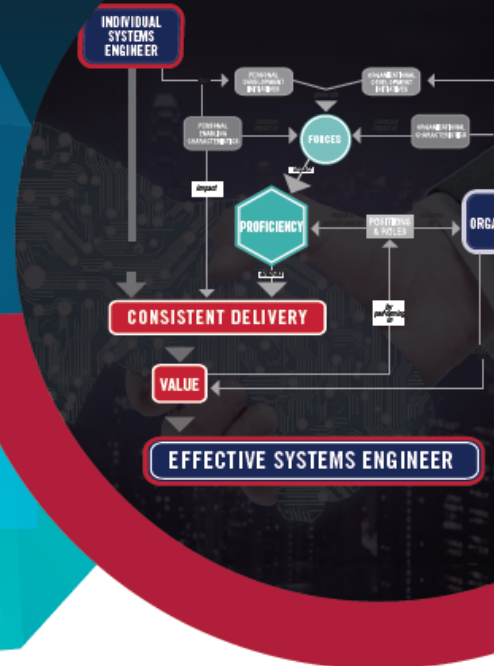
BENEFITS FROM PARTICIPATING IN HELIX

Benefits for Individuals

- Tailored proficiency profiles and career maps
- Insights into your organization

Benefits for Organizations

- Specifically tailored proficiency model.
- Assessment and analysis of individual proficiencies and career paths – this will provide baseline understanding of overall workforce proficiency.
- Understanding of organizational culture and governance – the Helix team will work with the organization's leadership to explore and understand the state of governance and the organizational culture, including micro-cultures associated with specific organizational elements, and their impact on systems engineering effectiveness.

- BKCASE Editorial Board, 2017. The Guide to the Systems Engineering Body of Knowledge (SEBoK), v. 1.9. R.D. Adcock (EIC). Hoboken, NJ: The Trustees of the Stevens Institute of Technology. Accessed 13 April 2018. Retrieved from www.sebokwiki.org
- Cameron, K. S. and Quinn, R.E. (2011). *Diagnosing and changing organization culture based on the competing values framework. Third Edition*. San Francisco, CA. Jossey-Bass.
- Cameron, K. S. and Quinn, R. E. *The Competing Values Culture Assessment: A Tool from the Competing Values Product Line*. Accessed 12 May 2018. Retrieved from: http://cf2015.bhcarroll.edu/files/session-1-congregational-development/quinn-and-cameron-organizational-culture-assessment-instrument.pdf
- Campbell, D. T., Bownas, E. A., Peterson, N. G. and Dunnette, M. D. (1974). *The measurement of organizational effectiveness: A review of relevant research and opinion.* Minneapolis, MN: Navy Personnel Research and Development Center.
- Department of Defense, 2013. "SPRDE Functional Career Field: Critical Acquisition Workforce Data FY 2013-Q3 (as of June 20, 2013)." U.S. Department of Defense, Office of the Undersecretary of Defense for Acquisition, Technology, and Logistics (OUSD (AT&L)).
- GAO, 2008. "Defense Acquisitions: Assessments of Selected Weapon Programs". Government Accountability Office (GAO). GAO-08-467SP.
- GAO, 2011. "Weapons Acquisition Reform: Actions Needed to Address Systems Engineering and Developmental Testing Challenges". Government Accountability Office (GAO). GAO- 11-806.
- GAO, 2012. "Weapons Acquisition Reform: Reform Act Is Helping DOD Acquisition Programs Reduce Risk, but Implementation Challenges Remain". Government Accountability Office (GAO). GAO-13-103.
- GAO, 2013. *"High Risk Series: An Update"*. Government Accountability Office (GAO). GAO-13-283.
- GAO, 2018. *"Federal Acquisitions: Congress and the Executive Branch Have Taken Steps to Address Key Issues, but Challenges Endure"*. Government Accountability Office (GAO). GAO-18-627.
- Gordon, G. W., 1985. *The relationship between corporate culture and industry sector and corporate performance*. In Kilmann, R. H. and Associates, *Gaining control of corporate culture*. San Francisco: Jossey-Bass.
- Hofstede, G., 1980. *Culture's consequences.* Thousand Oaks, CA: Macmillan.
- Hutchison, N., Verma D., Burke P., Clifford M., Giffin R., Luna, S., and Partacz, M., 2018. *"Atlas1.1: An update to the Theory of Effective Systems Engineers"*. Hoboken, NJ: Systems Engineering Research Center, Stevens Institute of Technology.
- Hutchison, N., Verma D., Burke P., Clifford M., Giffin R., Luna, S., and Partacz, M., 2018b. *"Atlas Career Path Guidebook: Patterns and Common Practices in Systems Engineer's Development"*. Hoboken, NJ: Systems Engineering Research Center, Stevens Institute of Technology.
- Kotter, J. P. and Heskett, J. L. (1992). *Corporate culture and performance*. New York: Free Press.
- Martin, J. (1992). *Cultures in organizations*. New York: Oxford University Press.

- Manning, C., M. Surdeanu, J. Bahuer, J. Finkel, S. Bethhard and D. McClosky. 2014, "The Standford CoreNLP Natural Language Processing Toolkit". In proceedings of 52nd Annual Meeting of the Association for Computational Linguistics: Systems Demonstrations, pages 55-60.
- Partacz, M., Hutchison N., Verma, D., 2017. "Building a Better Business Case for Systems Engineering: The Relationship between a Systems Engineer's Career Path, Proficiency, and Project Performance". Hoboken, NJ: Stevens Institute of Technology.
- Pyster, A., Henry, D., Hutchison, N., Lasfer, K., Rifkin, S., 2013a. "The Helix Project". Systems Engineering Research Center, Stevens Institute of Technology.SERC-2013-TR-038-1, May 20, 2013.
- Pyster, A., Pineda, R., Henry, D., Hutchison, N., 2013b. "Helix – Phases 1 and 2". Systems Engineering Research Center, Stevens Institute of Technology. SERC-2014-TR-038-2, December 20, 2013.
- Pyster, A., Pineda, R., Henry, D., Hutchison, N., 2014. "Helix – Phase 3". Systems Engineering Research Center, Stevens Institute of Technology. SERC-2014-TR-038-3, April 19, 2014.
- Reynolds, A. and Lewis, D. (2017). *Teams solve problems faster when they are more cognitively diverse*. *Harvard Business Review*, March 30, 2017. Retrieved from https://hbr.org/2017/03/teams-solve-problems-faster-when-theyre-more-cognitively-diverse
- Reynolds, A. and Lewis, D. (2018). *The two traits of the best problem-solving teams*. *Harvard Business Review*, April 2, 2018. Retrieved from https://hbr.org/2018/04/the-two-traits-of-the-best-problem-solving-teams
- Salton, G., and Buckley, C., 1988. Term-weighting approaches in automatic text retrieval. Information Processing Management.
- Schein, E. H., 1983. Organizational culture. *Organizational Dynamics*, 83:12, 13-28.
- Schein, E. H., 2010. *Organizational culture and leadership*, (4th edition). San Francisco: Jossey-Bass.
- Swensen, S., and Mohta, N. S., 2018. *MEJM Catalyst Leadership Survey Why Big Gaps in Organizational Alignment Matter.* NEJM Catalyst, March 2018.
- Sheard, S., 1996. "*Twelve Systems Engineering Roles*." Proceedings of the International Council on Systems Engineering (INCOSE) Sixth Annual International Symposium, Boston, MA.

Questions?