Helix: Understanding Systems Engineering Effectiveness through Modeling

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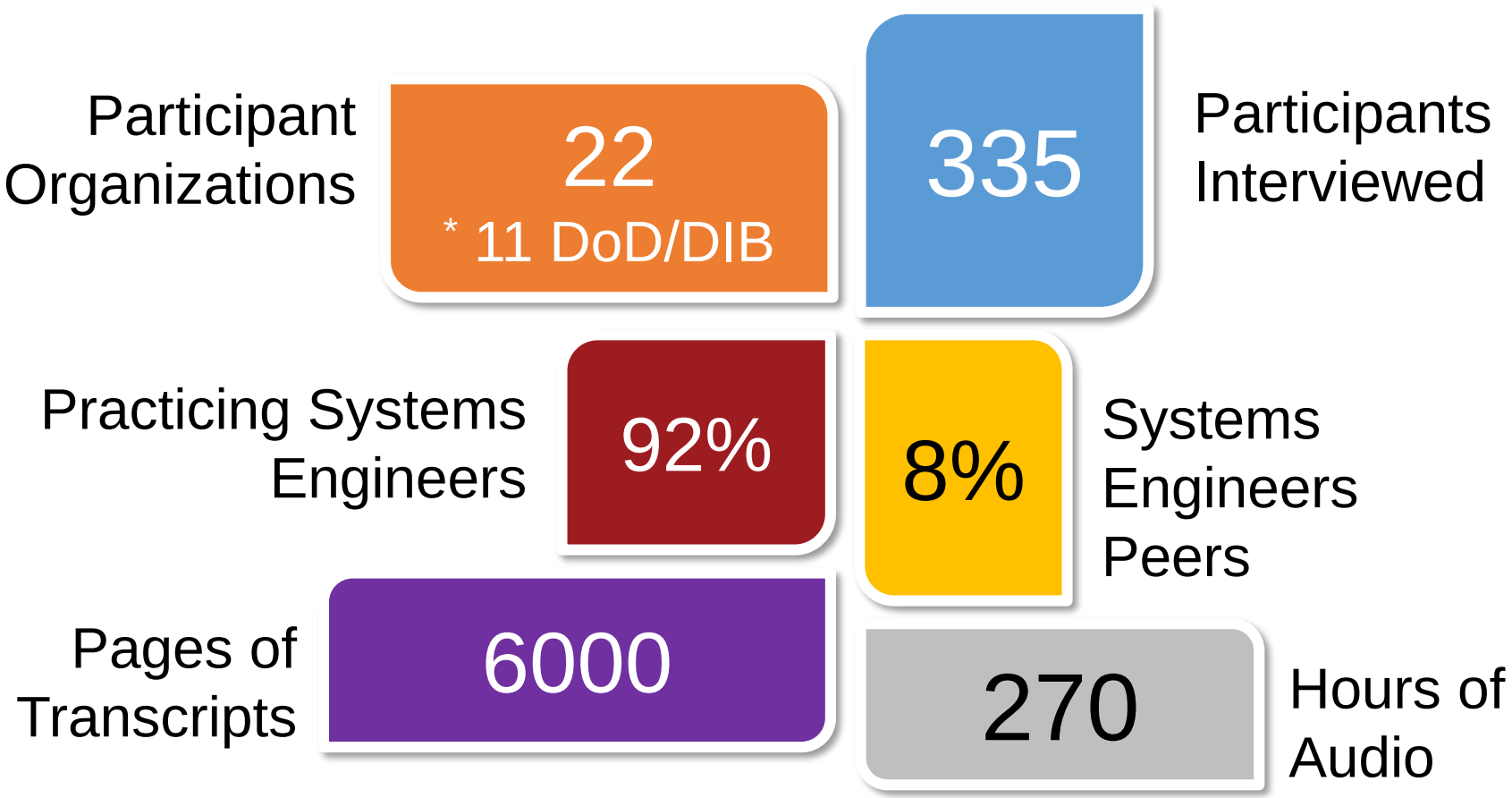
Background on Helix Research

- Helix is a multi-year longitudinal study building an understanding of the systems engineering workforce in the DoD, the Defense Industrial Base (DIB), and other sectors that perform systems engineering.
- From 2012-2016, Helix focused on three main research questions:
  1. What are the characteristics of systems engineers?
  2. How effective are those who perform SE activities and why?
  3. What are employers doing to improve the effectiveness of systems engineers?
- Most data collection has been through face-to-face, semi-structured interviews with systems engineers
- Reporting is done in an aggregated anonymous manner that does not reveal the identities of participating individuals or organizations

Helix Progress

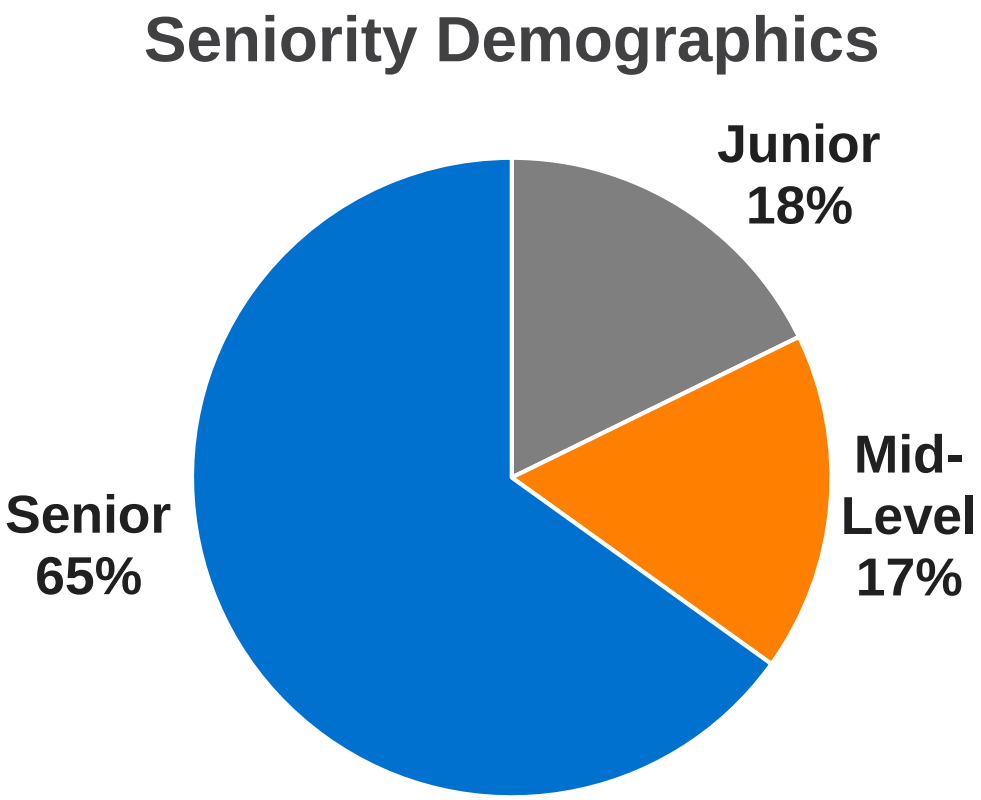
- Research Methodology is based on a Grounded Theory approach
  - —Initially open-ended, exploratory interviews intended to provide a broad variety of data
  - —Analysis focused on identifying key patterns and themes
  - —Further interviews explored the patterns identified
  - —Analysis of career paths to understand the development of Systems Engineers
- **Main product of Helix is the first phase of *Atlas* – The Theory of Effective Systems Engineers**
  - —Version 1.0 released December 2016

Helix Dataset



Seniority of Systems Engineers

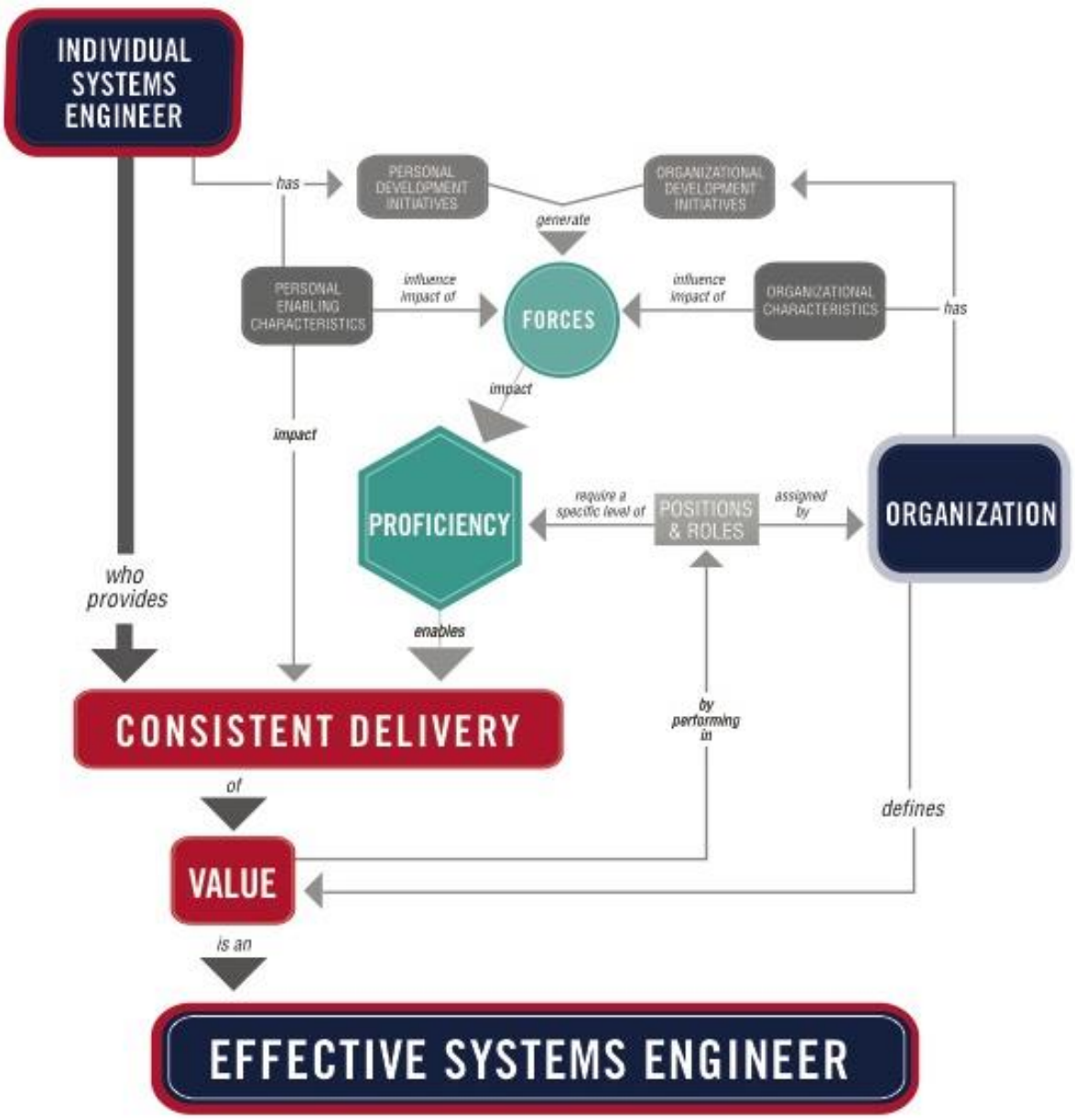
Helix data



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


INDIVIDUAL SYSTEMS ENGINEER
has
PERSONAL DEVELOPMENT INITIATIVES
ORGANIZATIONAL DEVELOPMENT INITIATIVES
generate
PERSONAL ENABLING CHARACTERISTICS
influence impact of
FORCES
influence impact of
ORGANIZATIONAL CHARACTERISTICS
has
impact
impact
PROFICIENCY
require a specific level of
POSITIONS & ROLES
assigned by
ORGANIZATION
who provides
enables
by performing in
CONSISTENT DELIVERY
of
defines
VALUE
is an
EFFECTIVE SYSTEMS ENGINEER

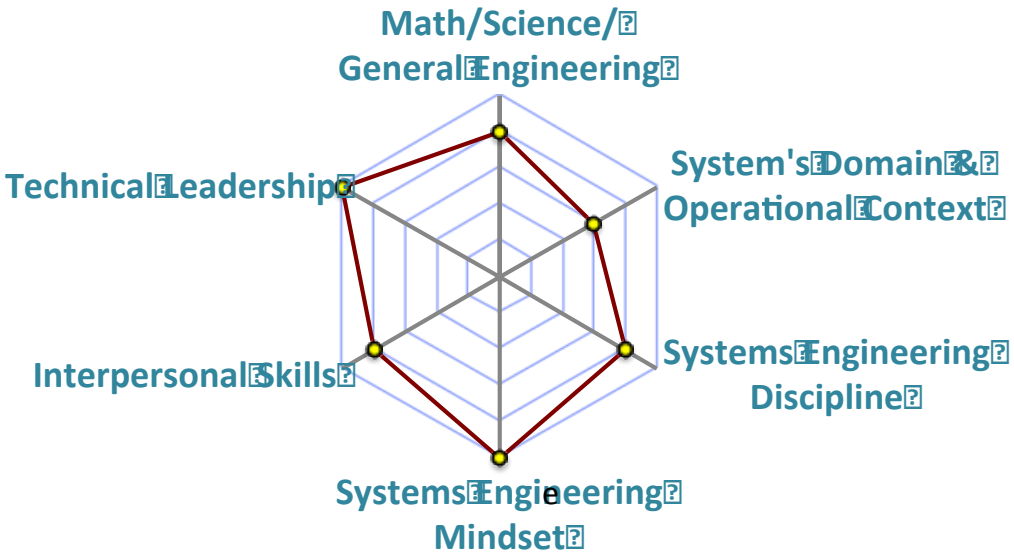
Proficiencies, Forces, Characteristics

Forces that Impact Level of Proficiency
(may be generated by Personal and Organizational Development Initiatives)

- Experiences
- Mentoring
- Education & Training

Personal Enabling Characteristics
Self-Awareness
Ambition & Internal Motivation
Inquisitiveness
Lifelong Learning
Confid nce, Persistence, & Focus
Professionalism & Respect
Creativity

Profic ency of a Systems Engineer



Organizational Characteristics
Culture
Structure
Values
Appreciation of SE
Org. Definition of SE & Systems Engineer
Rewards & Recognitions
Career Growth Potential

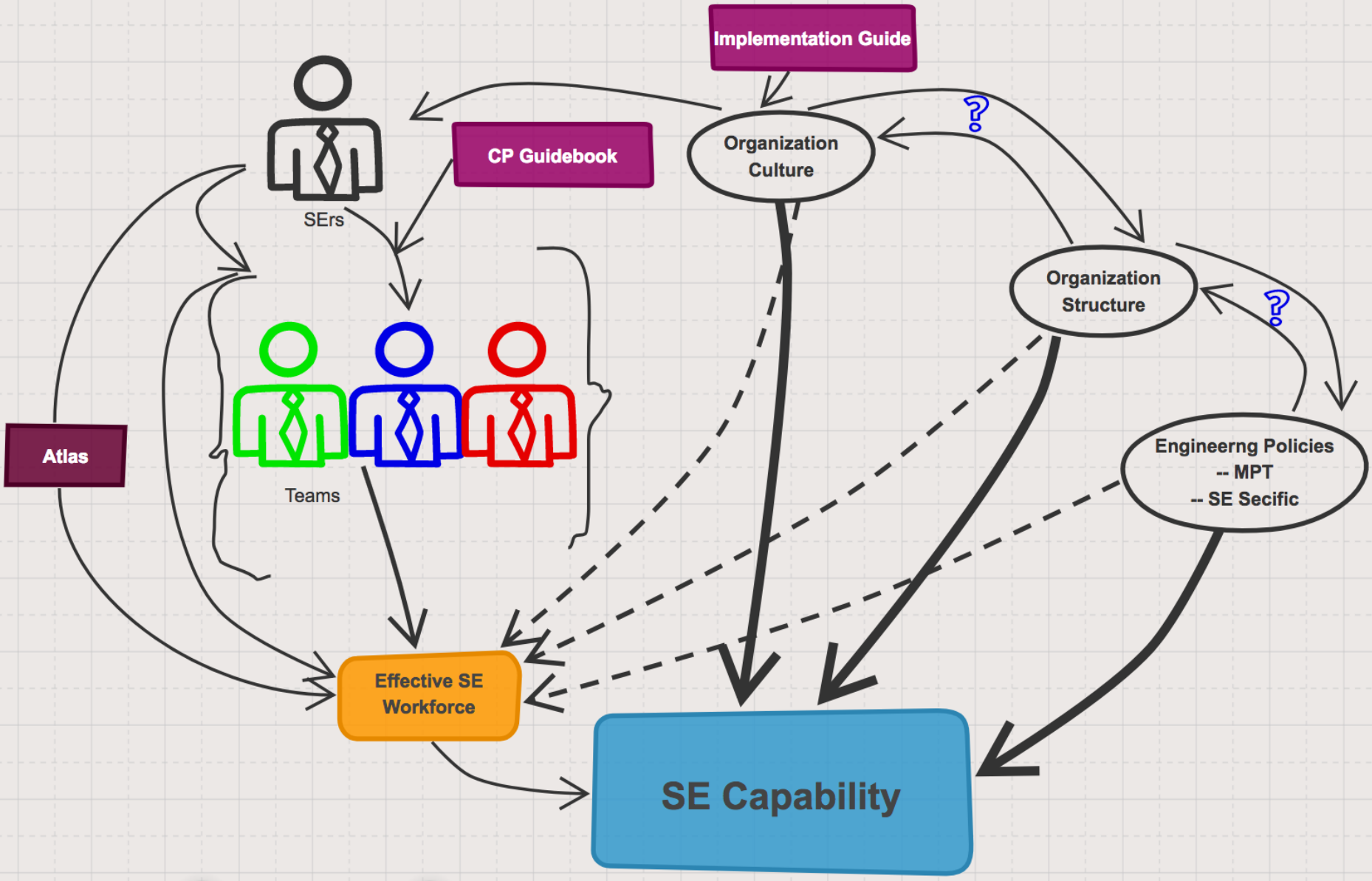
Current State of Helix

- How can organizations improve the effectiveness of their systems engineering workforce?
  - Carried over from the previous work, and though we answered this slightly, it was not to depth that we wanted to, so continuing to pursue.
- How does the effectiveness of the systems engineering workforce impact the overall systems engineering capability of an organization?
- What critical factors, in additional to workforce effectiveness, are required to enable systems engineering capability?

Why Model Helix? HELIX

- Qualitative analysis tool
  - —Further establish patterns and relationships
- Understand behaviors that general qualitative analysis does not provide
  - —Assess effects of individuals and collective entities on system as a whole
- Predictive tool moving forward
  - —Useful for exploratory purposes.

Overview Sketch



Modeling Helix

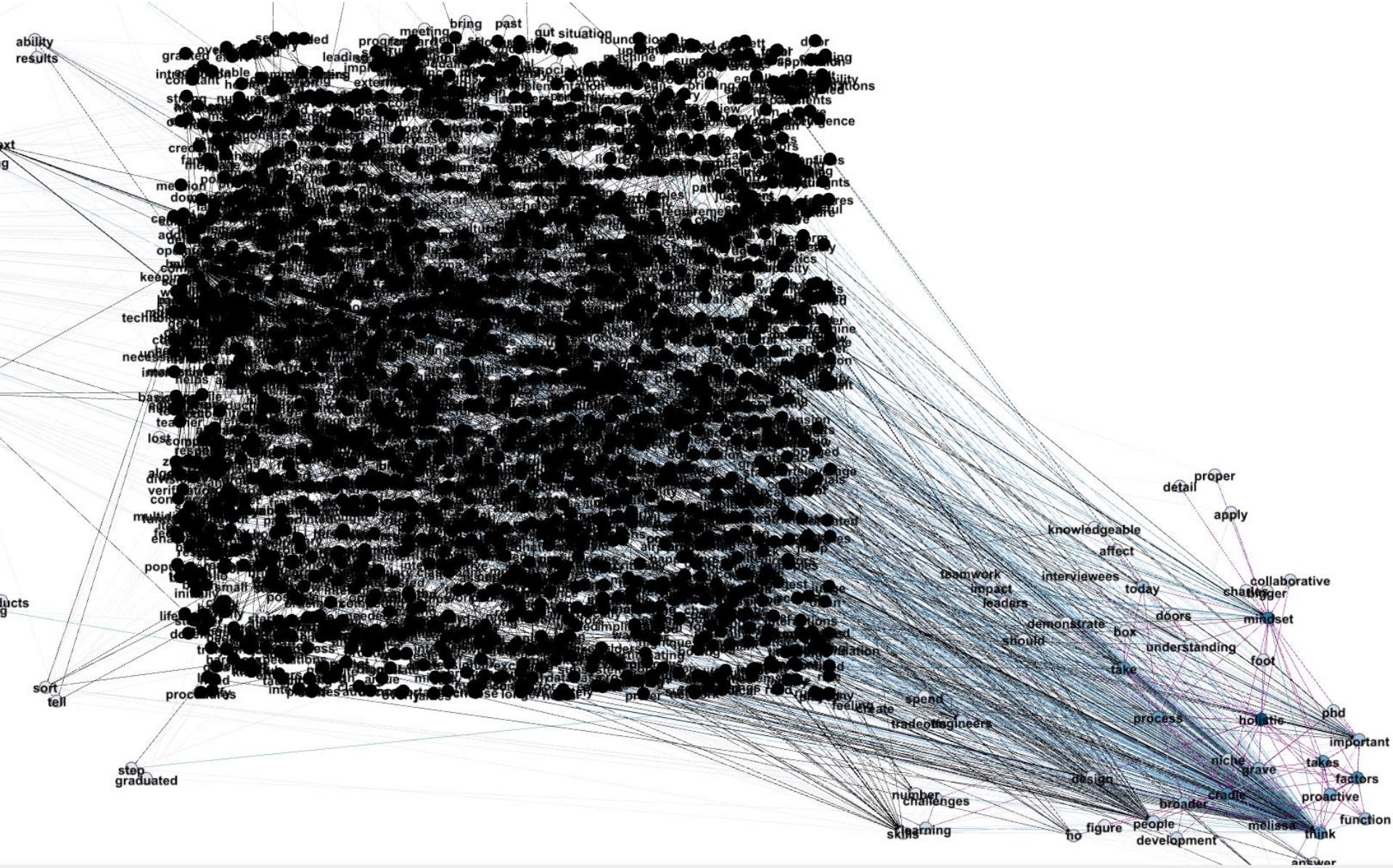
- Cluster Analysis, Syntagmatic and Paradigmatic
  - Deeper dive into the established proficiencies, forces, and characteristics (both personal and organizational) through cluster analysis, which will help further develop models.
    - Done within the 2017 work

- Modeling Career Path (Individual)
  - Utilize the grounded theory approach to then introduce the dynamism of numerous, both exogenous and endogenous, factors into an individual's career path and how they might best utilize their skill set, environment, and time to enhance their career path.
    - Partially completed with 2017 work

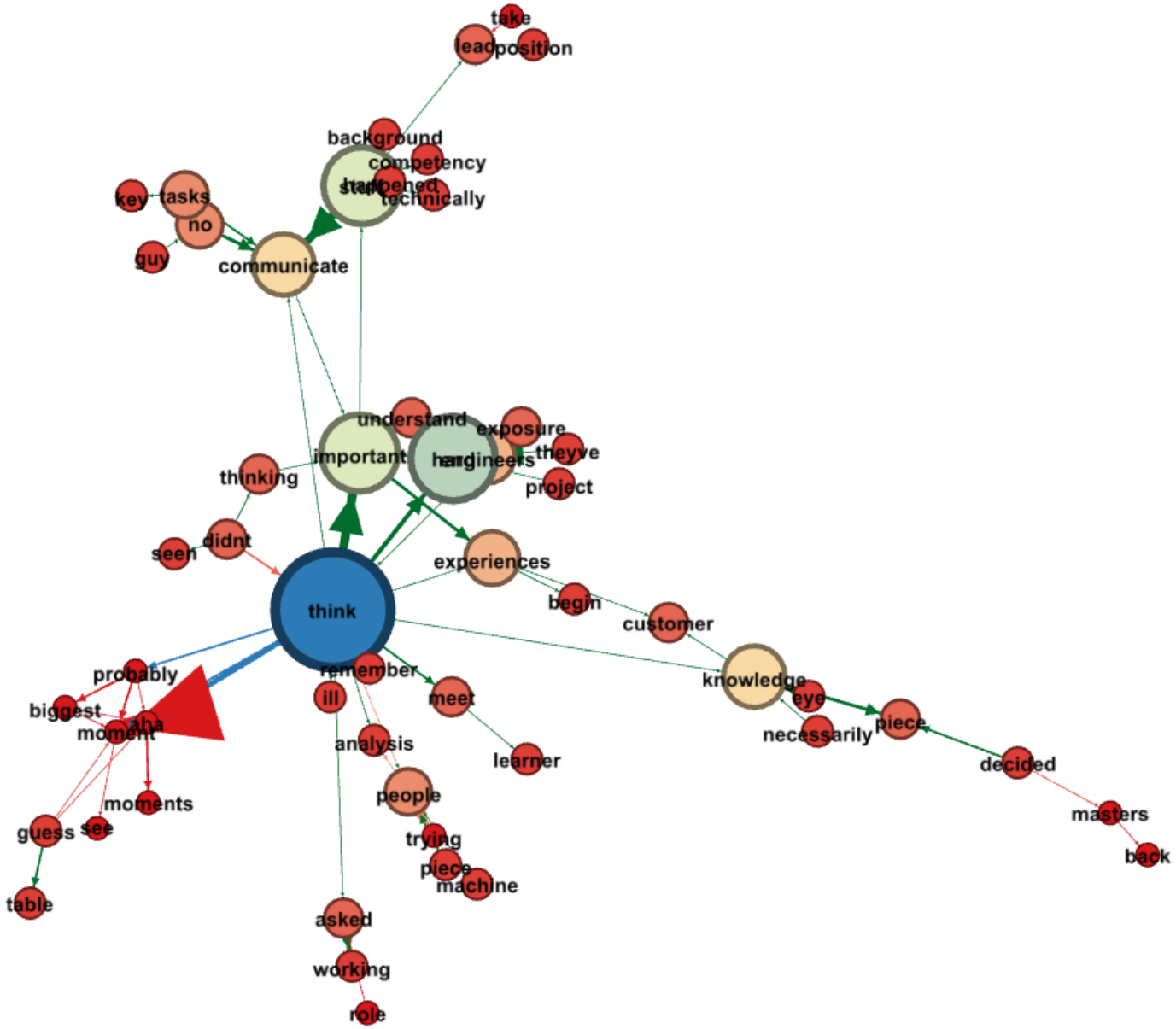
- Multilevel Model and Simulation (Organization)
  - Utilize the grounded theory approach to then introduce the dynamism of numerous criterion for an organization to enhance decision making to implement programs on growing and developing their systems engineering workforce and improve their overall systems perspective through the analysis.
    - Future work

- *Ontology*
  - *With over 6,000 pages of transcript, the team can engage in forming a higher level ontology for the community to have a streamlined discussion where little personal interpretation can be granted, therefore removing some human error.*

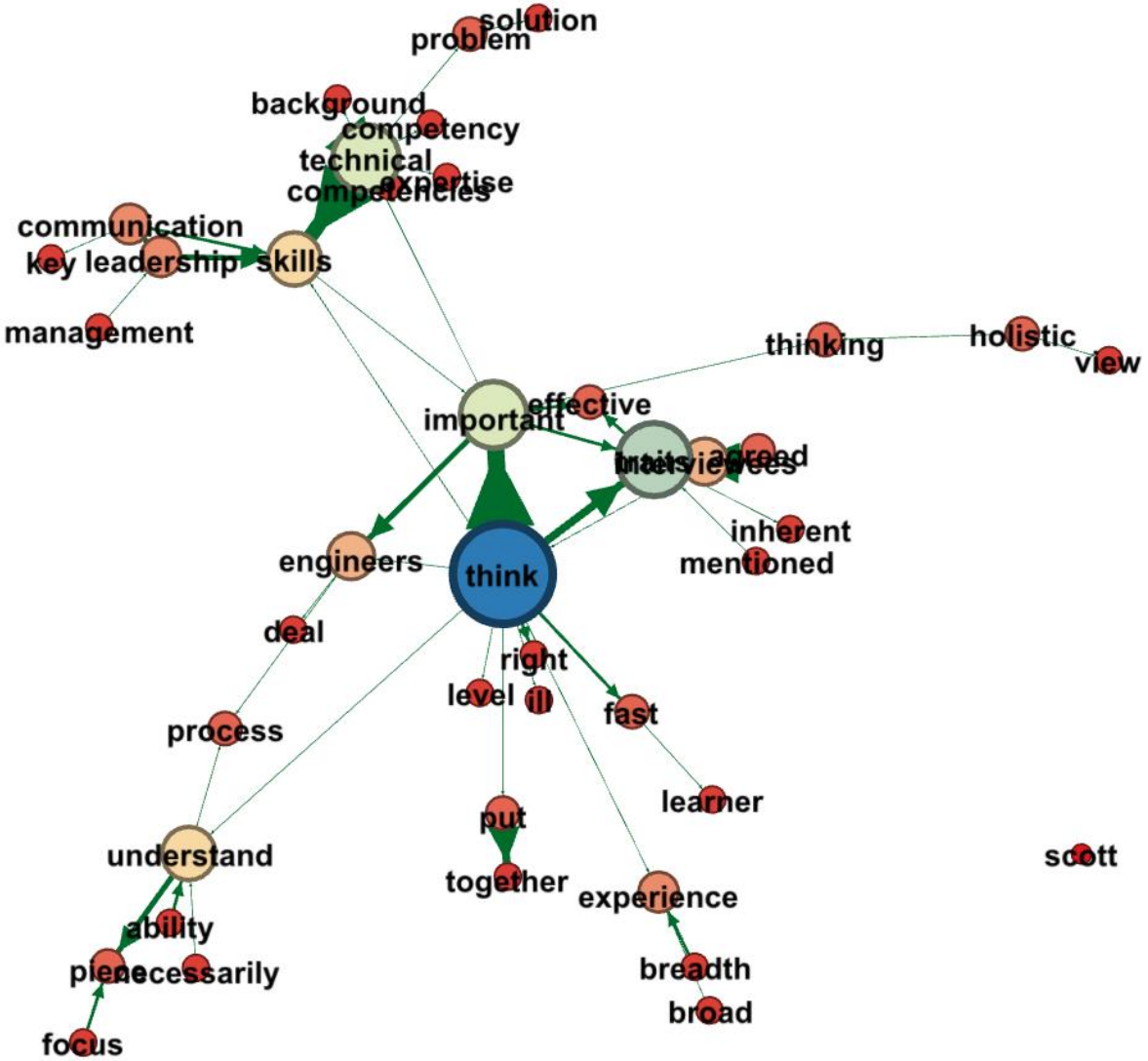
Cluster Analysis



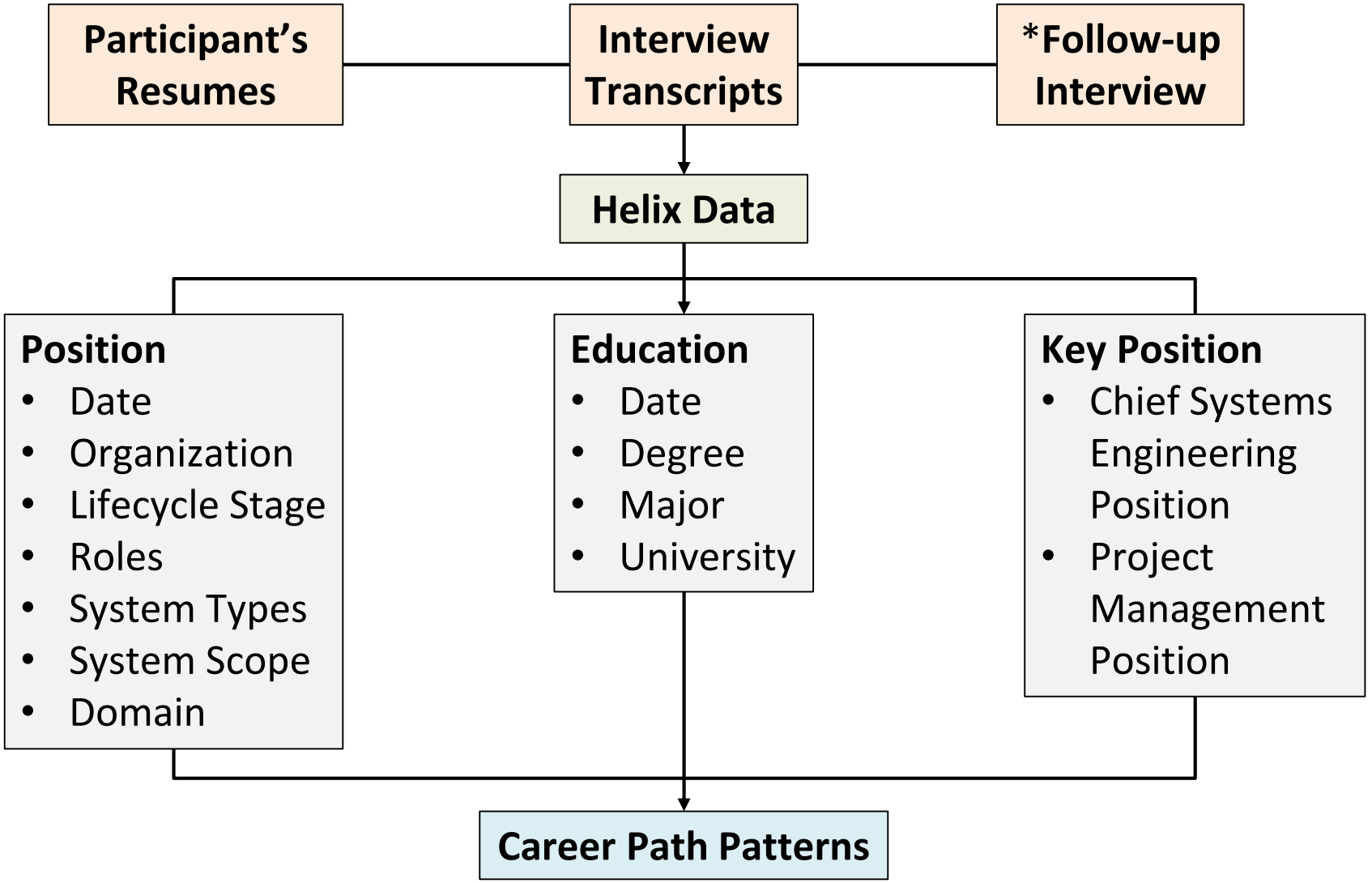
Cluster Analysis



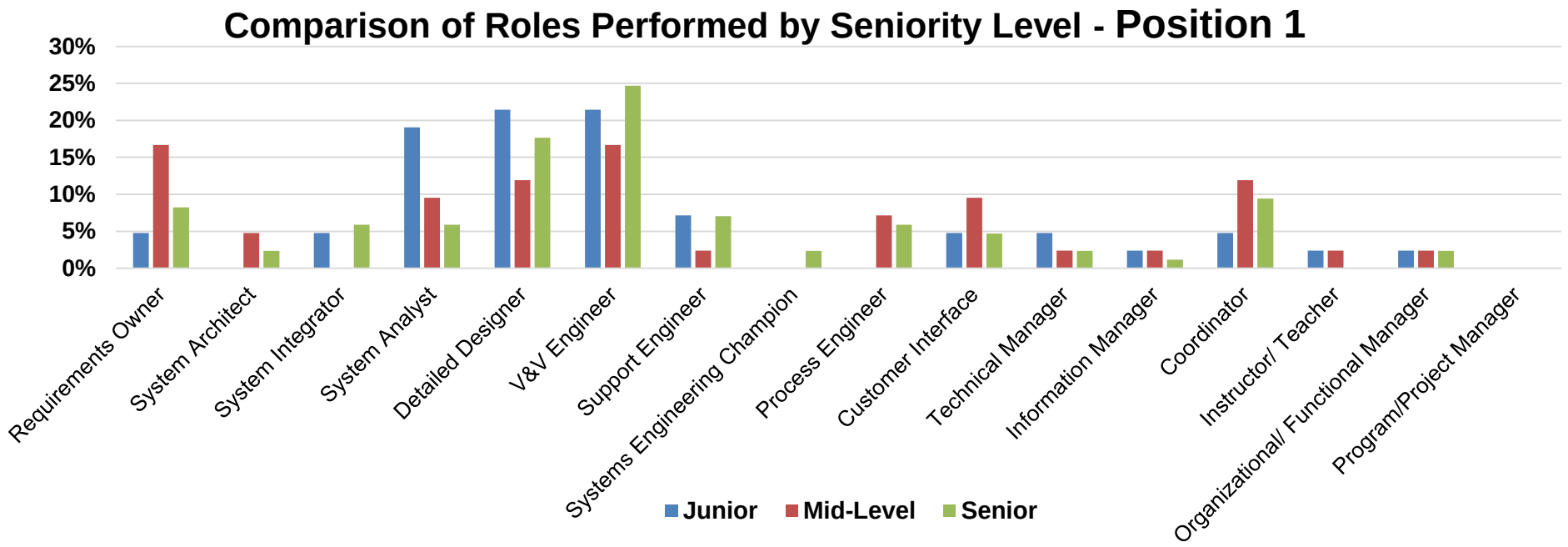
Cluster Analysis



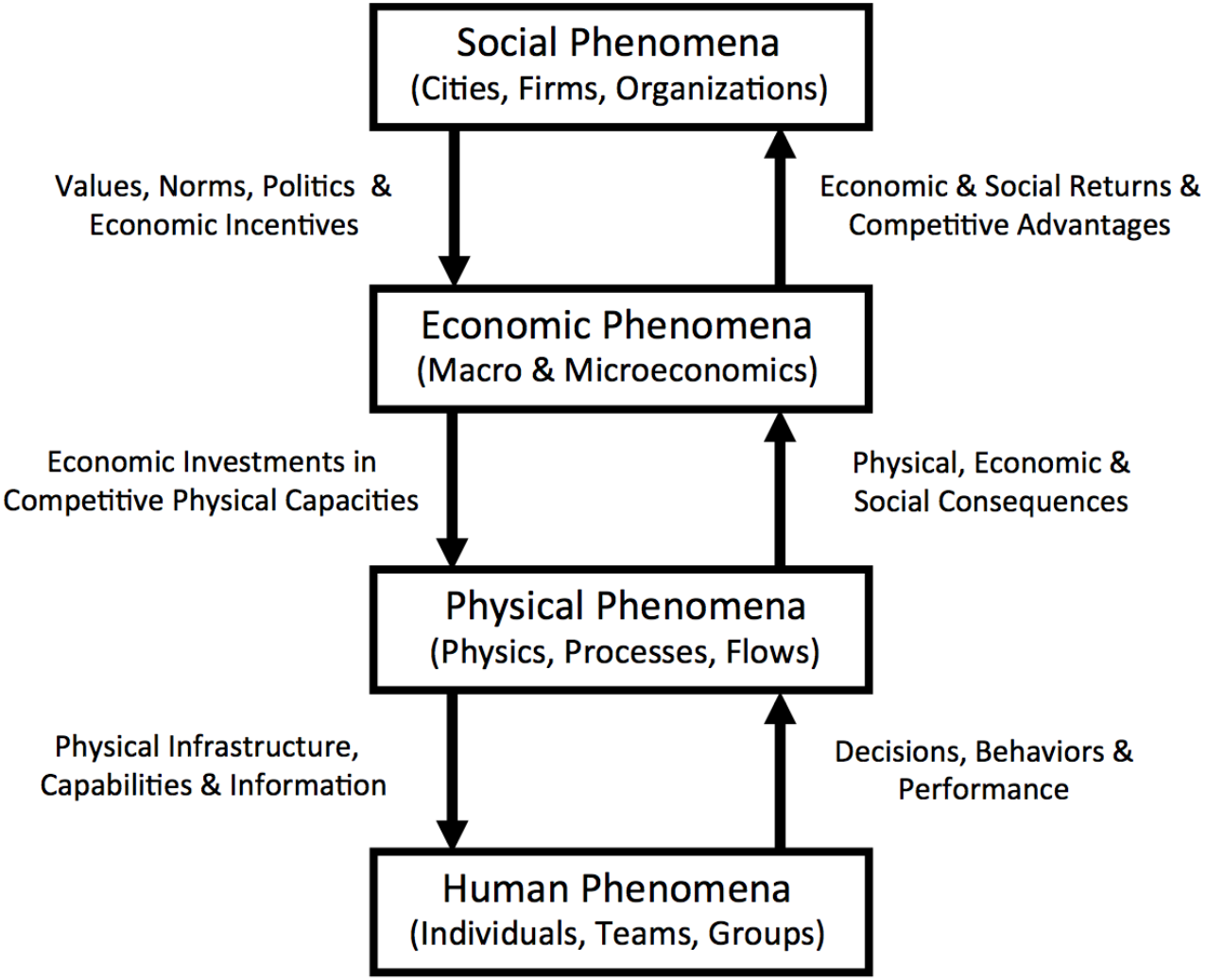
Methodology of Career Path Analysis



Modeling Effective Systems Engineers



Methodology for Multilevel Model (Framework) of Organization



Rouse, W.B., "Human interaction with policy flight simulators" In Applied Ergonomics, Issue 45, pp. 77-77, 2014

Constructing the Multilevel Model

- Step 1: Decide on the Central Questions of Interest
  - Organization's culture – need to understand impact on effective SE better than we do.
- Step 2: Define Key Phenomena Underlying These Questions
  - Policies and organizational structure, task behaviors and performance
- Step 3: Develop One or More Visualizations of Relationships Among Phenomena
  - Structures and roles affect employees movement within organization
- Step 4: Determine Key Tradeoffs That Appear to Warrant Deeper Exploration
- Step 5: Identify Alternative Representations of These Phenomena
- Step 6: Assess the Ability to Connect Alternative Representations
- Step 7: Determine a Consistent Set of Assumptions
- Step 8: Identify Data Sets to Support Parameterization
- Step 9: Program and Verify Computational Instantiations
- Step 10: Validate Model Predictions, at Least Against Baseline Data

Expected Outcomes

- In January, the Helix team will
  - Update Atlas (1.1)
  - Implementation Guide
  - Career Path Guidebook
- Included, the team will have set