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# Discovering Career Paths in Systems Engineering

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**Systems Engineering Research Center**

**Stevens Institute of Technology**

# Before we start . . .

# Motivation for Helix

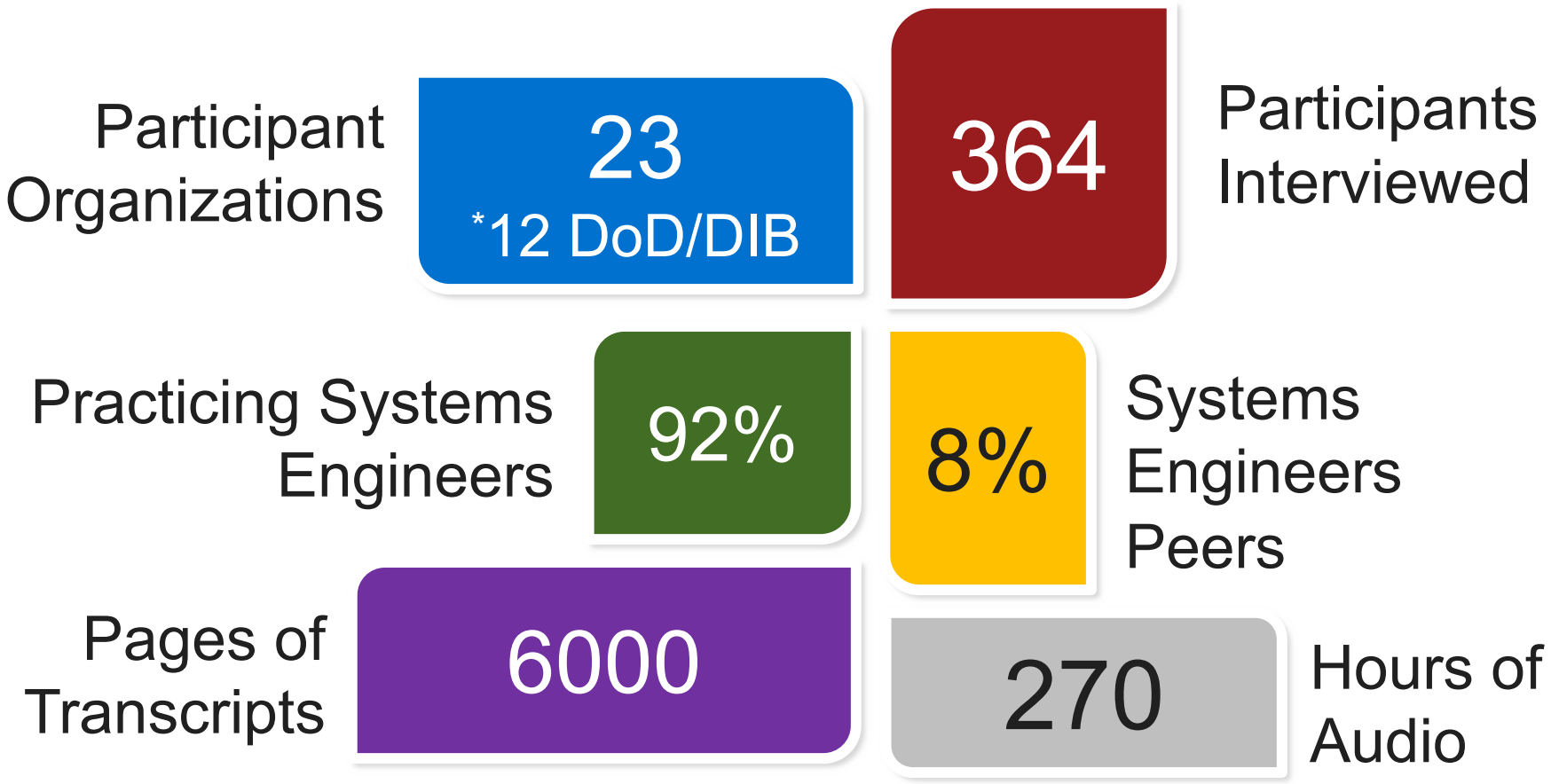
- DoD and DIB are facing major challenges in the development of tailored systems.

- **U.S. Department of Defense 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.

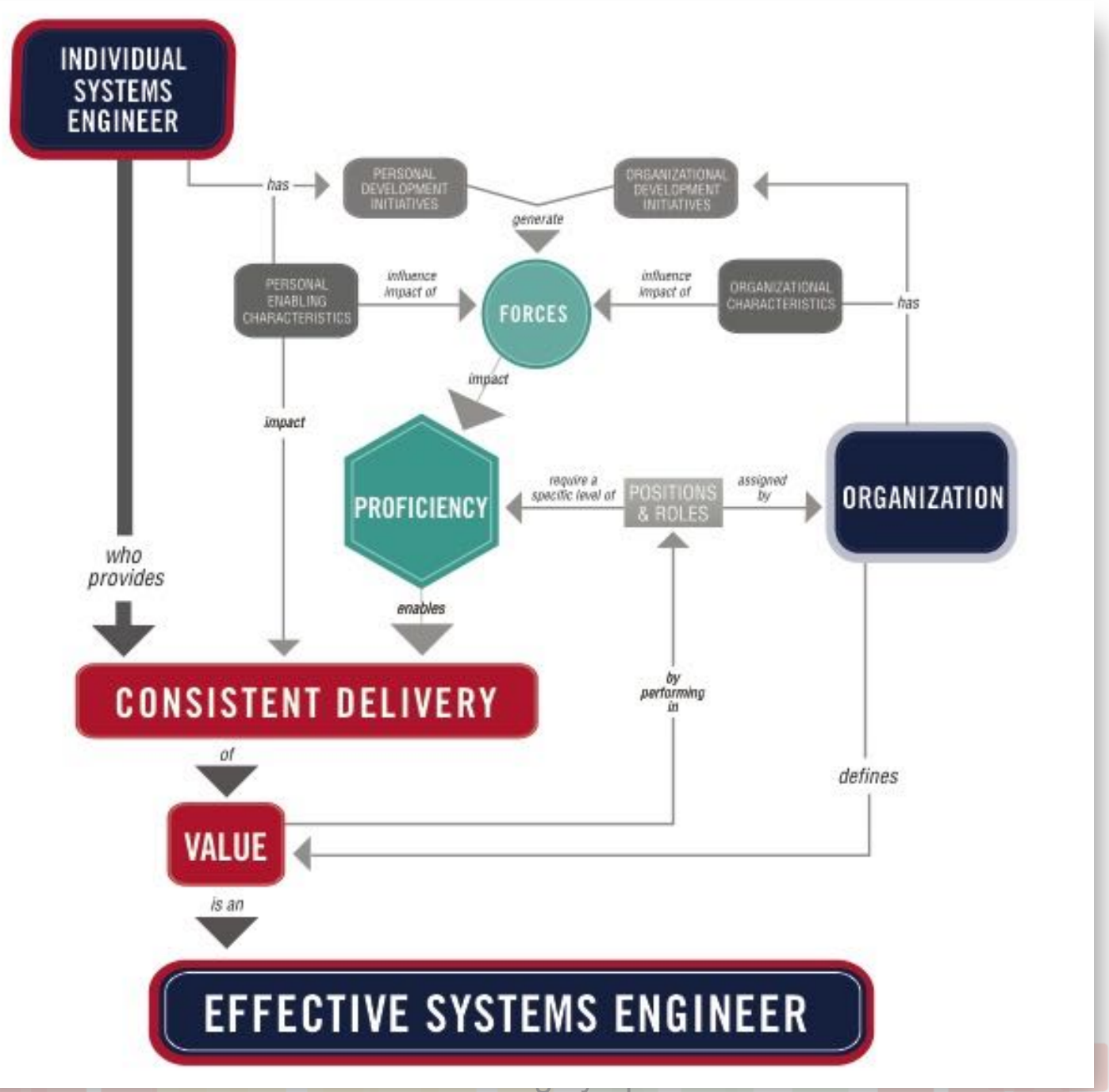
# Overview of Helix Project

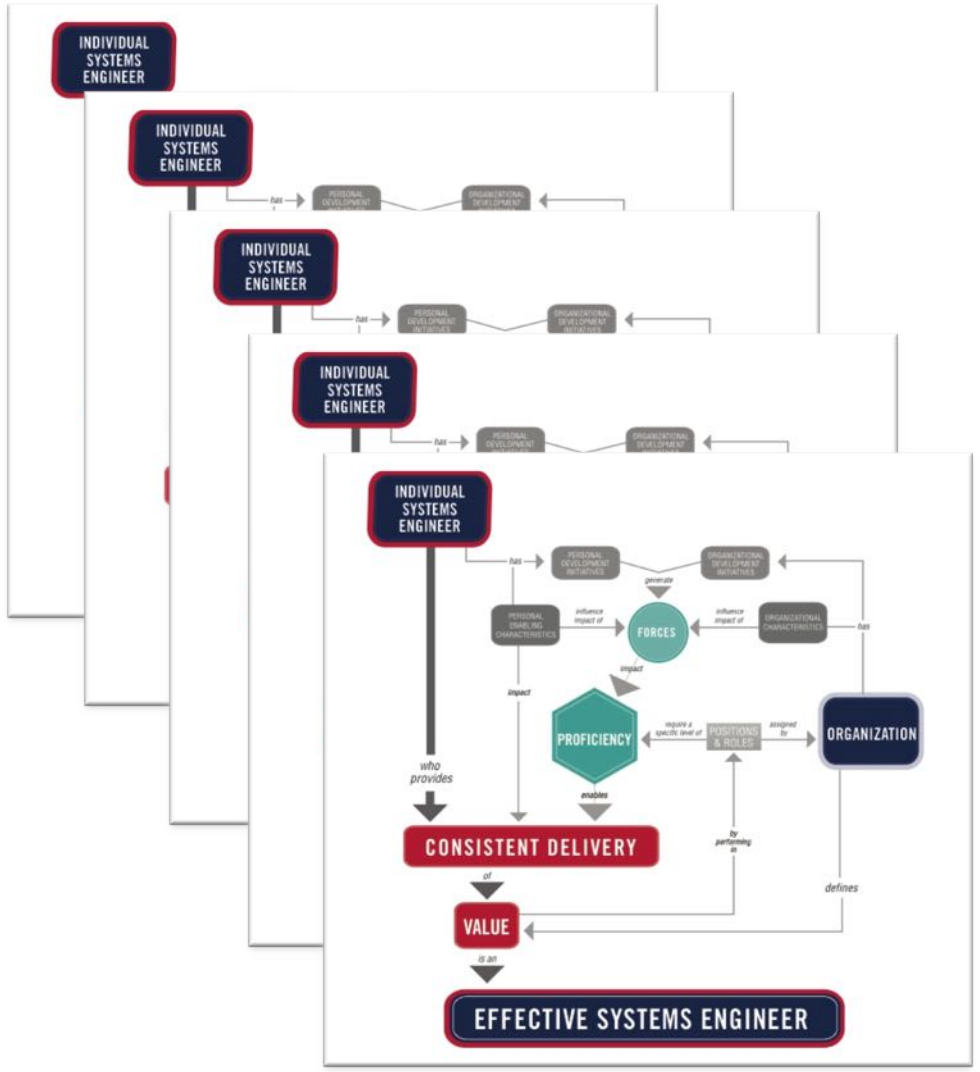
- Helix is a multi-year longitudinal study designed to build an understanding of the systems engineering workforce in the DoD and DIB. *(that scope is expanding)*
- Data collection has primarily been through semi-structured interviews with systems engineers.
- Reporting is done in an aggregated anonymous manner that does not reveal the identities of participating individuals or organizations.

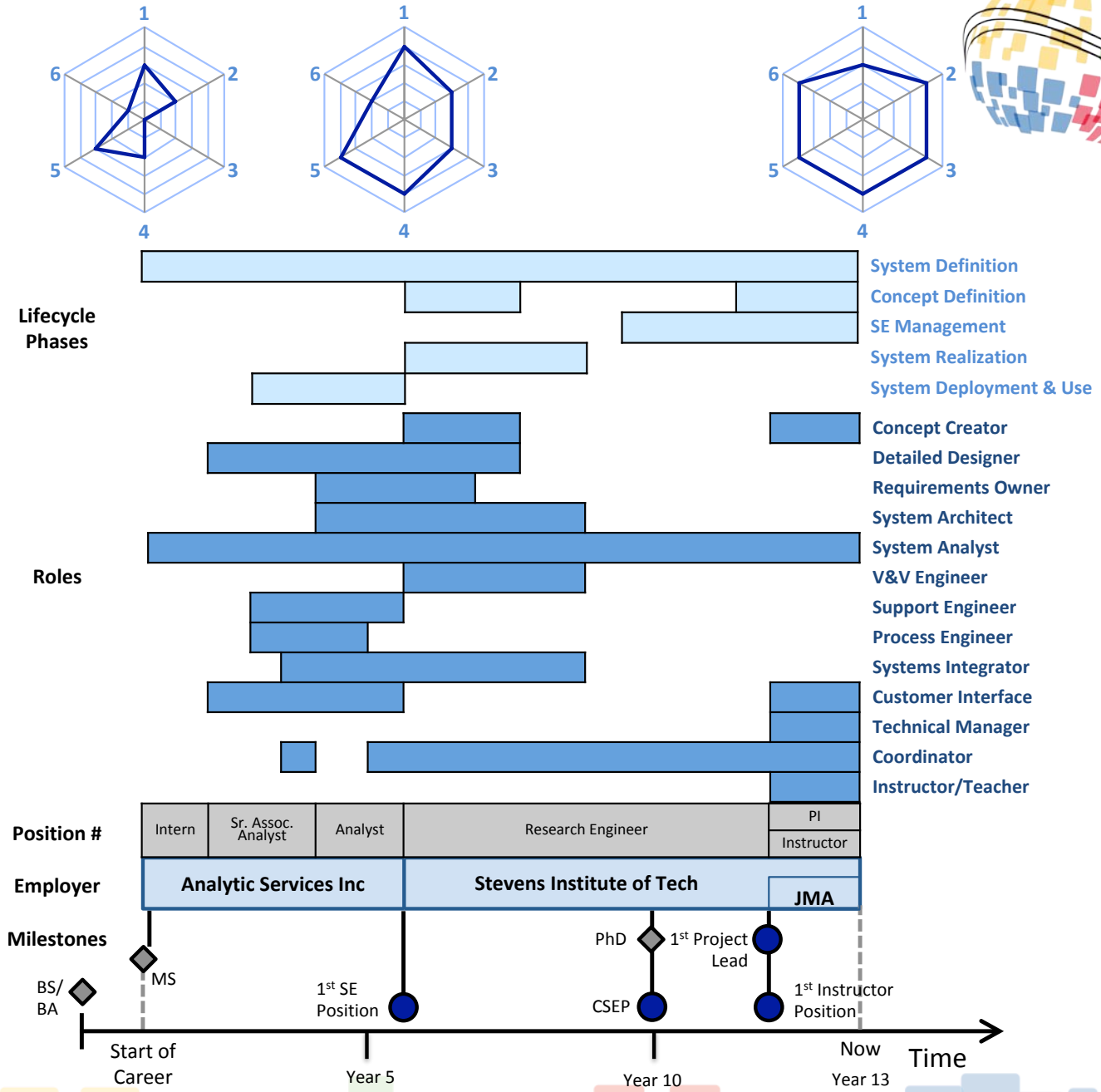
# Helix Dataset



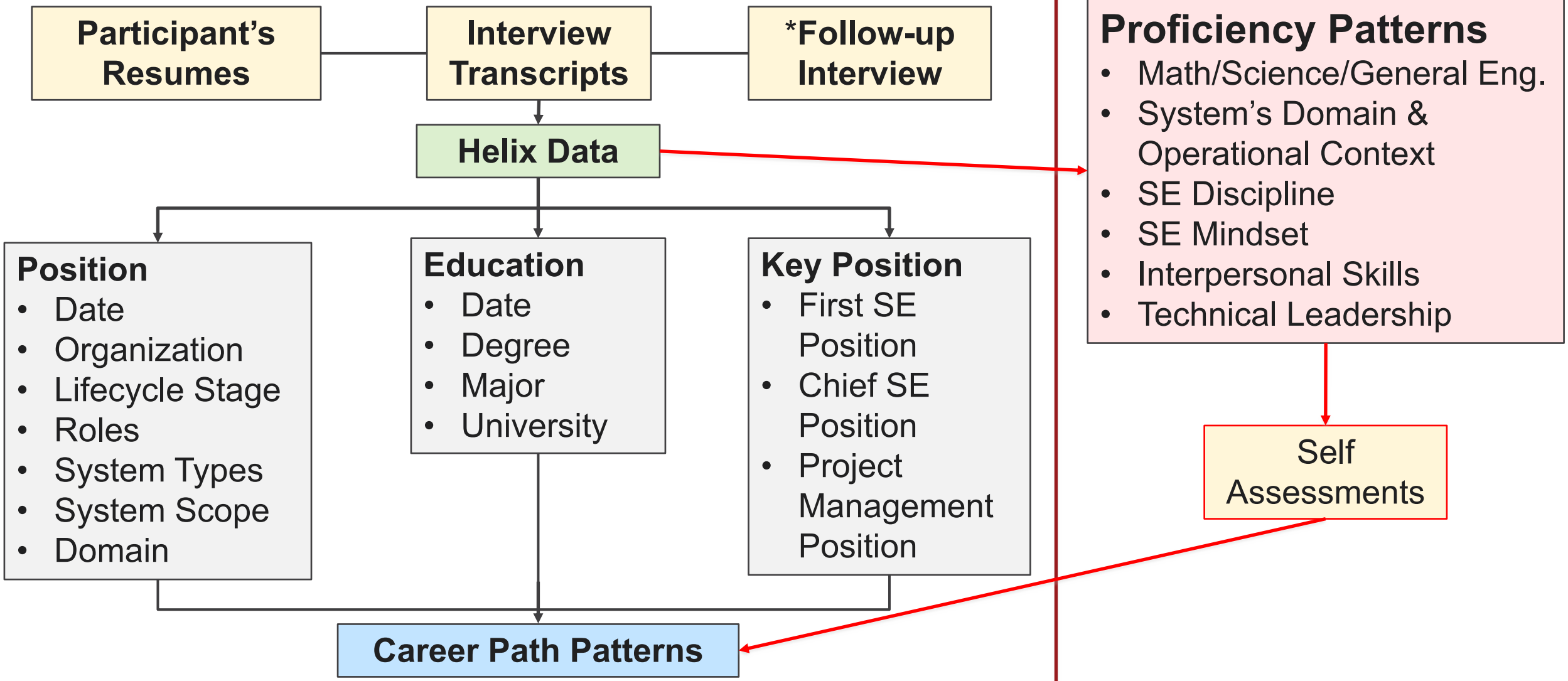
# Atlas


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
CONSISTENT DELIVERY
by performing in
of
defines
VALUE
is an
EFFECTIVE SYSTEMS ENGINEER


INDIVIDUAL SYSTEMS ENGINEER
FORCES
PROFICIENCY
POSITIONS & ROLES
ORGANIZATION
CONSISTENT DELIVERY
VALUE
EFFECTIVE SYSTEMS ENGINEER
Time


Lifecycle Phases
System Definition
Concept Definition
SE Management
System Realization
System Deployment & Use
Roles
Concept Creator
Detailed Designer
Requirements Owner
System Architect
System Analyst
V&V Engineer
Support Engineer
Process Engineer
Systems Integrator
Customer Interface
Technical Manager
Coordinator
Instructor/Teacher
Position #
Intern
Sr. Assoc. Analyst
Analyst
Research Engineer
PI
Instructor
Employer
Analytic Services Inc
Stevens Institute of Tech
JMA
Milestones
BS/ BA
MS
1st SE Position
PhD
CSEP
1st Project Lead
1st Instructor Position
Start of Career
Year 5
Year 10
Now
Year 13
Time

# Methodology

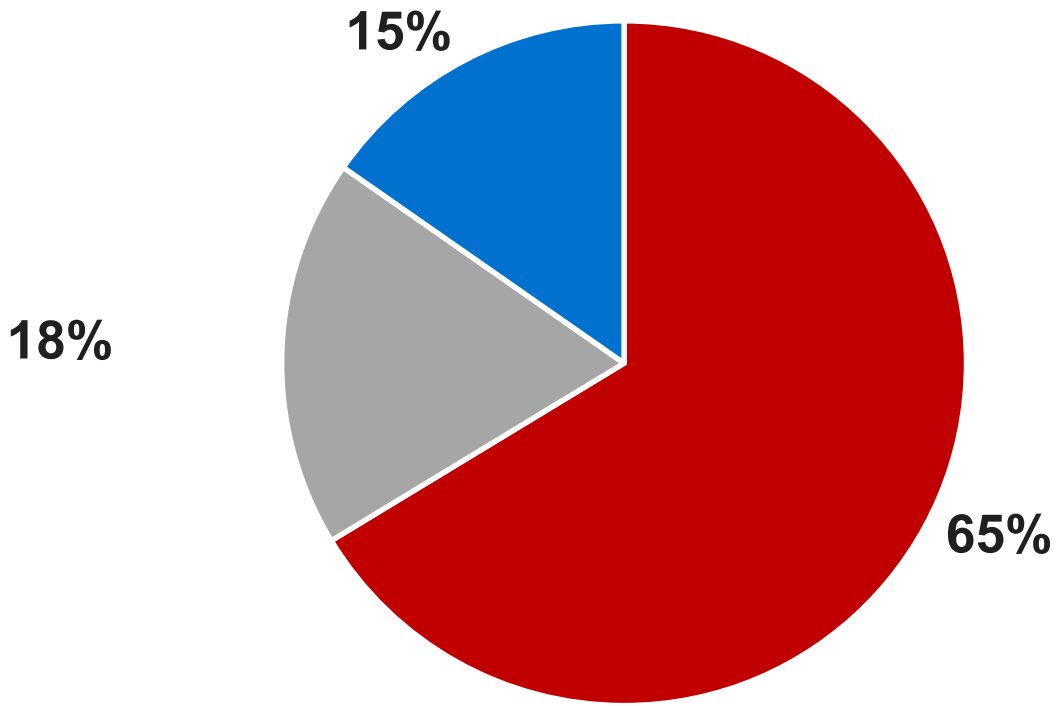


# Seniority Classification of Systems Engineers

| Criteria | Junior | Mid-level | Senior |
|---|---|---|---|
| **Leadership** | Primarily works as an individual contributor; has had zero or one formal leadership positions, which can be as an official supervisor or as a task leader | At least two formal leadership positions over teams or tasks of significant size and scope; viewed as a leader in a project, program, or business unit of the larger enterprise | Three or more formal leadership positions over teams or tasks of significant size and scope, including second-level management roles; viewed as a leader in the enterprise |
| **Complexity** | Relevant experiences on a simple project, system, or task, working primarily at the system components level or simple activities such as managing a requirements database | Relevant experiences on moderately complex projects or systems, working at the sub-system and system levels or on moderately complex activities such as managing the development and negotiation of requirements for a moderately complex system | Relevant experiences on complex projects or systems, working at the system and platforms/systems of systems levels or on quite complex activities such as managing the development and negotiation of requirements for a complex system of systems |
| **Lifecycle** | Relevant experiences in at least two phases of the systems lifecycle | Relevant experiences in at least three phases of the systems lifecycle | Relevant experiences in at least four phases of the systems lifecycle |
| **Roles** | Worked on up to 3 different roles, usually more detailed oriented | Worked on 4 to 6 different roles, with a mix of roles that are detail oriented and team and leadership oriented | Worked on 7 to 15 different roles with recent roles likely being more team and leadership focused rather than detail oriented |

# Demographics of Helix Participants

## Seniority Demographics

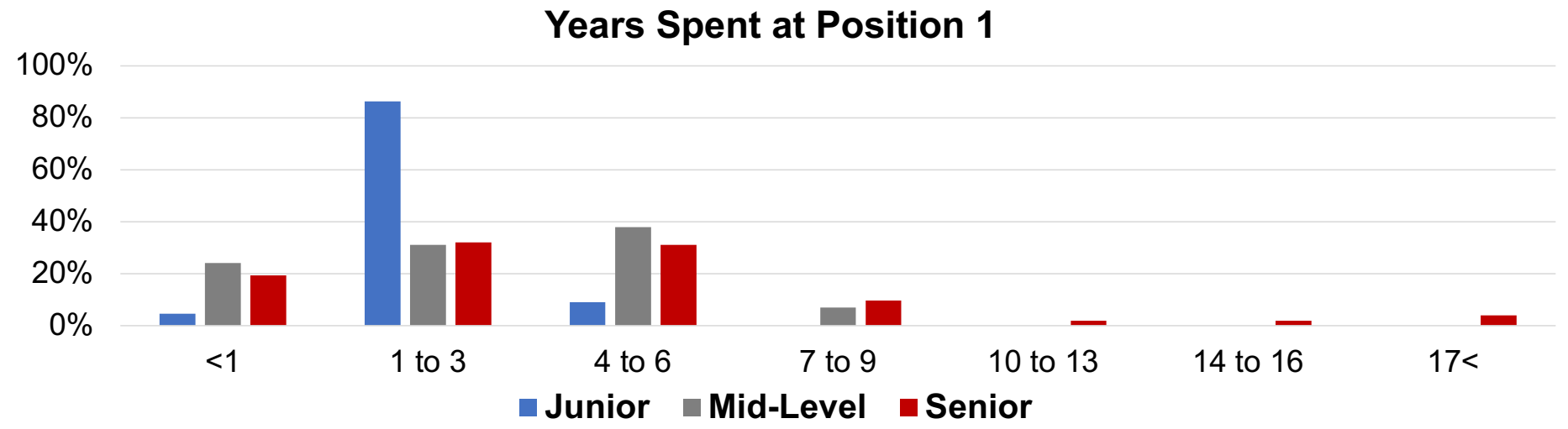


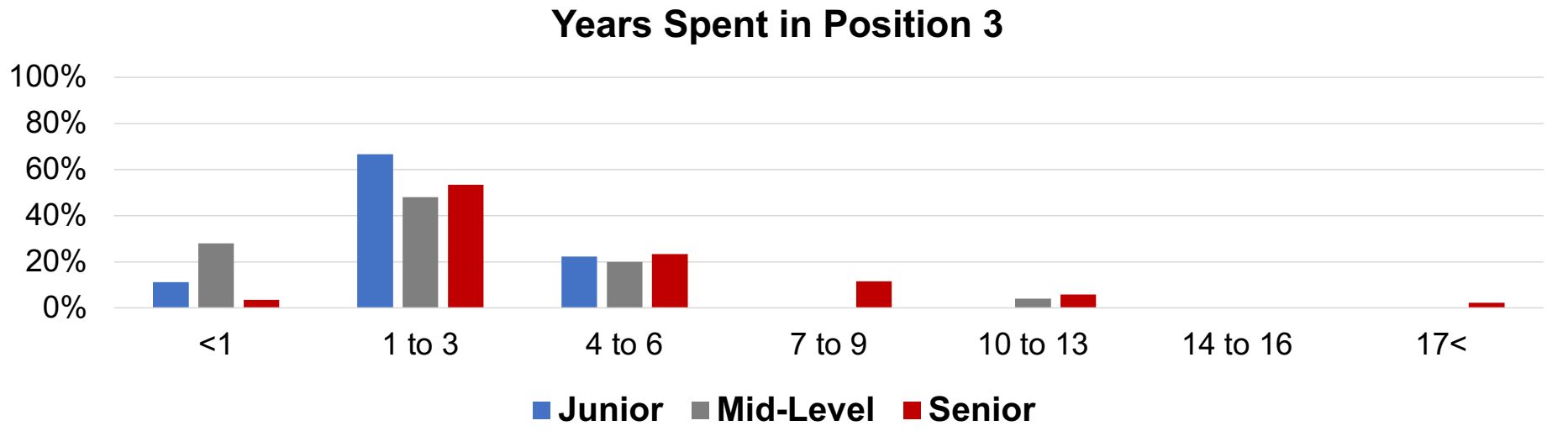

### Why do we care about seniority?

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

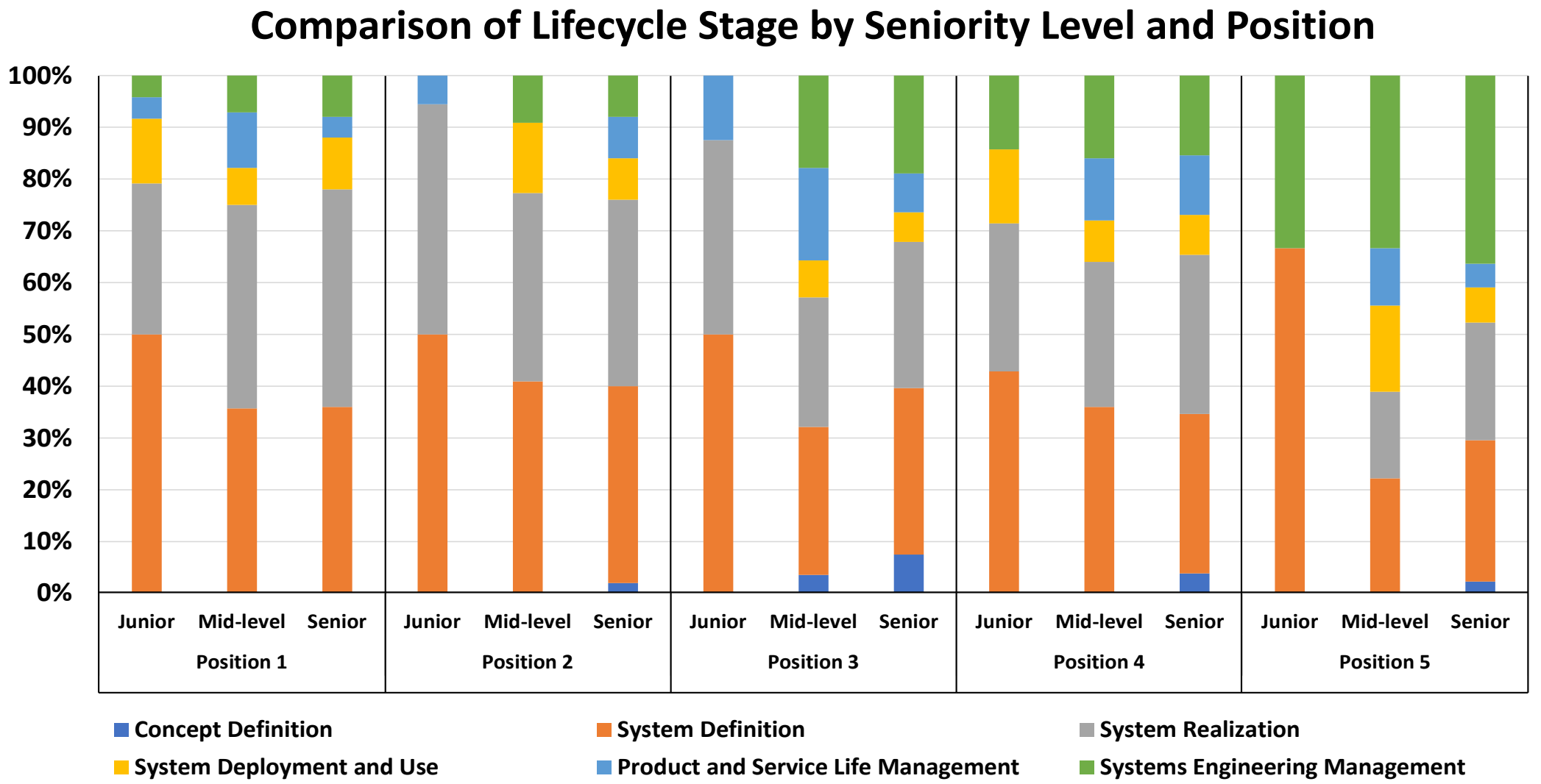
# Time in Positions

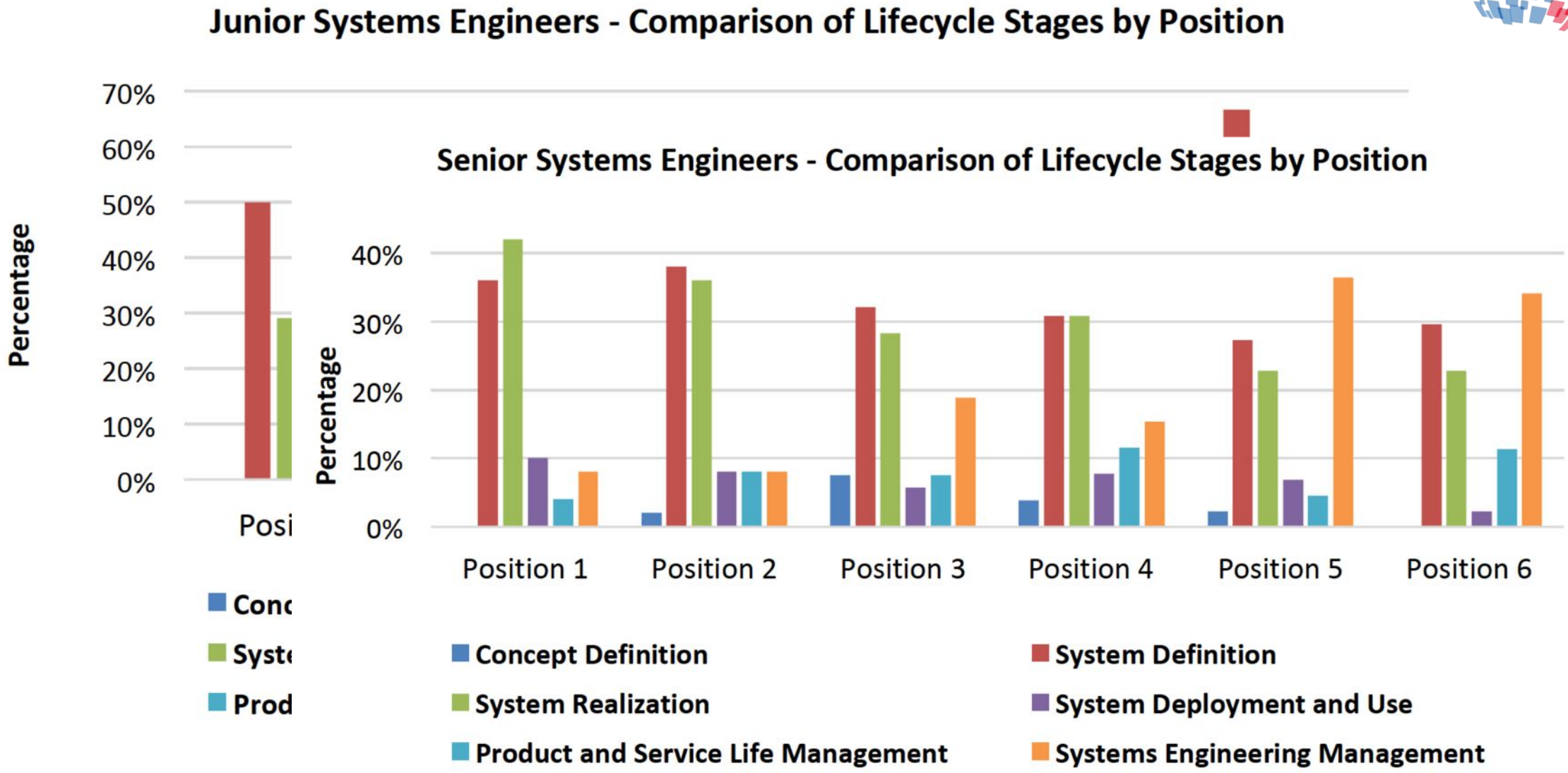


# Lifecycle Stage

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




Junior Systems Engineers - Comparison of Lifecycle Stages by Position
70%
60%
50%
40%
30%
20%
10%
0%
Percentage
Posi
Conc
Syste
Prod
Senior Systems Engineers - Comparison of Lifecycle Stages by Position
40%
30%
20%
10%
0%
Percentage
Position 1
Position 2
Position 3
Position 4
Position 5
Position 6
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

# The Roles of Systems Engineers

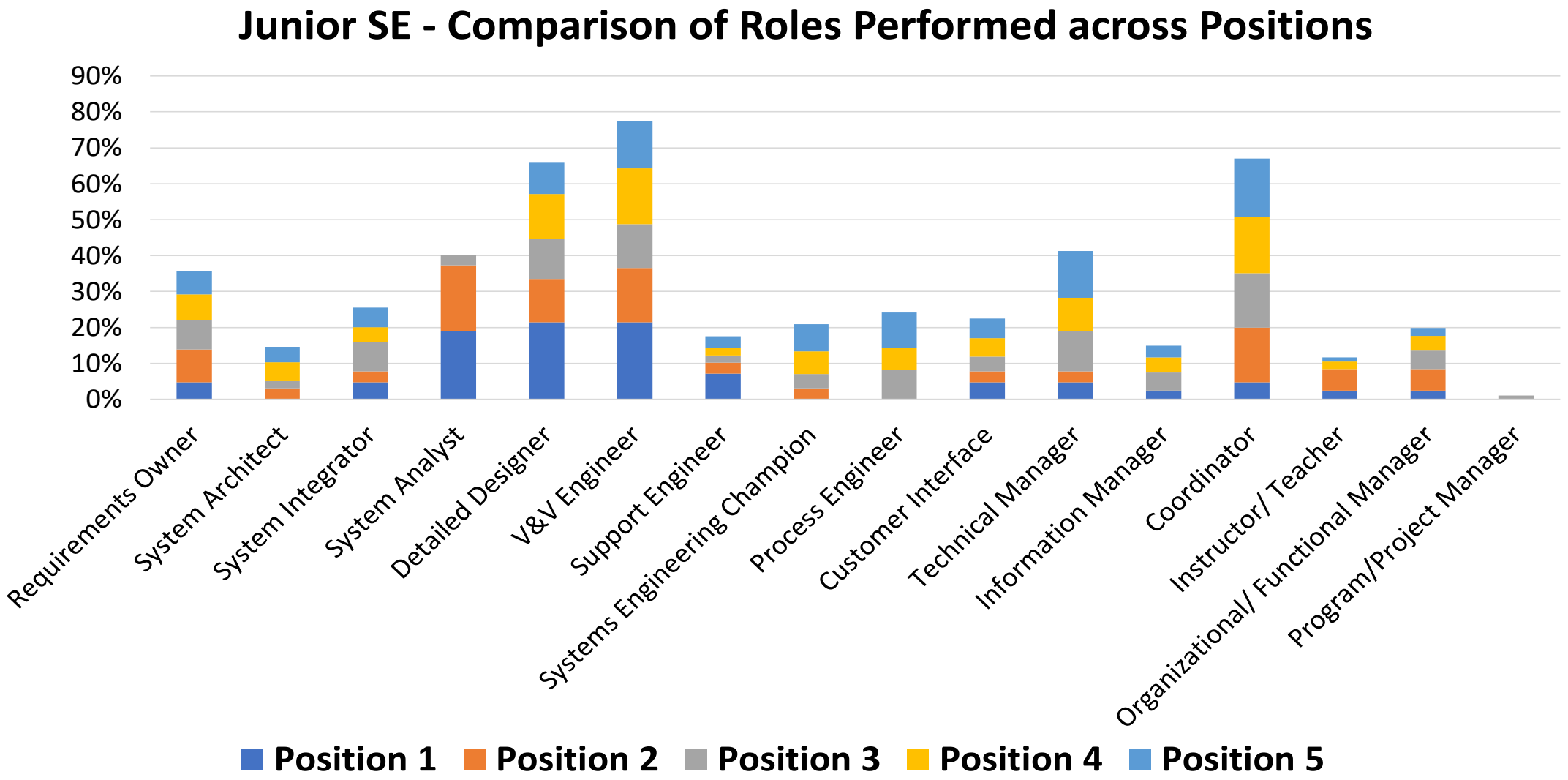
**Roles Focused on SE Process and Organization:**

- Systems Engineering Champion
- Process Engineer

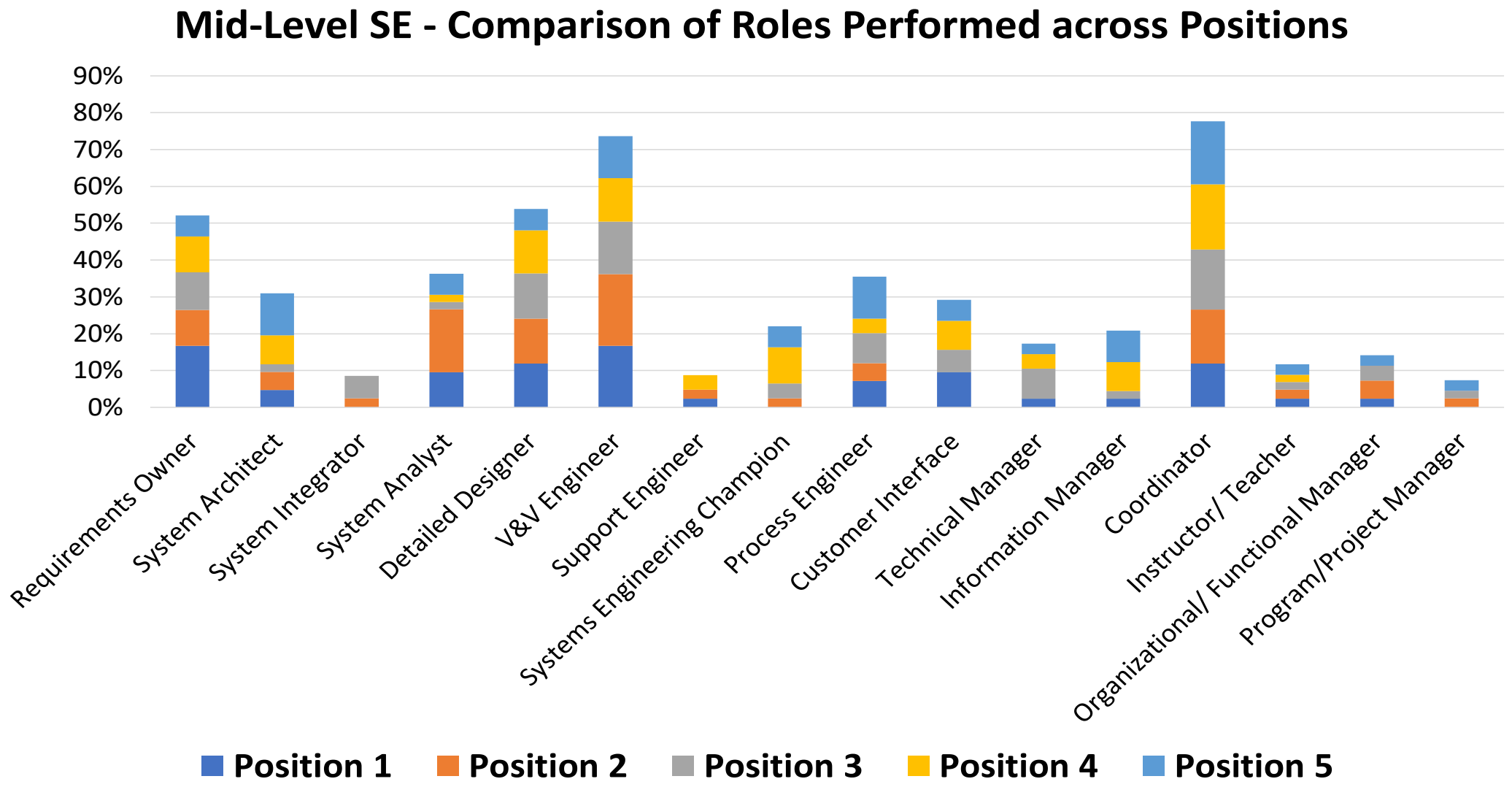
**Roles Focused on Teams That Build Systems:**

- Customer Interface
- Technical Manager
- Information Manager
- Coordinator
- Instructor/Teacher

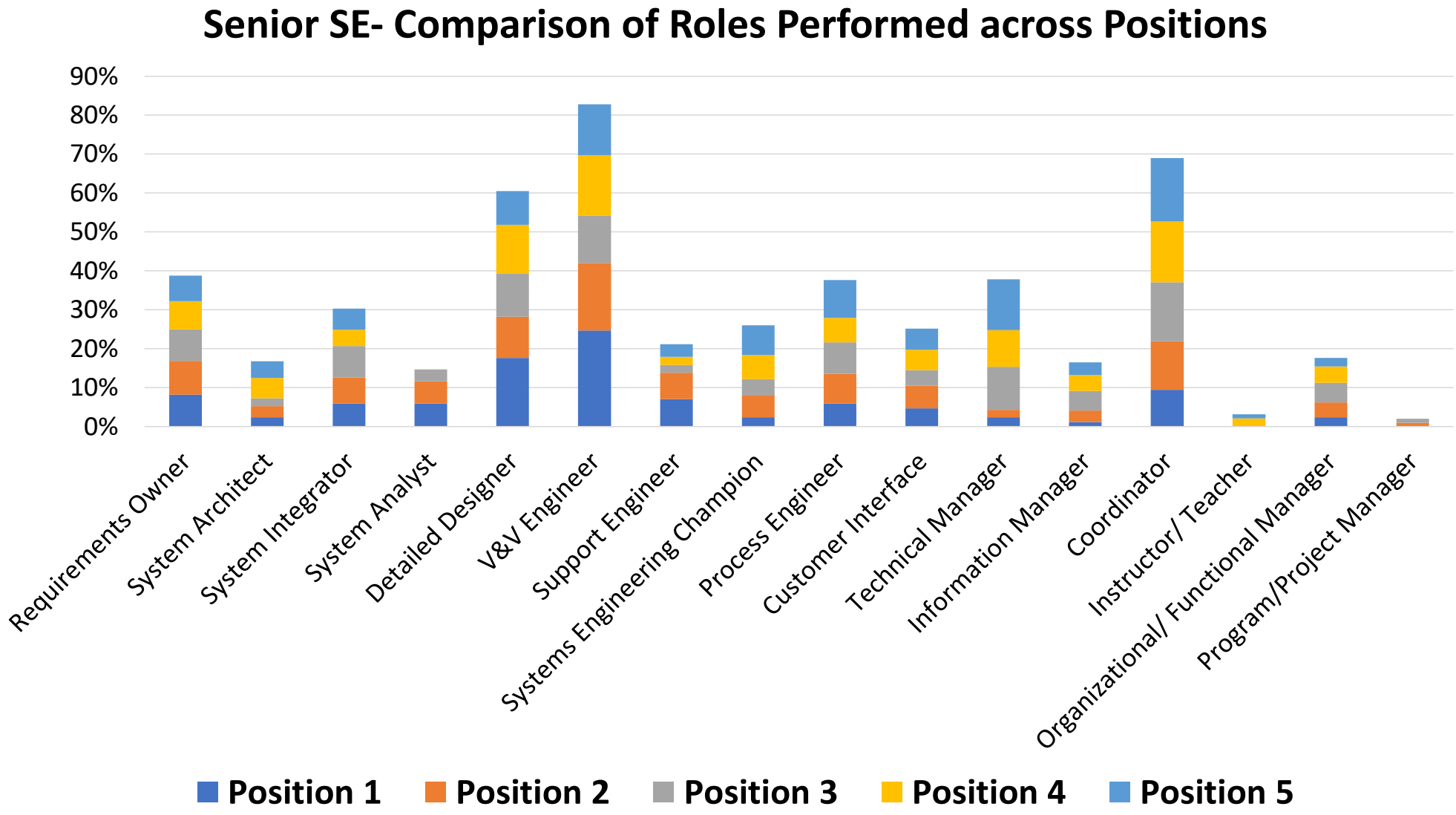
# Roles Performed by Junior Systems Engineers



# Roles Performed by Mid-Level Systems Engineers



# Roles Performed by Senior Systems Engineers



# An Example 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**

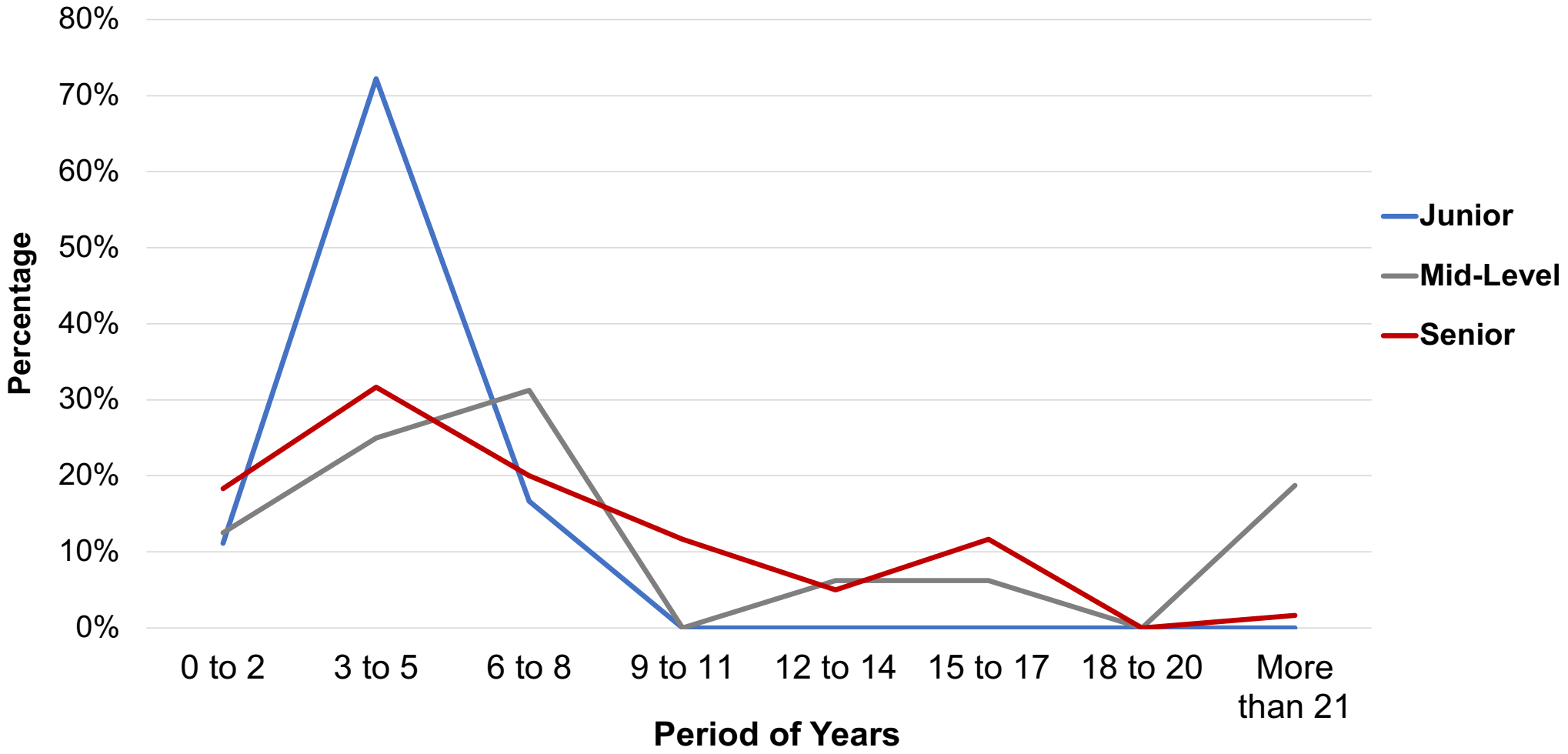
System Architect
V&V Engineer
Systems Engineering Champion
Process Engineer
Customer Interface
Technical Manager
Information Manager
Coordinator

**Position 12**

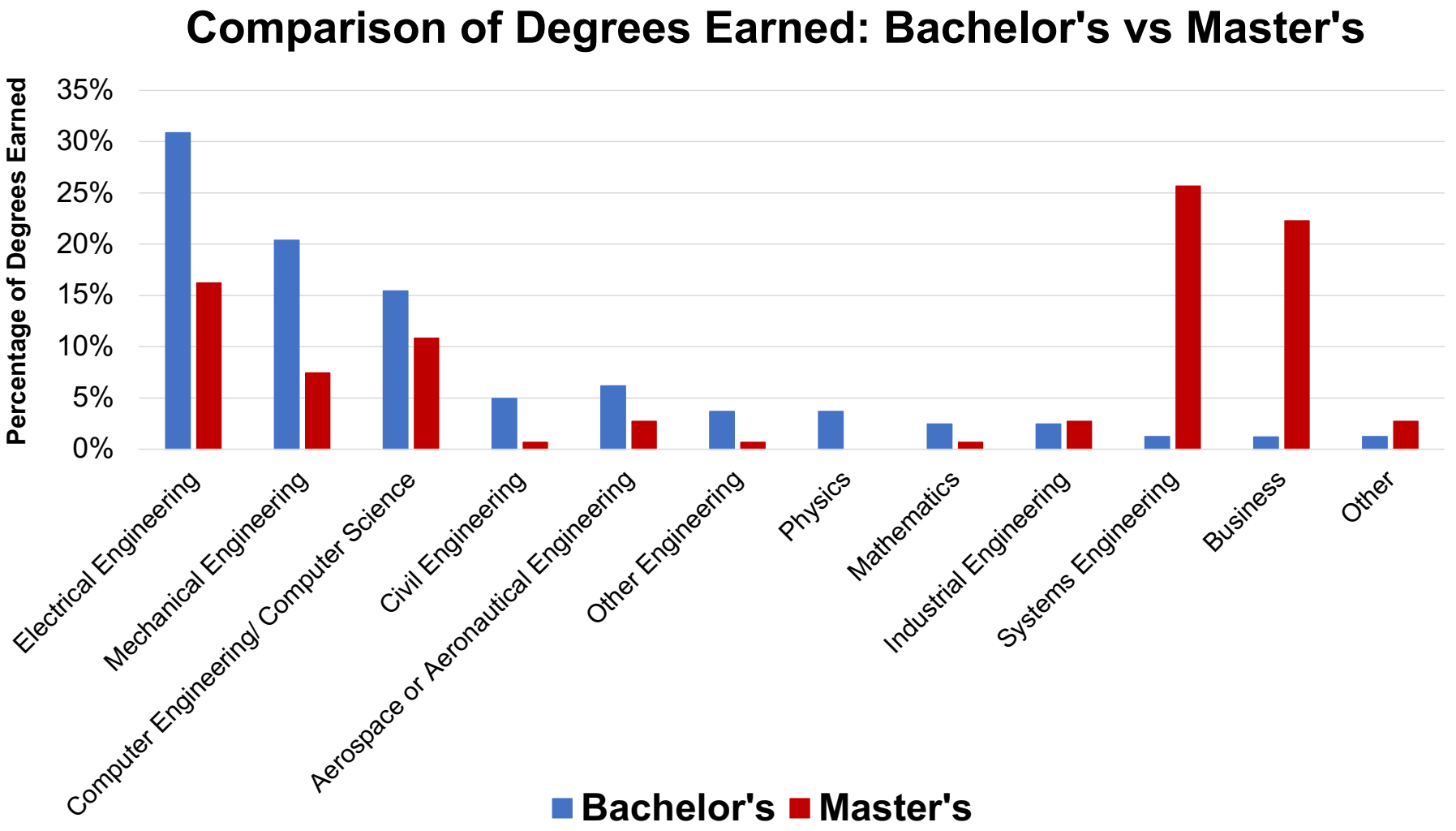
Instructor/Teacher

# Education Patterns

## Time between Completion of Undergraduate and Graduate Education

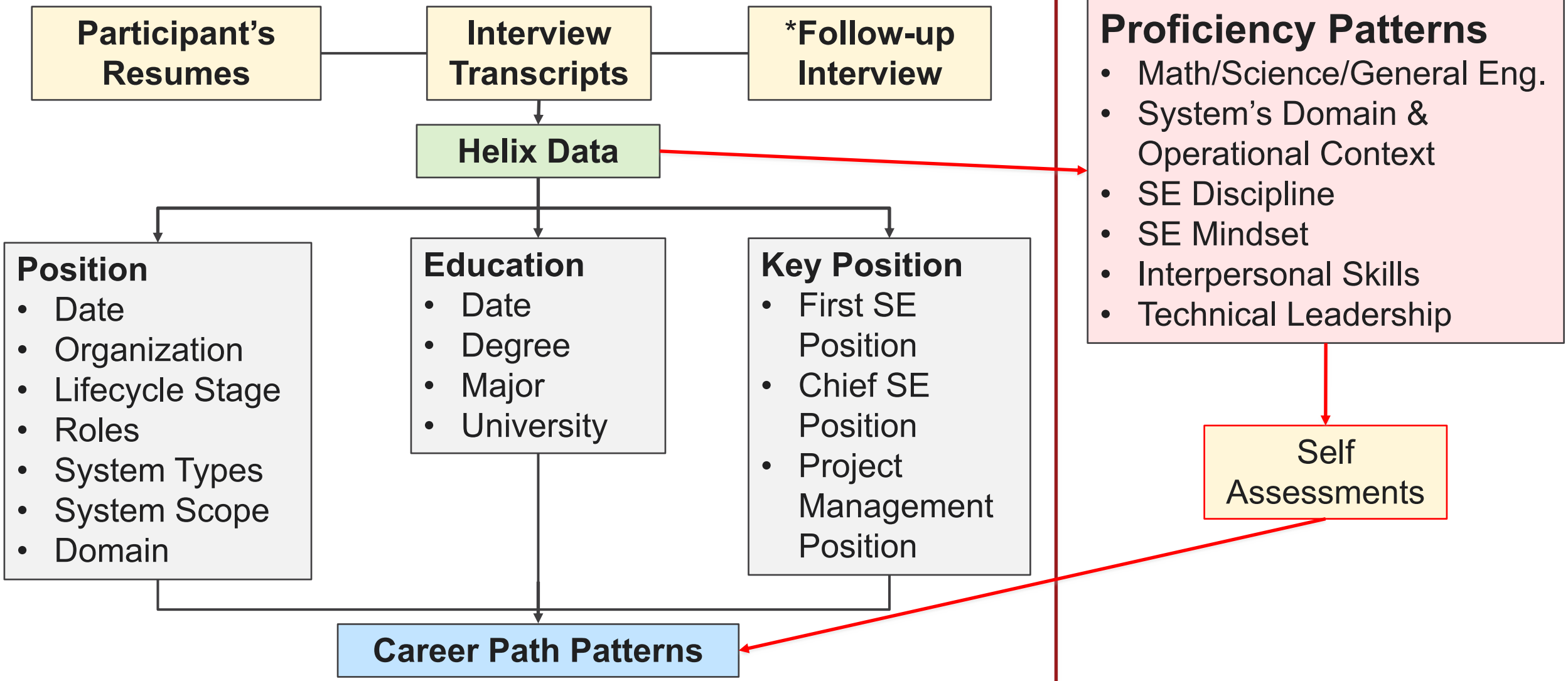


# Frequent Degrees Earned



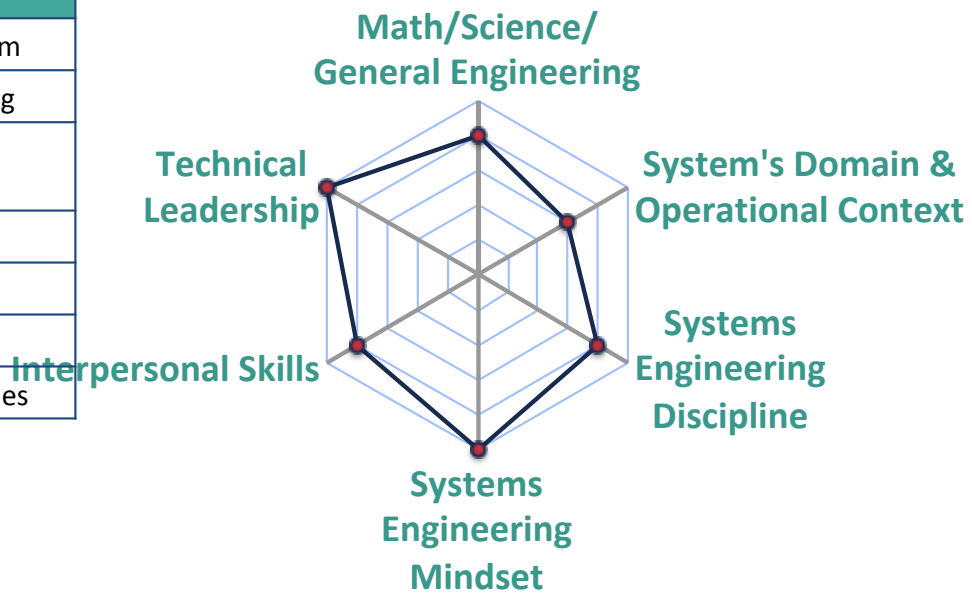
# Proficiency Patterns

# Methodology



# Proficiency of a Systems Engineer

| 6. Technical Leadership |
|---|
| Building & Orchestrating a Diverse Team |
| Balanced Decision Making & Risk Taking |
| Guiding Stakeholders with Diverse/ Conflicting Needs |
| Conflict Resolution & Barrier Breaking |
| Business & Project Management Skills |
| Establishing Technical Strategies |
| Enabling Broad Portfolio-Level Outcomes |




| 1. Math / Science / General Engineering |
|---|
| Natural Science Foundations |
| Engineering Fundamentals |
| Probability & Statistics |
| Calculus & Analytical Geometry |
| Computing Fundamentals |

| 5. Interpersonal Skills |
|---|
| Communication |
| Listening & Comprehension |
| Working in a Team |
| Influence, Persuasion, & Negotiation |
| Building a Social Network |

| 2. System's Domain & Operational Context |
|---|
| Principle and Relevant Domains |
| Familiarity with System's Concept of Operations (ConOps) |
| Relevant Domains |
| Relevant Technologies |
| Relevant Disciplines and Specialties |
| System Characteristics |

| 4. SE Mindset |
|---|
| 'Big Picture' Thinking |
| Paradoxical Mindset |
| Flexible Comfort Zone |
| Multi-Scale Abstraction |
| Foresight & Vision |

| 3. SE Discipline |
|---|
| Lifecycle |
| Systems Engineering Management |
| Systems Engineering Methods, Processes, & Tools |
| Systems Engineering Trends |

# Career Paths of Helix Participants

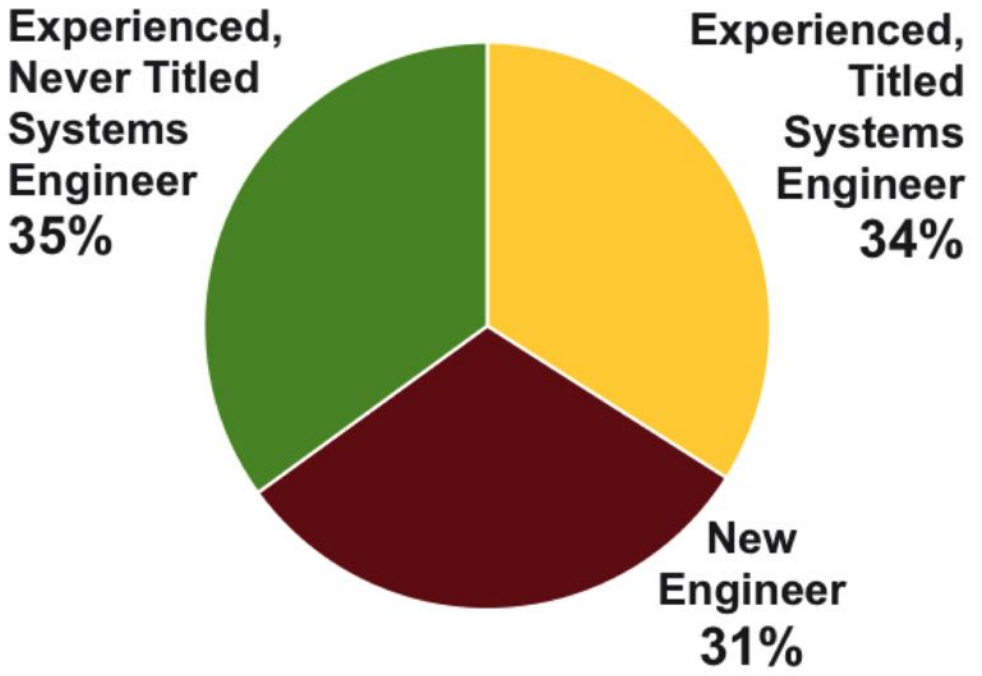
## Why do we care about General Career Path?

It allows us to:

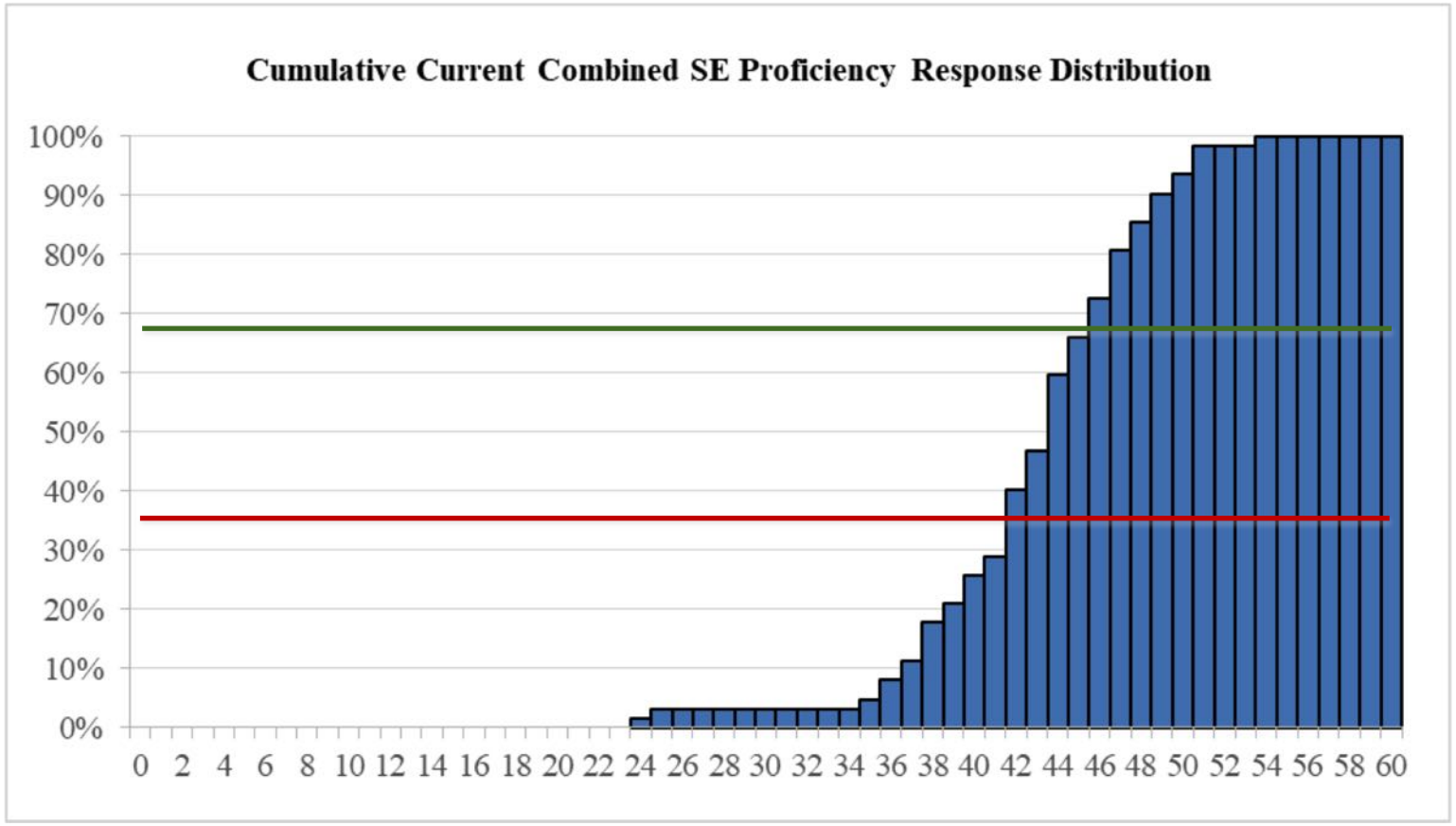
- Discover if career path has a quantifiable impact on an individuals systems engineering proficiency

| | New Engineer | Experienced, Never Titled Systems Engineer | Experienced, Titled Systems Engineer |
|---|---|---|---|
| Years of Experience | Less than 9 years | Equal to or greater than 9 years | Equal to or greater than 9 years |
| Position Title's | - | 0 years titled as Systems Engineer | Greater than 0 years titled as Systems Engineer |

## General Career Path Classification

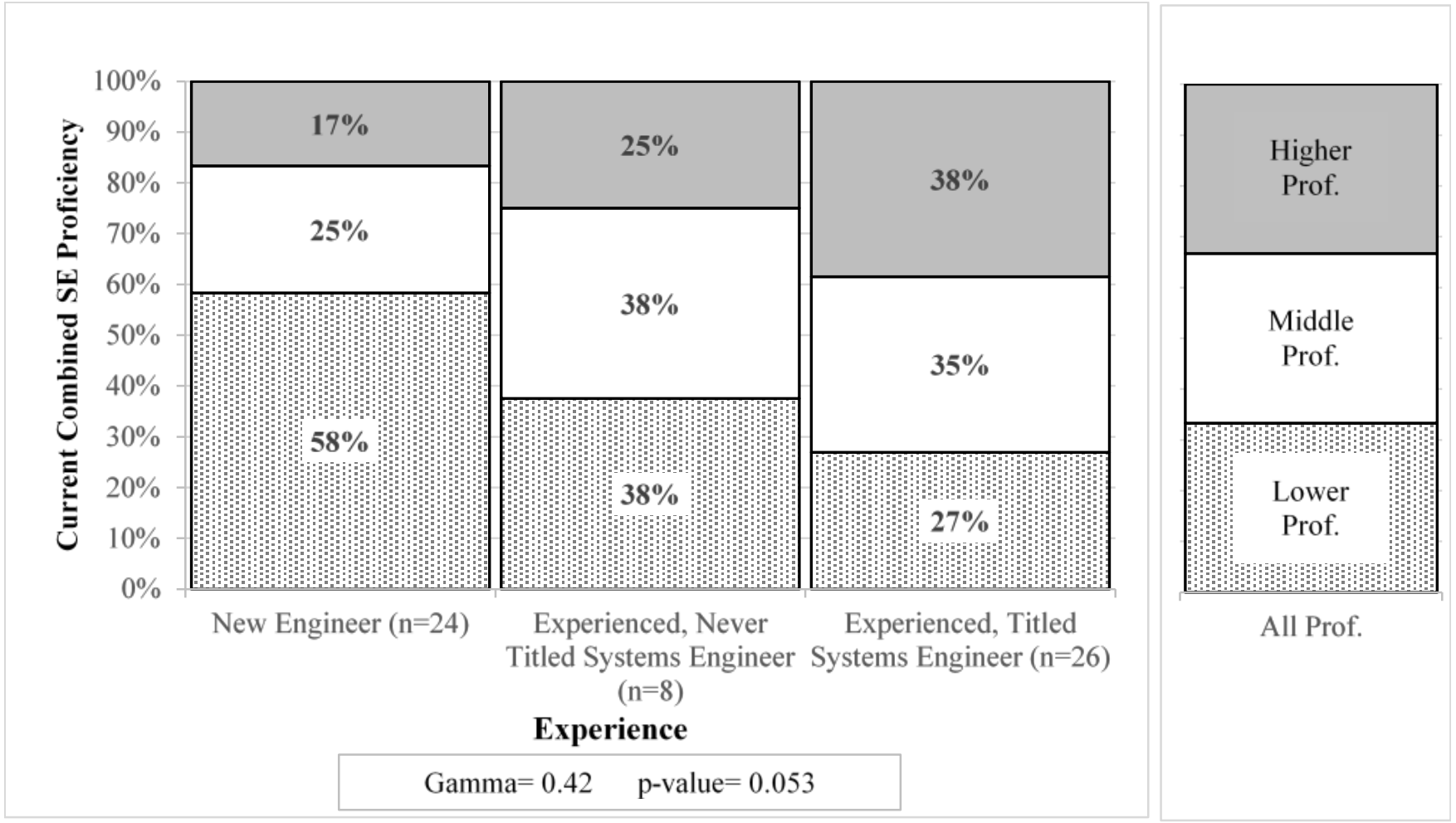


# Self Assessment Response Distribution




| | Lower Proficiency | Middle Proficiency | Higher Proficiency |
|---|---|---|---|
| Combined Proficiency | $0 \le x \le 42$ | $43 \le x \le 46$ | $47 \le x \le 60$ |

# Combined SE Proficiency



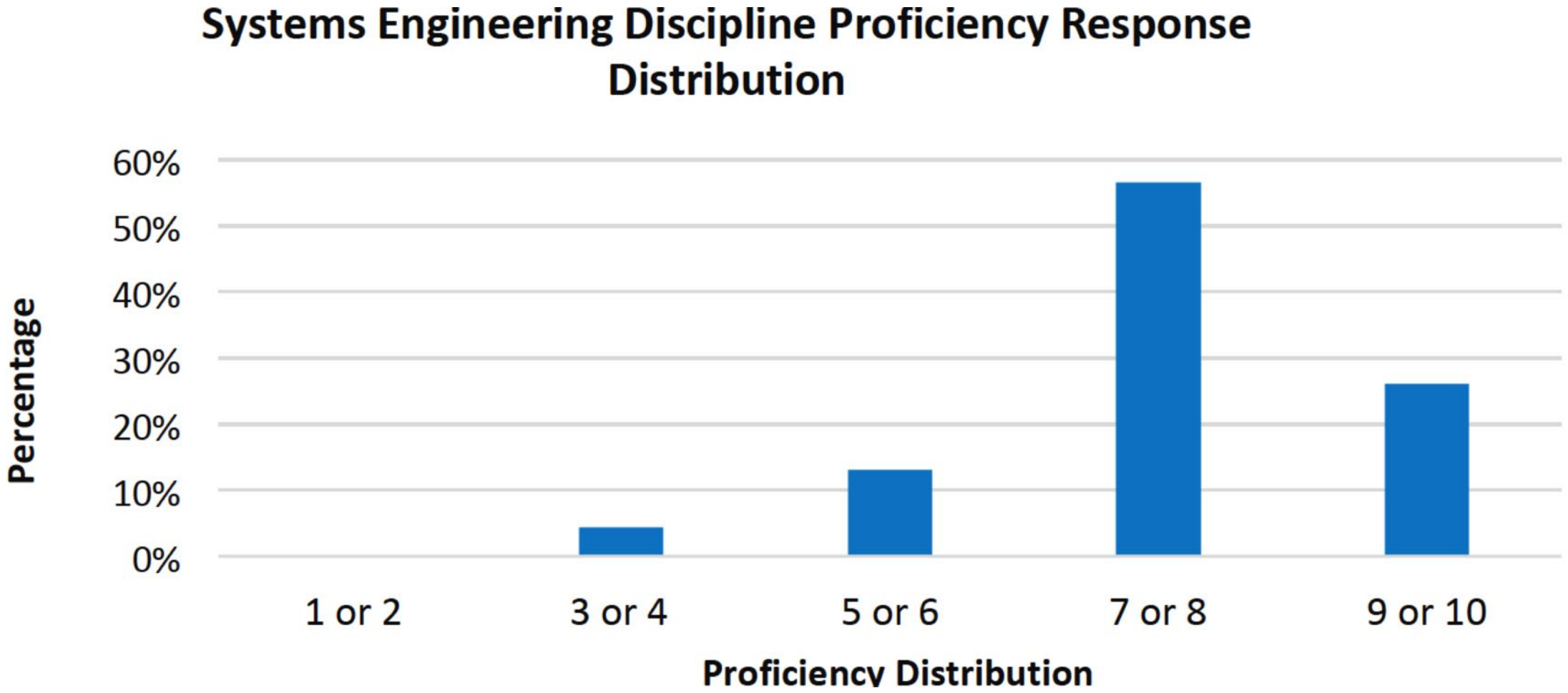
# Proficiency Patterns Summary

- The relationship between experience and combined SE proficiency
  - Reveals a very strong positive relationship (Gamma=0.42)
  - Has a confidence of 94.7% (p-value=0.053)

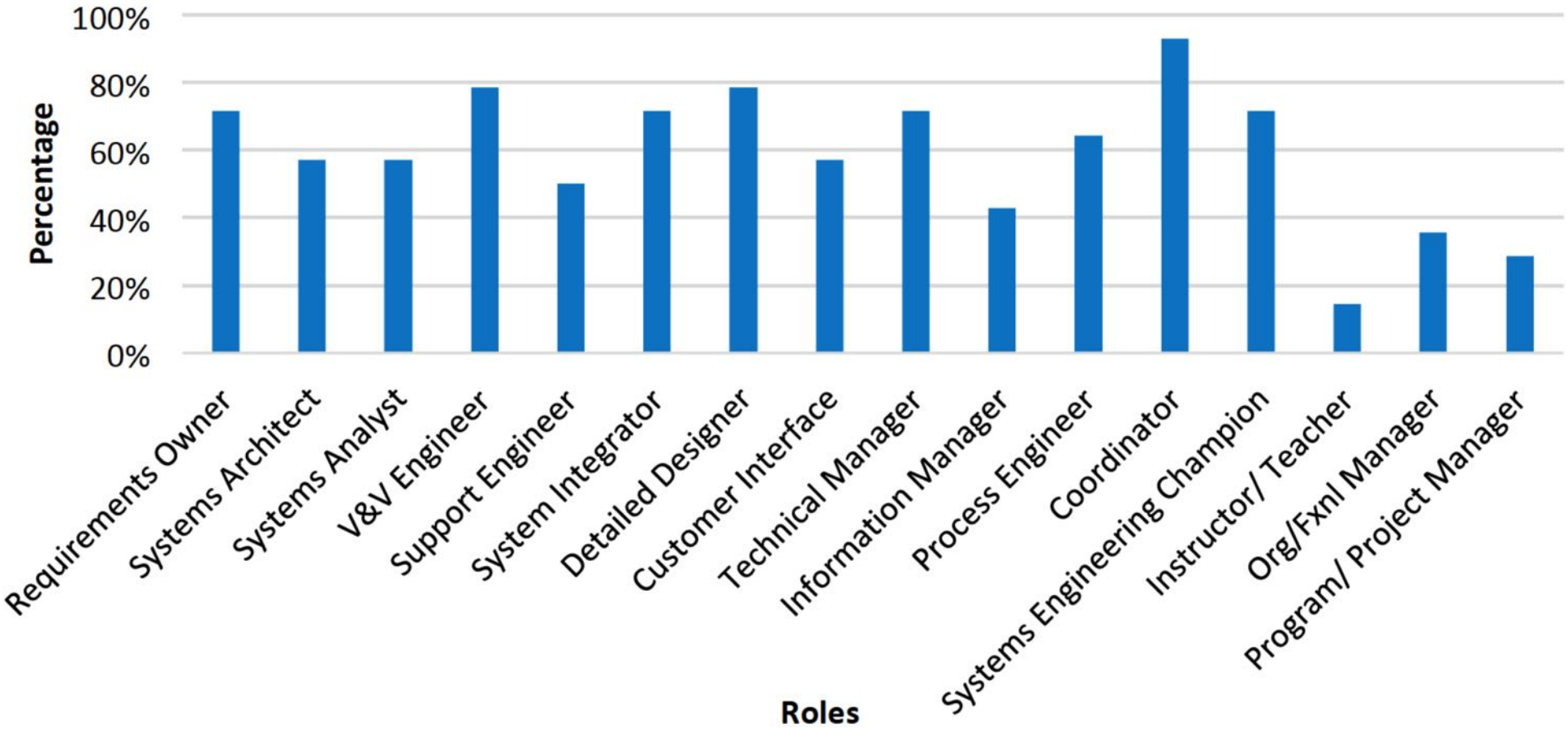
# Matthew's Conclusions

- Get more data and explore relationships with better refinement
- Get statistical relationships between proficiency and all other aspects of experience to feed models
- Relate project performance to systems engineers' proficinecy

# Relating Proficiencies and Career Path



# Roles and Proficiency (7-8)



# In the end . . .

- Identifying patterns that can be used to help systems engineers grow
- No one “career path” – but there are common approaches that lead to certain proficiencies
- For more details, see the *Career Path Guidebook*
- For more information: helix@stevens.edu

# Conclusions - Nicole

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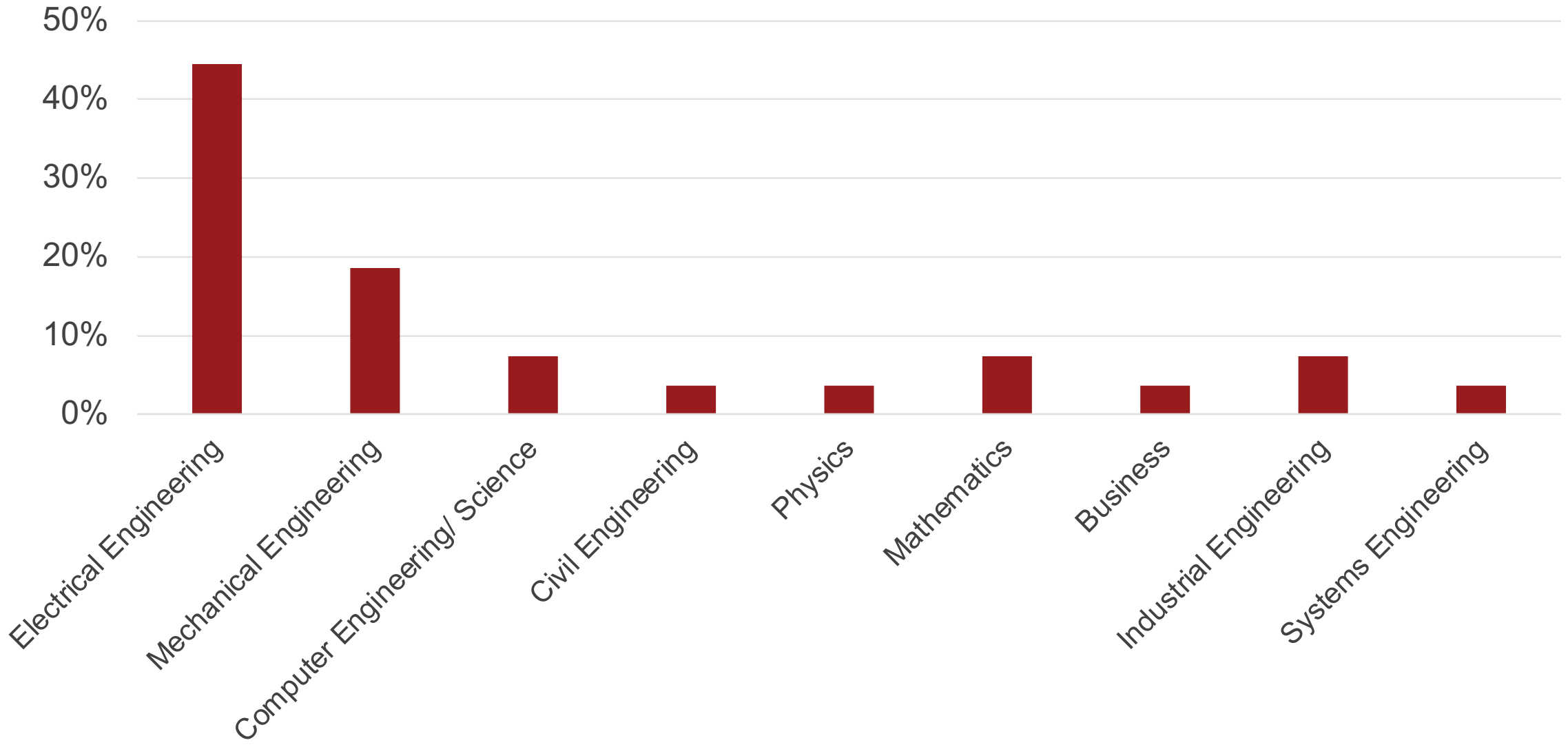
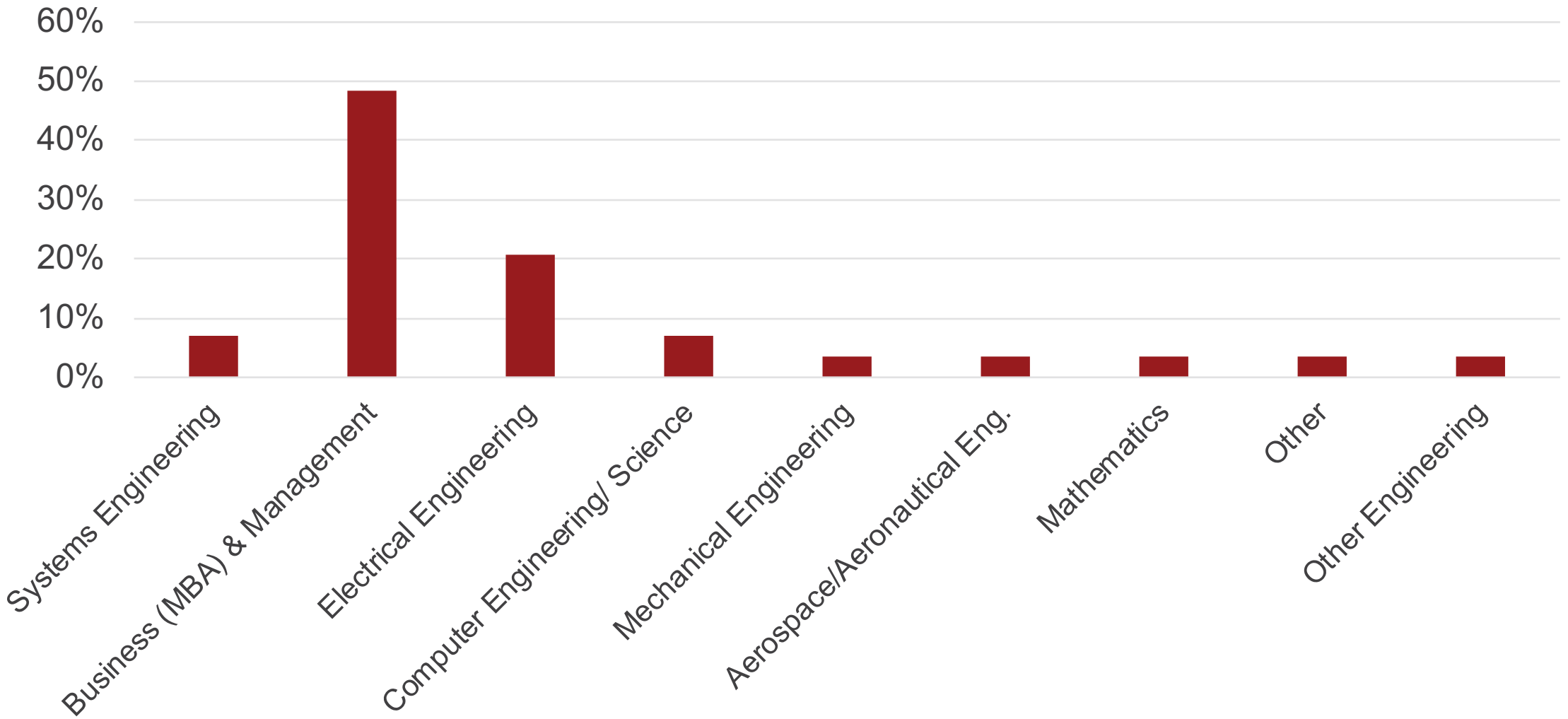
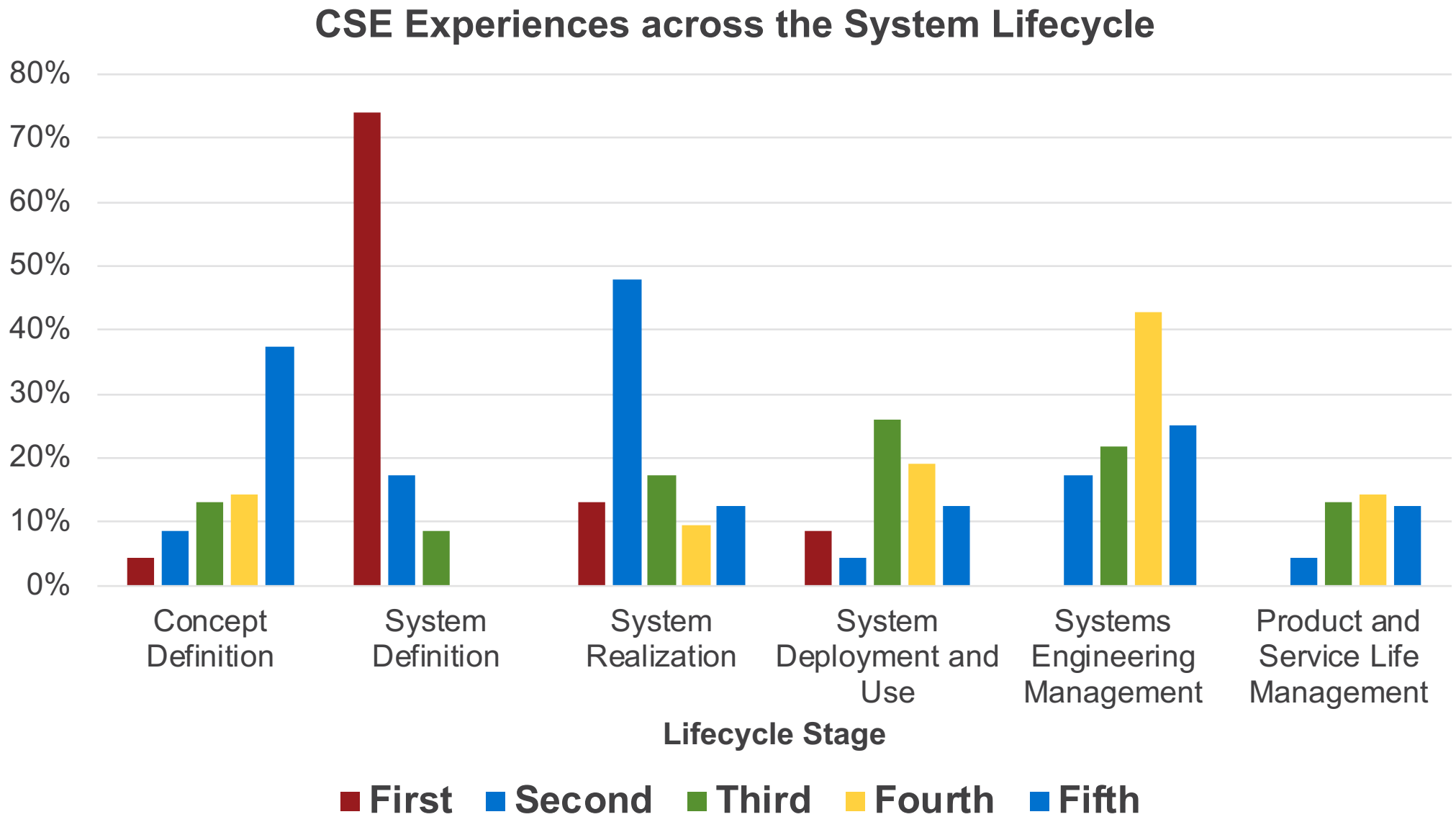
# Bachelor's Degree Majors of CSE's

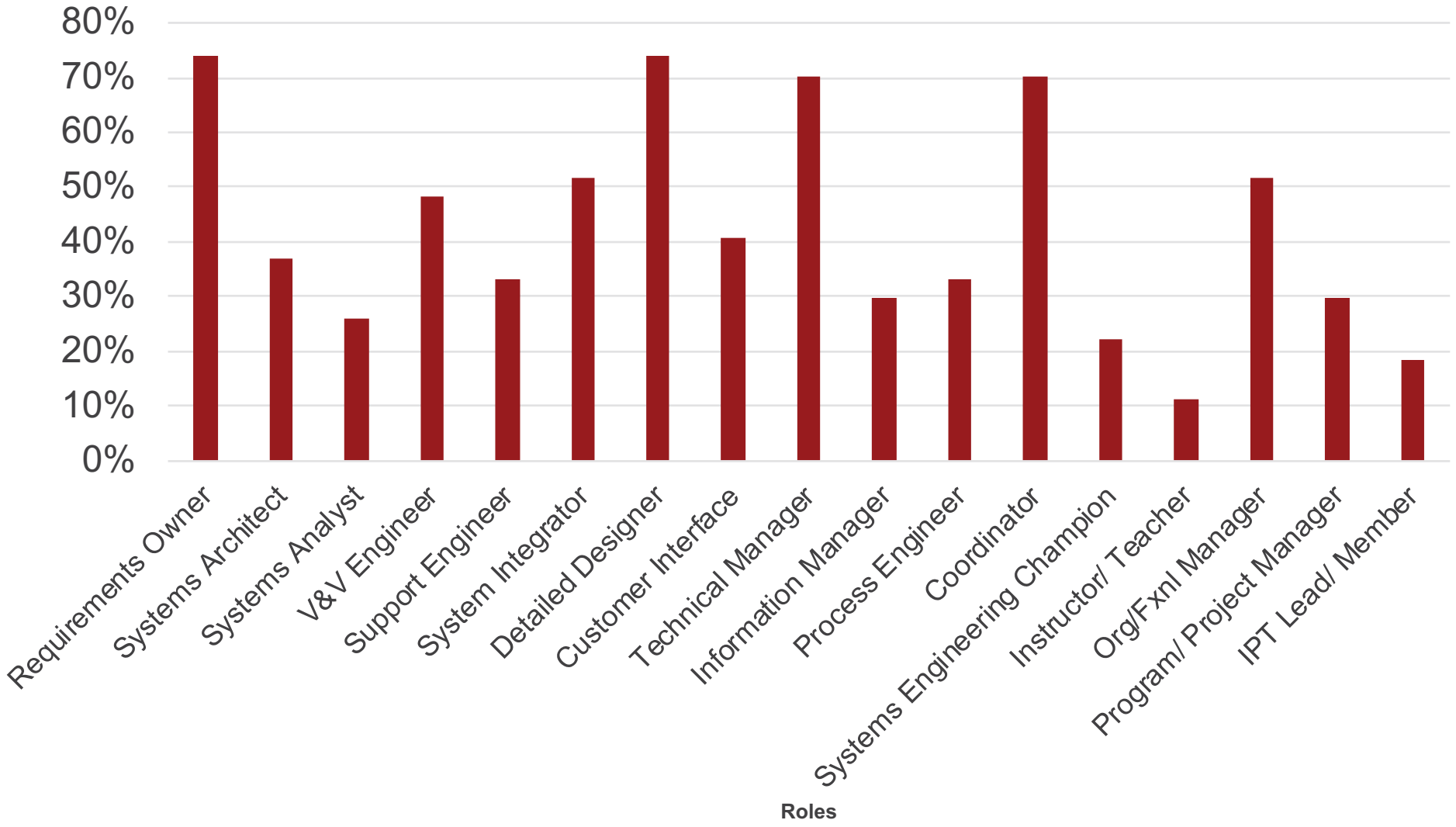


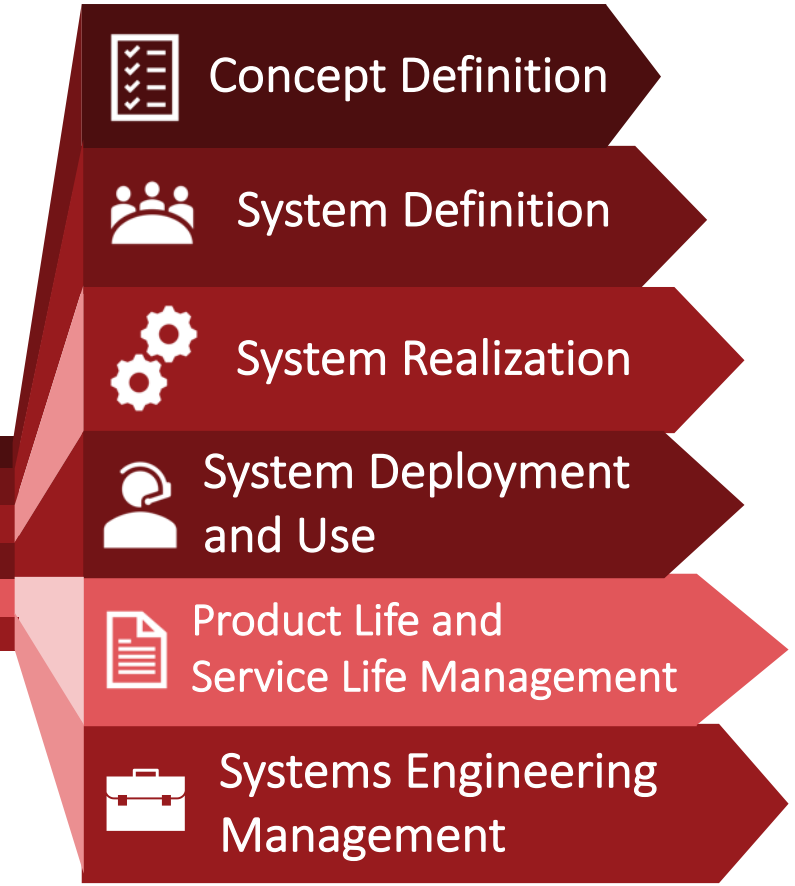
# Master's Degree Majors of CSE's




CSE Experiences across the System Lifecycle
80%
70%
60%
50%
40%
30%
20%
10%
0%
Concept Definition
System Definition
System Realization
System Deployment and Use
Systems Engineering Management
Product and Service Life Management
Lifecycle Stage
First
Second
Third
Fourth
Fifth

# Frequency of Roles Played by CSE's




Concept Definition
System Definition
System Realization
System Deployment and Use
Product Life and Service Life Management
Systems Engineering Management

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