



Helix & Atlas: The Theory of Effective Systems Engineers

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- 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.
- Helix is 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
 - 287 participants from 20 organizations
- Reporting is done in an aggregated anonymous manner that does not reveal the identities of participating individuals or organizations

- **systems engineering** – An interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis and system validation while considering the complete problem. Including Operations, Performance, Test, Manufacturing, Cost & Schedule, Training & Support, and Disposal.

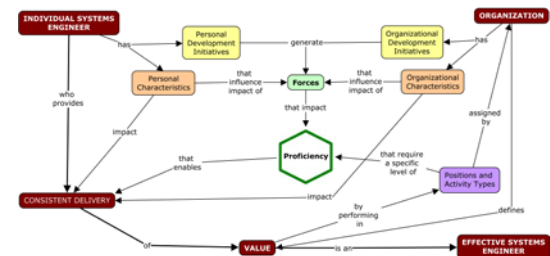
Systems engineering integrates all the disciplines and specialty groups into a team effort forming a structured development process that proceeds from concept to production to operation. Systems engineering considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs.(INCOSE 2015)

- **systems engineer** – An individual who performs systems engineering activities and is recognized (either formally or informally) by his or her organization for their ability to perform these activities.

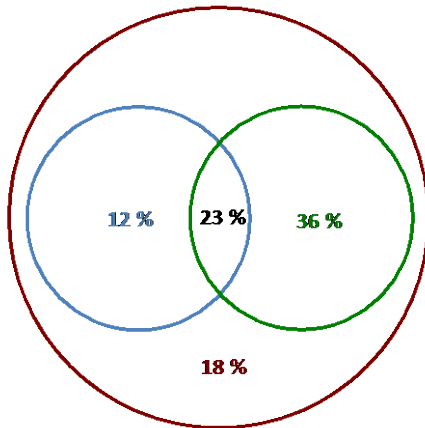
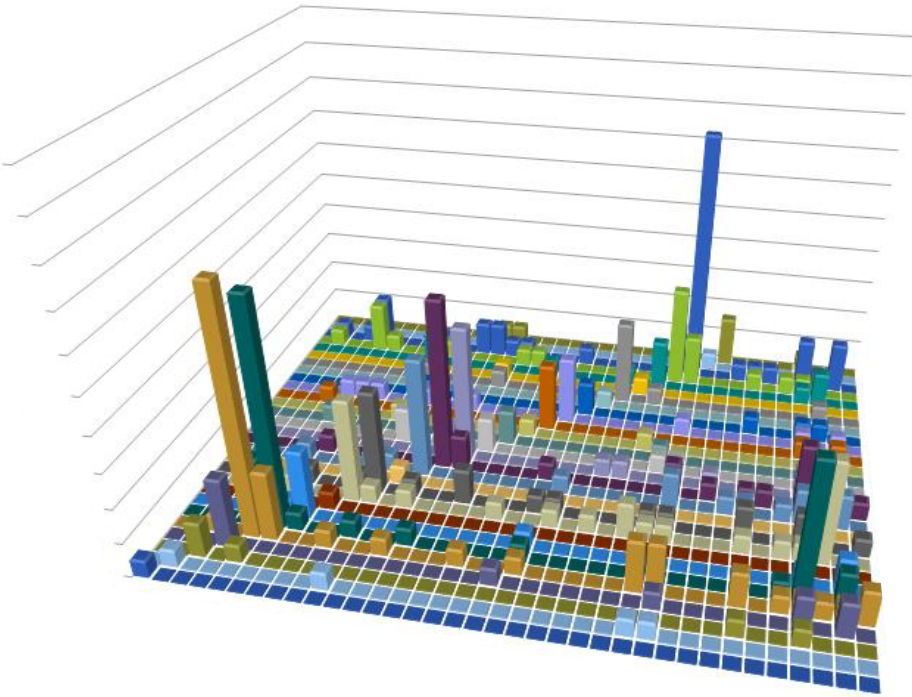
Helix vs Atlas



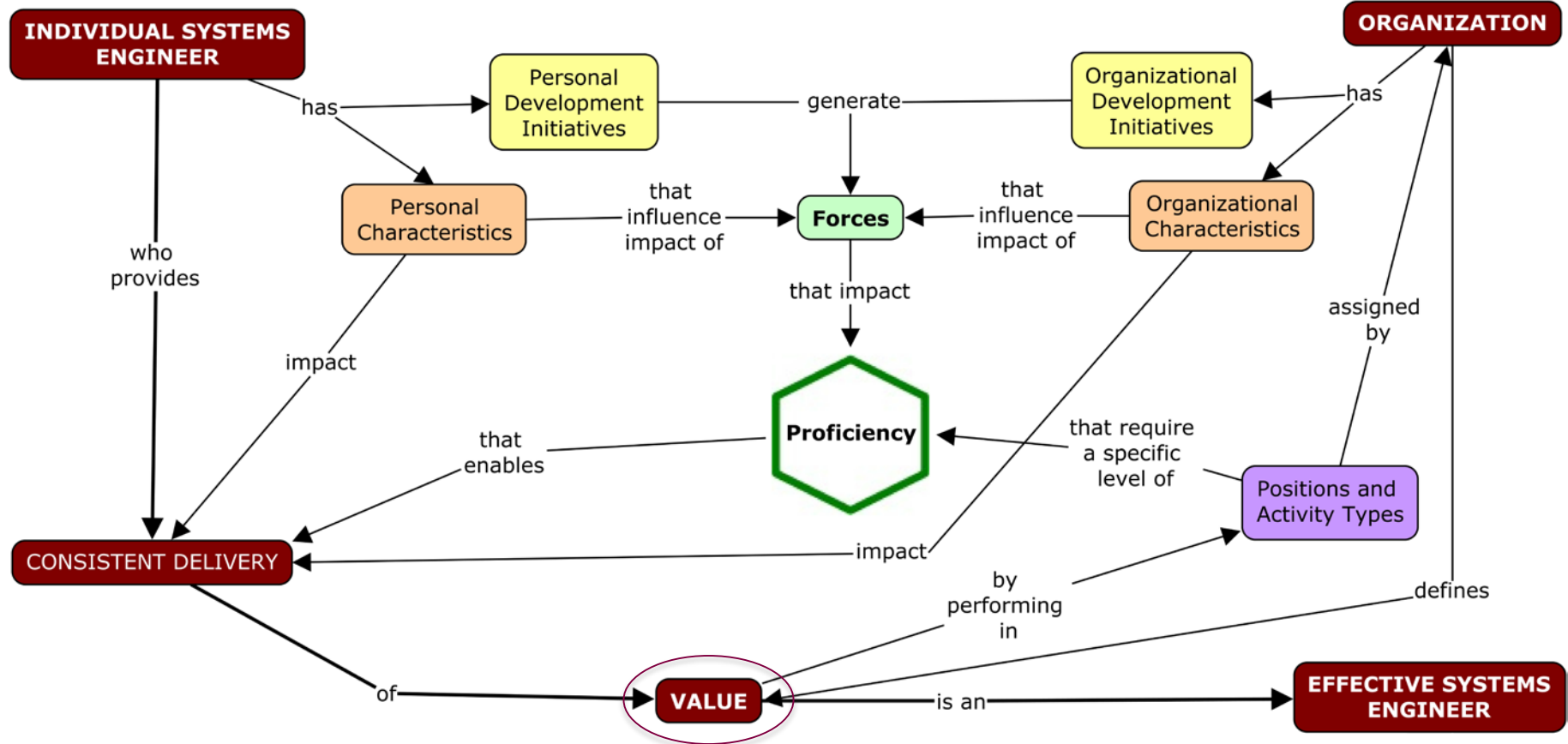
Helix is the *project* focused on understanding what makes systems engineers effective.



Atlas is the primary *product* of Helix – the theory of effective systems engineers developed from the Helix project over time.



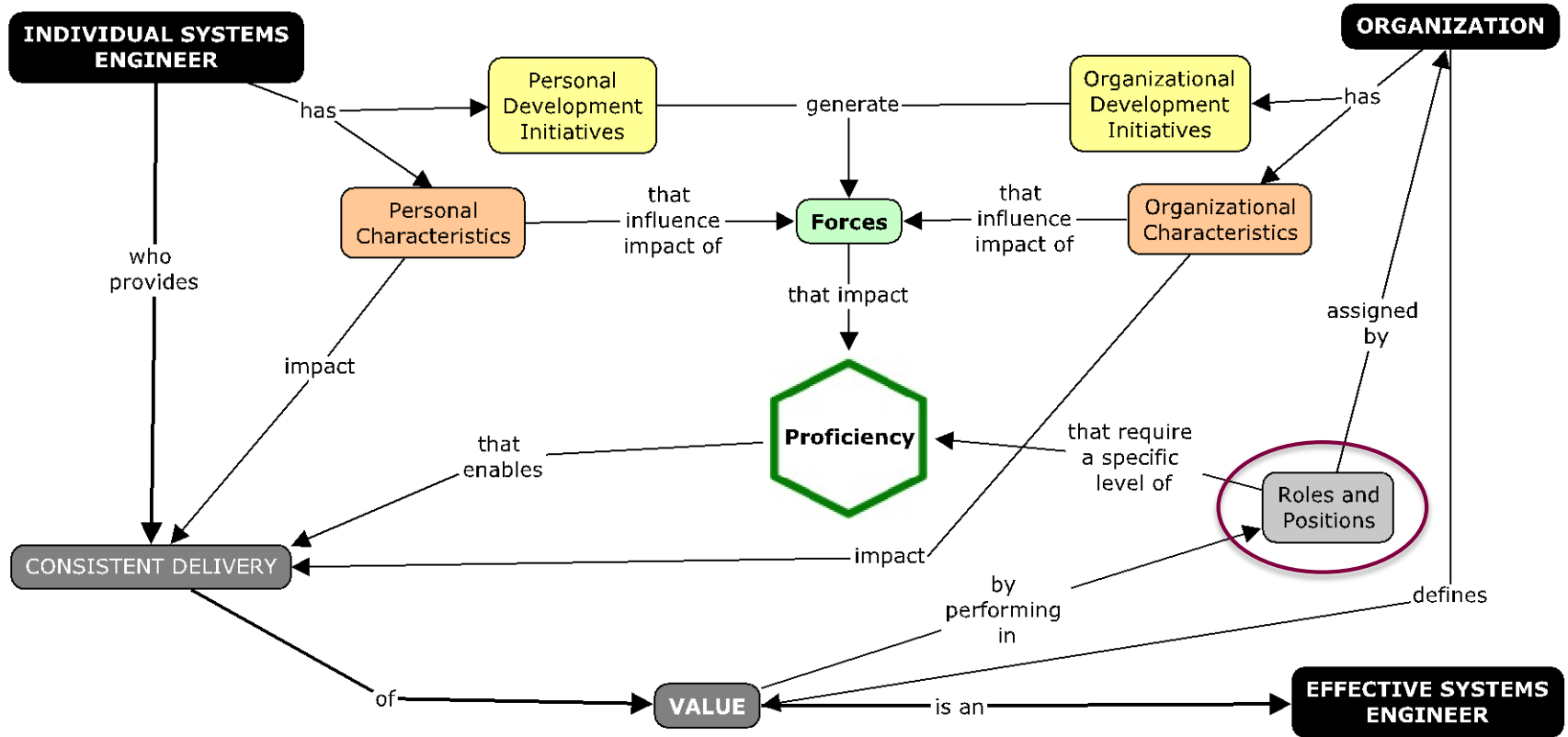
- Initially Grounded theory
- Currently aligning with existing research frameworks
- In-depth interviews with
 - Systems Engineers
 - Systems Engineering Managers
 - Peers (Project Managers, Classic Engineers, etc.)
 - HR
- Interview data mining
 - Coding
 - Qualitative analysis



- Translation of technical jargon into business or operational terms and vice versa (11%)
- Keeping and maintaining the system vision (11%)
- Enabling diverse teams to successfully develop systems. (10%)
- Managing emergence in both the project and the system (7%)
- Enabling good technical decisions at the system level (7%)
- Supporting the business cases for systems (7%)

Keeping and maintaining the system vision (11%) is enabled by:

- Getting the “true” requirements from the customer and creating alignment between the customer and the project team. (39%)
- Seeing relationships between the disciplines and helping team members understand and respect those relationships. (33%)
- Balancing technical risks and opportunities with the desired end result. (36%)
- Providing the big picture perspective for the system. (44%)



SE Roles

Focus on System:

- Concept Development
 - Concept Creator
- Support & Sustainment
 - Support Engineering

Focus on System:

- Concept Development
 - Requirements Owner
- Systems Architecture & Design
 - System Architect
 - System Integrator
 - System Analyst
- Implementation
 - Detailed Designer
 - V&V Engineer

Focus on Teams that Build Systems:

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

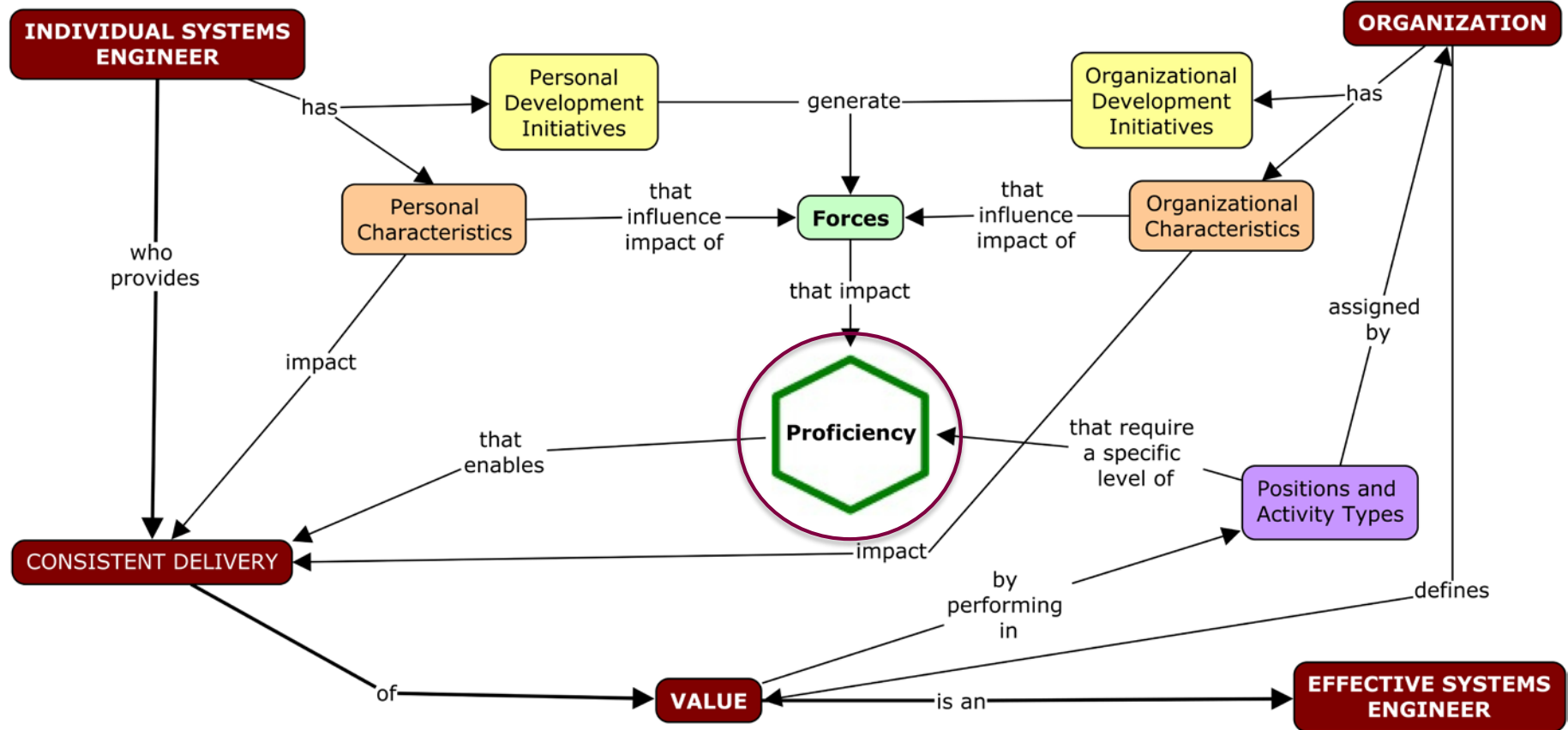
Focus on Process & Organization:

- Utilization of SE
 - SE Evangelist
- Process
 - Process Engineer

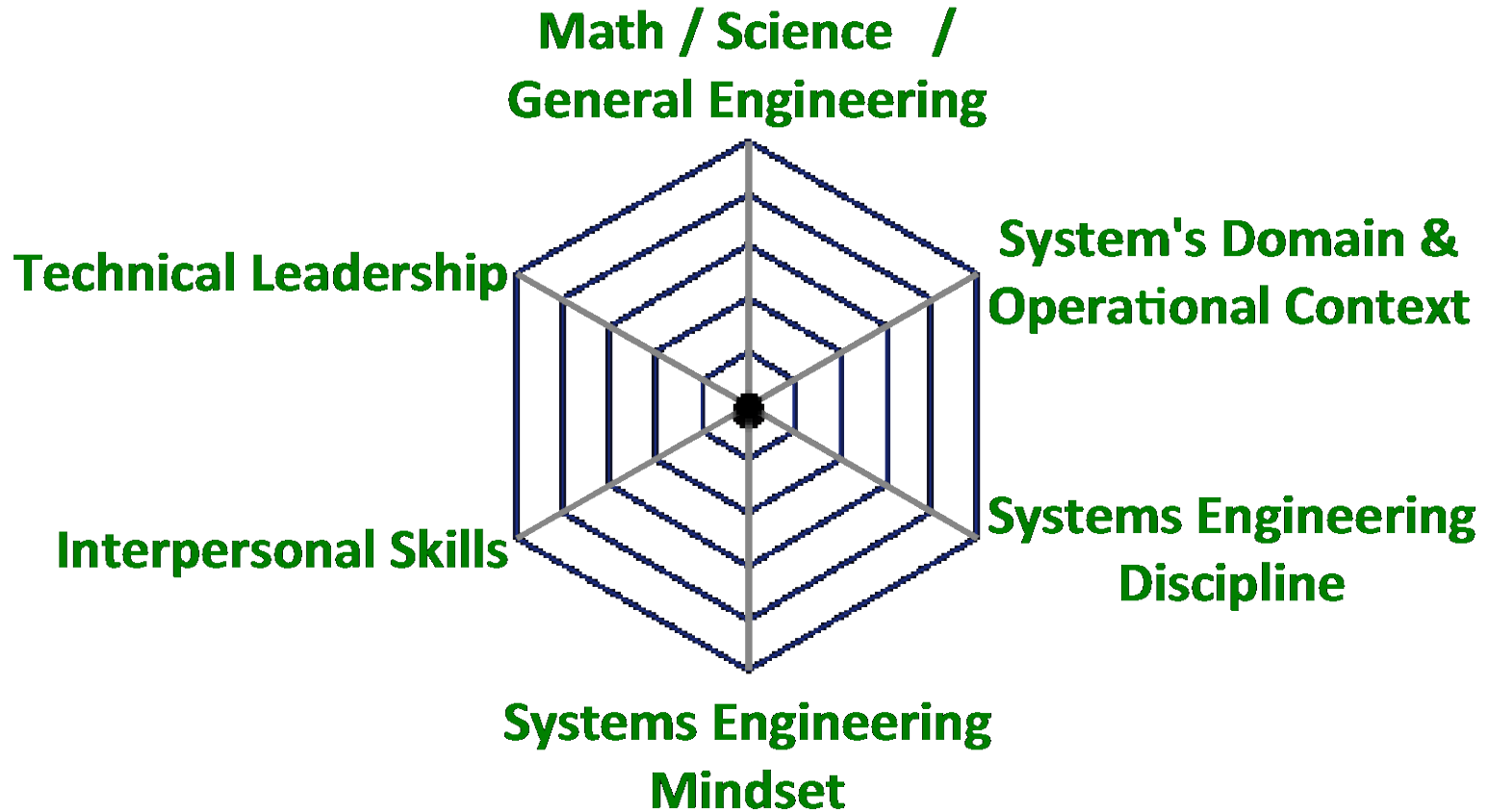
Roles Held by SEs

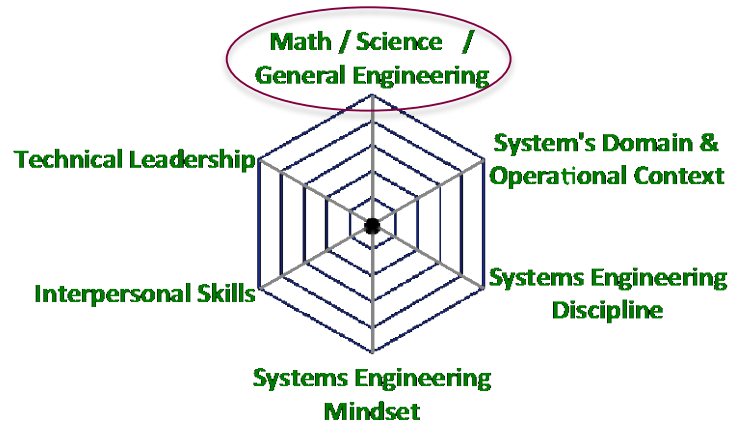
Non-SE Roles Common to Systems Engineers

- Organizational/Functional Manager
- Program/Project Manager



- MITRE *Systems Engineering Competency Model* (MITRE Corporation 2007) (summary)
- U.S. Department of Defense (DoD) Systems Planning, Research, Development, and Engineering—*Systems Engineer/Program Systems Engineer (SPRDE-SE/PSE) Competency Model* (2007)
- U.S. National Aeronautics and Space Administration (NASA) *Systems Engineering Competencies* (2009)
- NASA *Competencies Common to Project Management and Systems Engineering* (2009)
- INCOSE *Systems Engineering Competencies Framework* (2010)
- Software Engineering Institute (SEI) *Models for Evaluating and Improving Architecture Competence* (2008)
- U.S. DoD *DoD Program Management Career Field Functional Competencies* (2007), specifically topic 3 “systems engineering” and topic 4 “software”.
- *INCOSE draft Competency Framework*

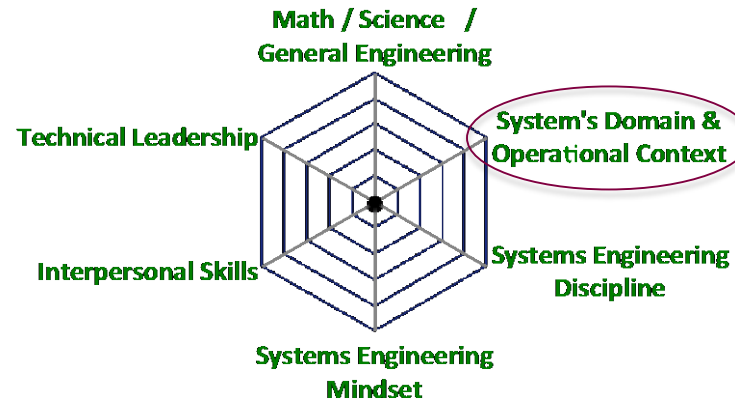




Category

- 1.1. Natural Science Foundations
- 1.2. Engineering Fundamentals
- 1.3. Probability and Statistics
- 1.4. Calculus and Analytical Geometry
- 1.5. Computing Fundamentals

Tailored to the topics most relevant to the organization, systems being developed, etc.

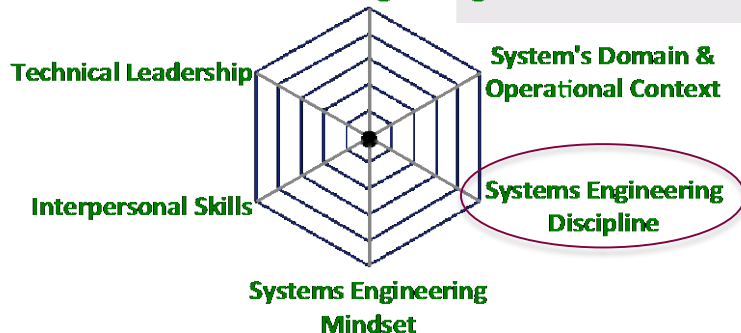


Category	Topics
2.1 Principal and Relevant Systems	< List of Principal and Relevant Systems >
2.2 Familiarity with Principal System's Concept of Operations (ConOps)	
2.3 Relevant Domains	< List of relevant Domains >
2.4 Relevant Technologies	< List of relevant Technologies >
2.5 Relevant Disciplines and Specialties	< List of relevant Disciplines and Specialties >
2.6 System Characteristics	< List of applicable System Types, Scales, and Levels >

Tailored to the topics most relevant to systems being developed.

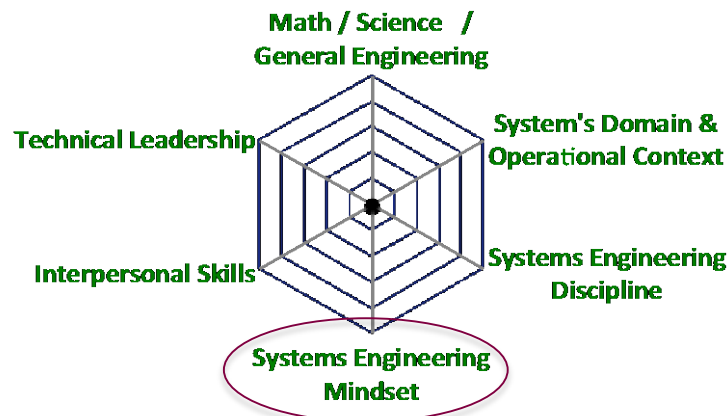
Category	Topics
3.1 Lifecycle	3.1.1 Lifecycle Models 3.1.2 Concept Definition 3.1.3 System Definition 3.1.4 System Realization 3.1.5 System Deployment and Use 3.1.6 Product and Service Life Management
3.2 Systems Engineering Management	3.2.1 Planning 3.2.2 Risk Management 3.2.3 Configuration Management 3.2.4 Assessment and Control 3.2.5 Quality Management
3.3 SE Methods, Processes, and Tools	3.3.1 Balance and Optimization 3.3.2 Modeling and Simulation 3.3.3 Development Process 3.3.4 Systems Engineering Tools
3.4 Systems Engineering Trends	3.4.1 Complexity 3.4.2 Model Oriented Systems Engineering 3.4.3 Systems Engineering Analytics 3.4.4 Agile Systems Engineering

Math / Science /
General Engineering

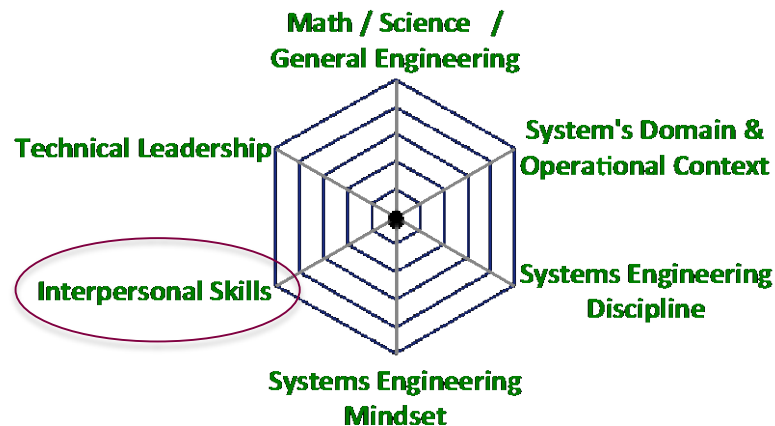


Tailored to the topics most relevant to systems being developed.

Category	Topics
4.1 Big-Picture Thinking	
4.2 Paradoxical Mindset	4.2.1 Big-Picture Thinking and Attention to Detail 4.2.2 Strategic and Tactical 4.2.3 Analytic and Synthetic 4.2.4 Courageous and Humble 4.2.5 Methodical and Creative
4.3 Flexible Comfort Zone	
4.4 Abstraction	
4.5 Foresight and Vision	
4.6 Big-Picture Thinking	

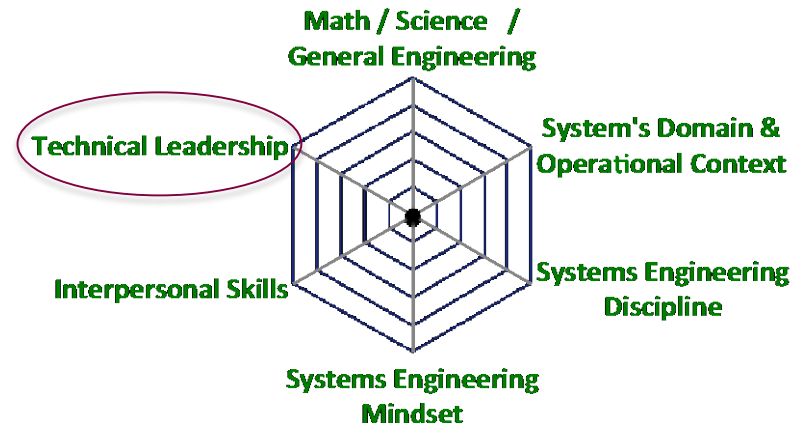


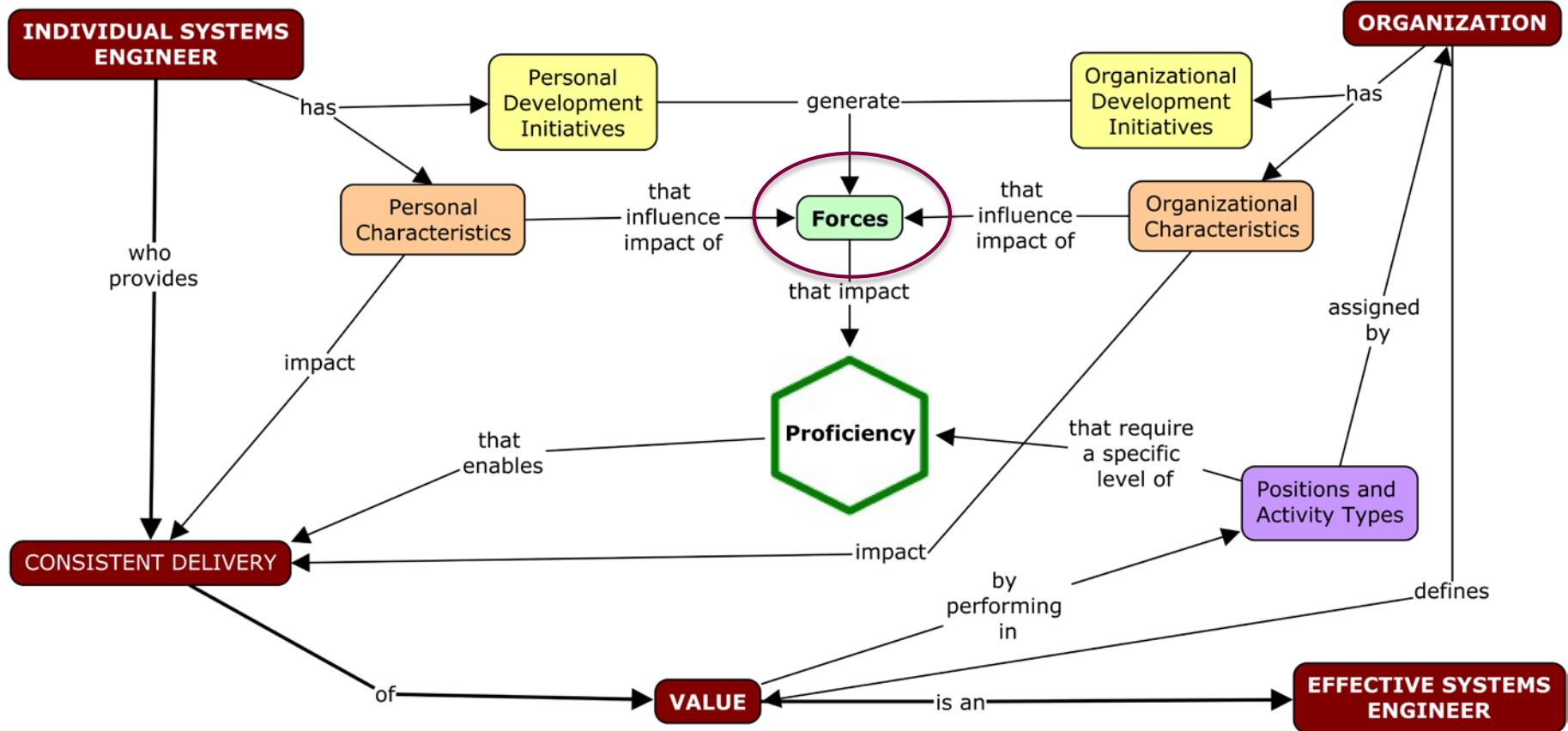
Category	Topics
5.1 Communication	5.1.1 Audience 5.1.2 Content 5.1.3 Mode
5.2 Listening and Comprehension	
5.3 Working in a Team	
5.4 Influence, Persuasion and Negotiation	
5.5 Building a Social Network	

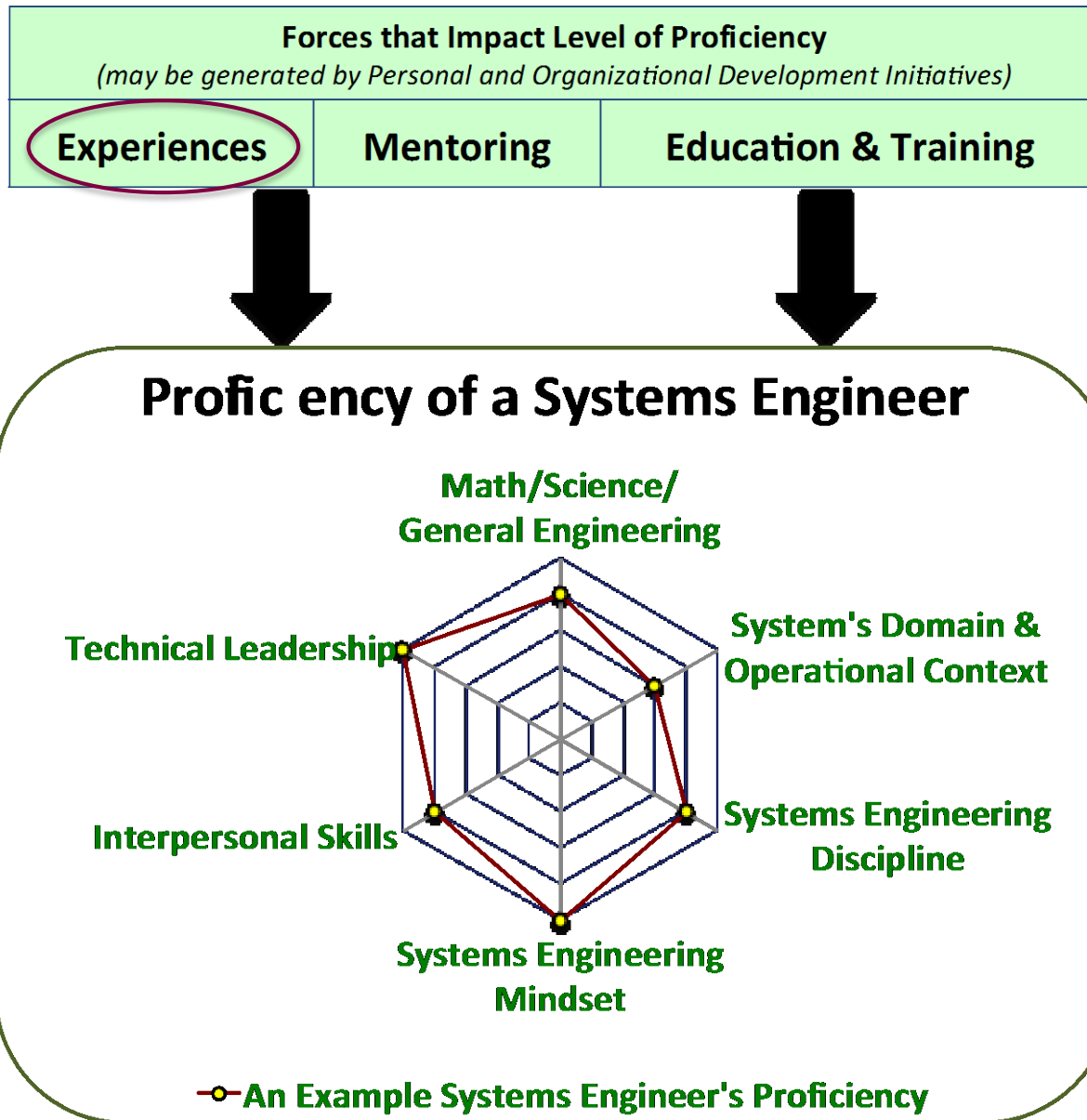


Category

- 6.1 Building and Orchestrating a Diverse Team
- 6.2 Balanced Decision Making & Rational Risk Taking
- 6.3 Managing Stakeholders and Their Needs
- 6.4 Conflict Resolution & Barrier Breaking
- 6.5 Business and Project Management Skills







- **Position**

- **Relevance**

- **Chronological Time**

- **Organization**

- **Organizational Sector**

- **Roles**

- **Lifecycle Phases**

- **Systems Characteristics**

- Domain

- Type

- Level

Organization-specified job, comprised of roles and responsibilities. This is the “unit” for experiences in Helix.

A ‘relevant’ position is one that enables a systems engineer to develop the proficiencies critical to systems engineering. A ‘systems engineering’ position is one where the individual’s primary focus was on SE activities.

In years

Organization and associated characteristics

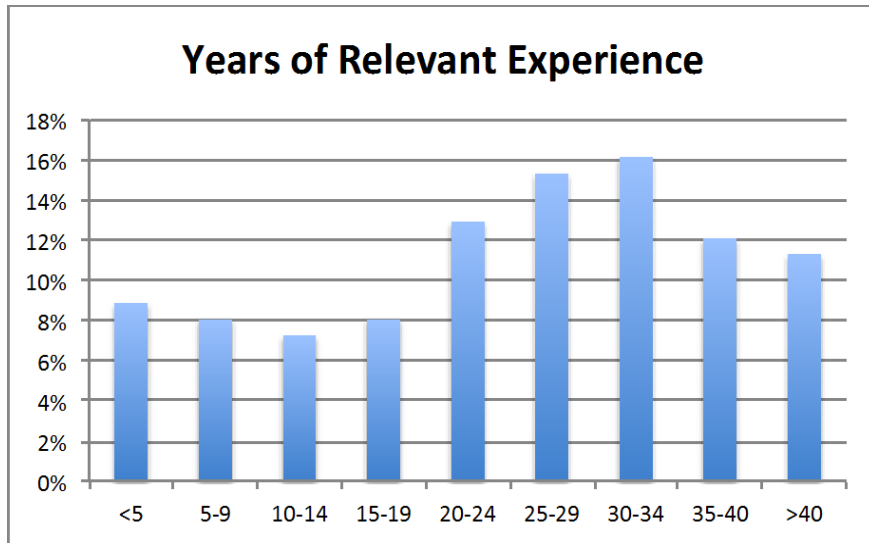
Government, Industry, or Academia

Groups of associated/similar activities

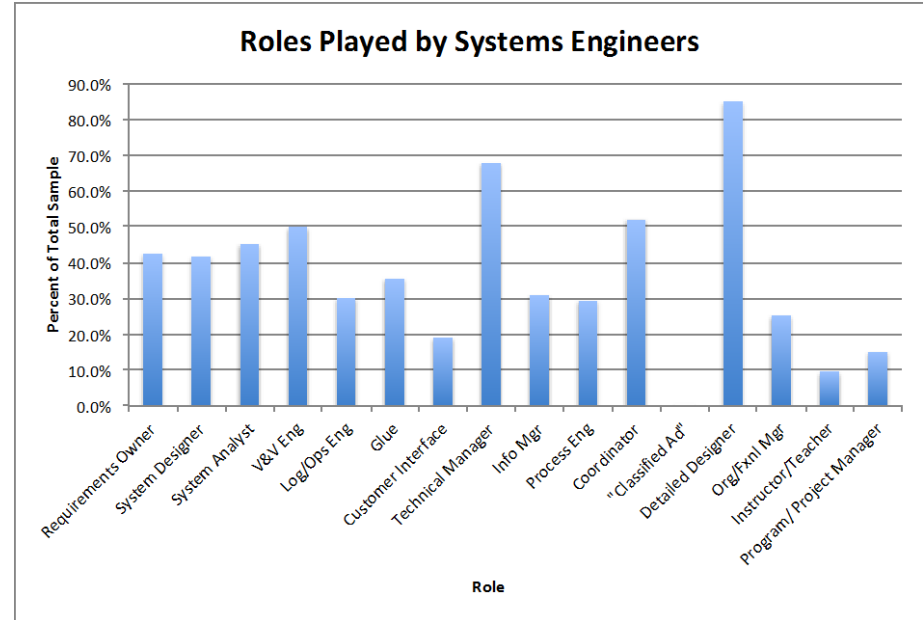
System lifecycle phases on which the work focuses

Characterization of the systems on which the work focuses

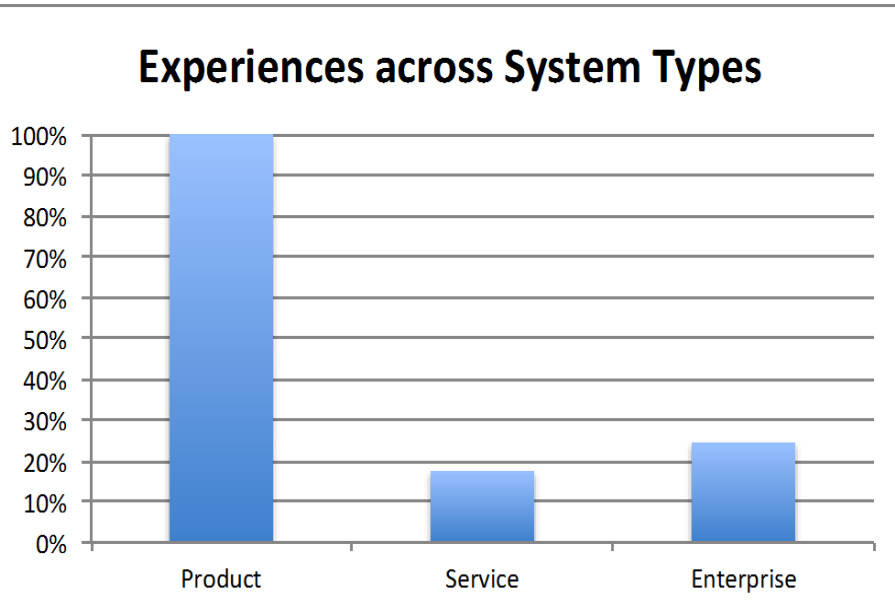
Years of Relevant Experience



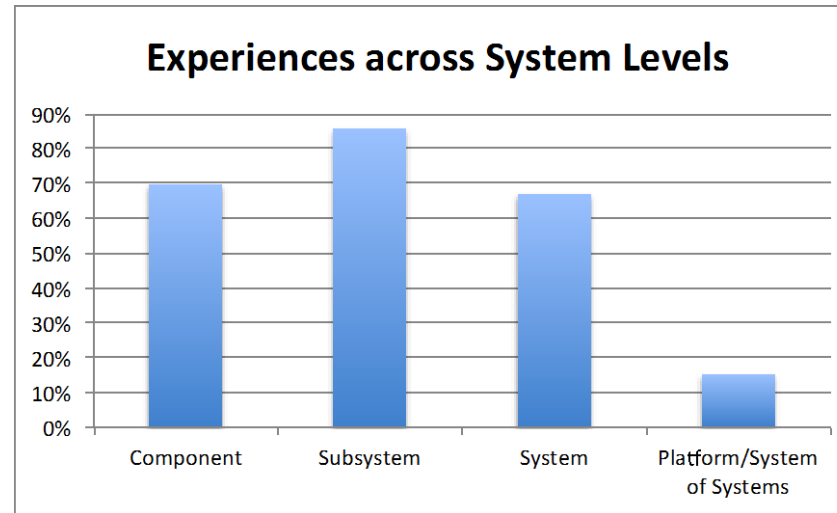
Roles Played by Systems Engineers



Experiences across System Types

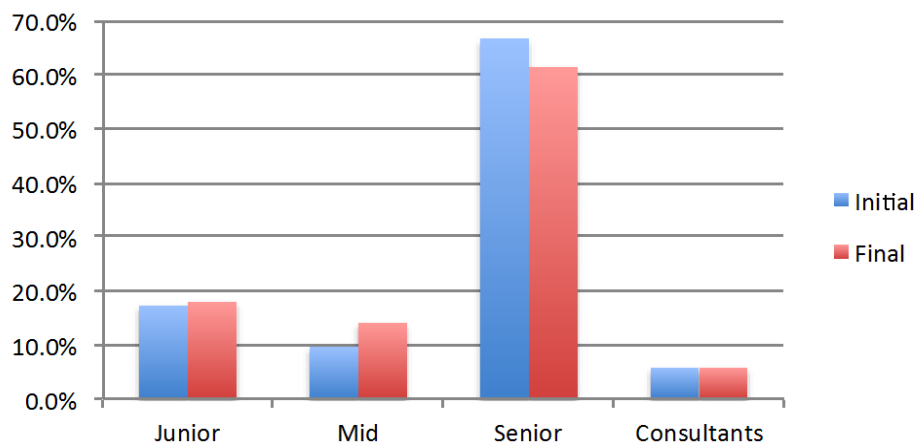


Experiences across System Levels

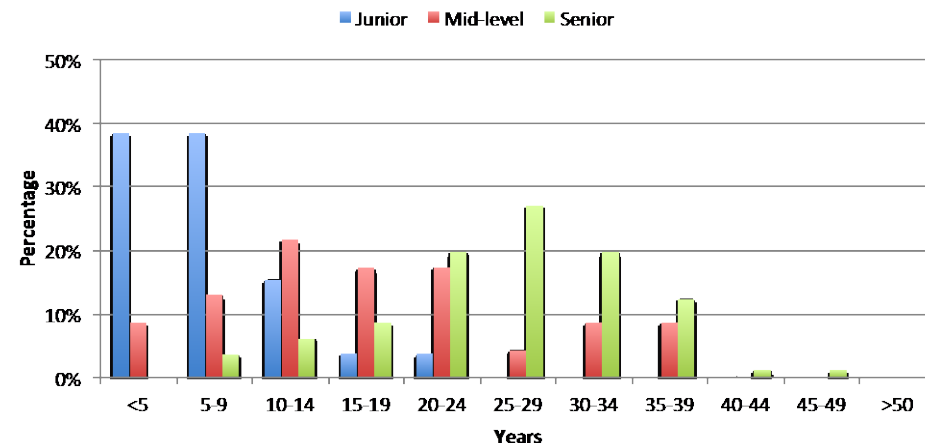


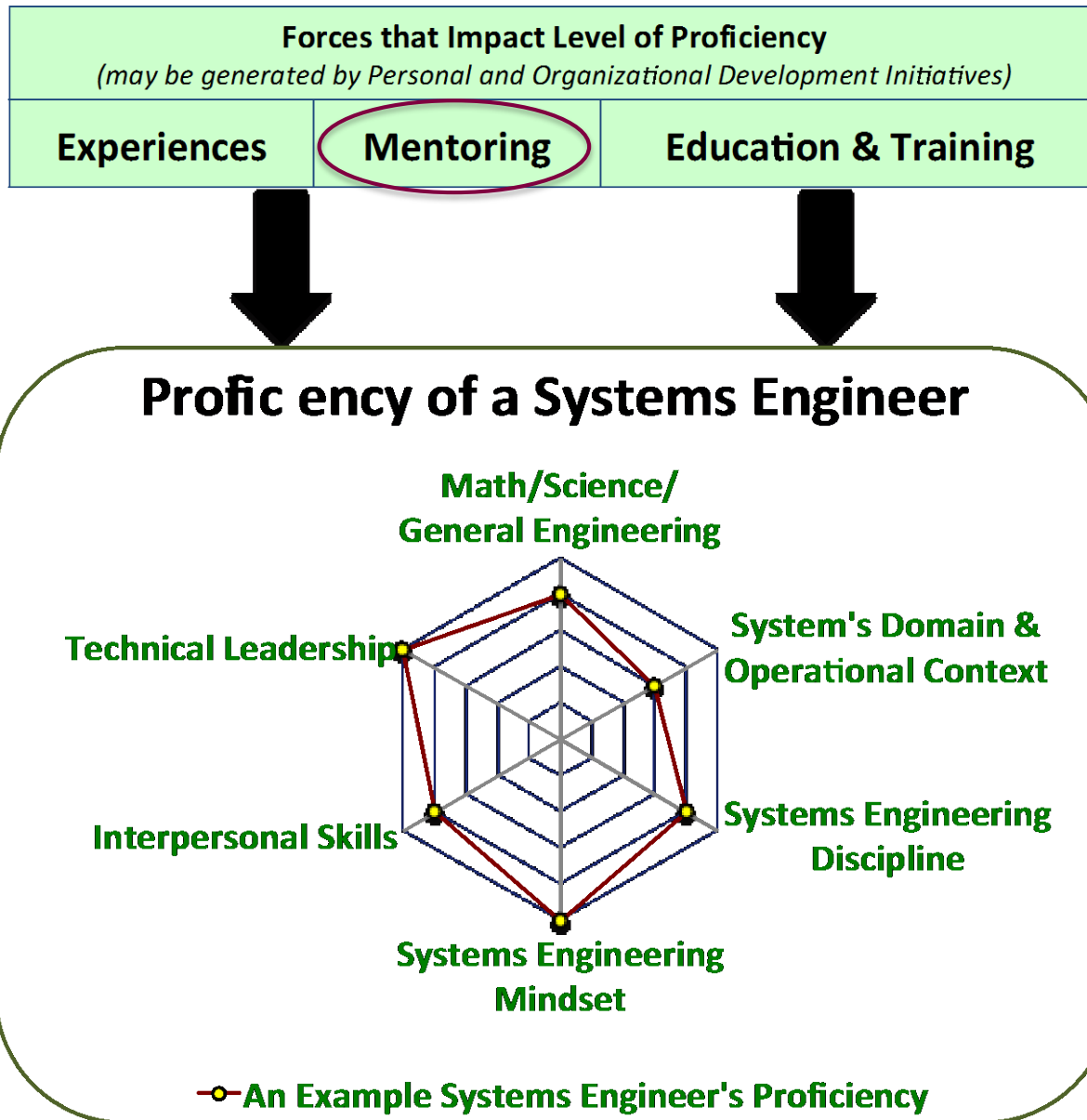
	Junior	Mid-level	Senior
1.	Not more than 1 formal leadership position	At least 2 formal leadership positions	More than 2 formal leadership positions
2.	Experiences primarily in components	Experiences in components and subsystems, and perhaps in systems	Experiences in components, subsystems, systems, and perhaps in systems of systems
3.	Experiences in at least 2 aspects of the systems lifecycle	Experiences in at least 3 aspects of the systems lifecycle	Experiences in at least 4 aspects of the systems lifecycle

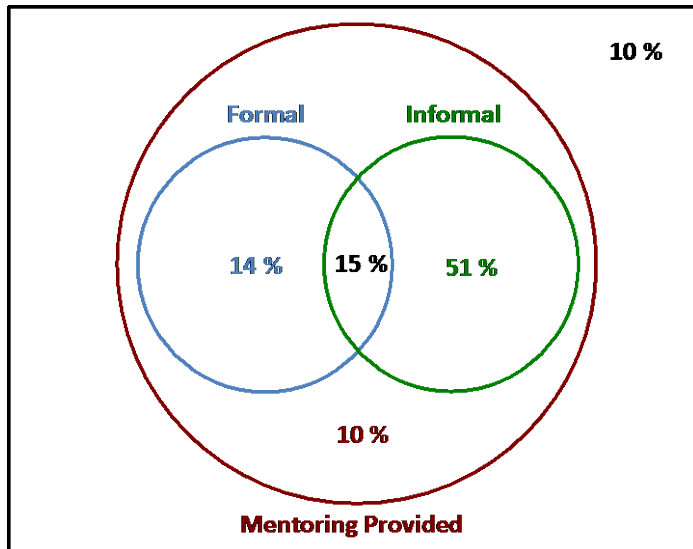
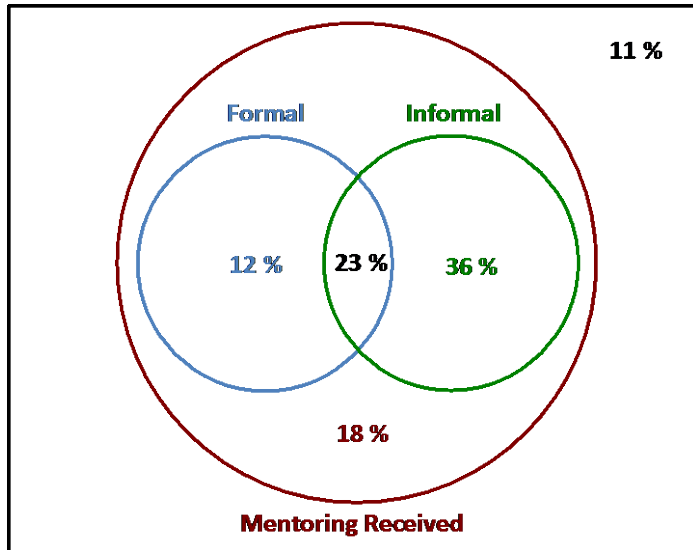
Seniority of Sample



Years of Relevant Experience, by Seniority

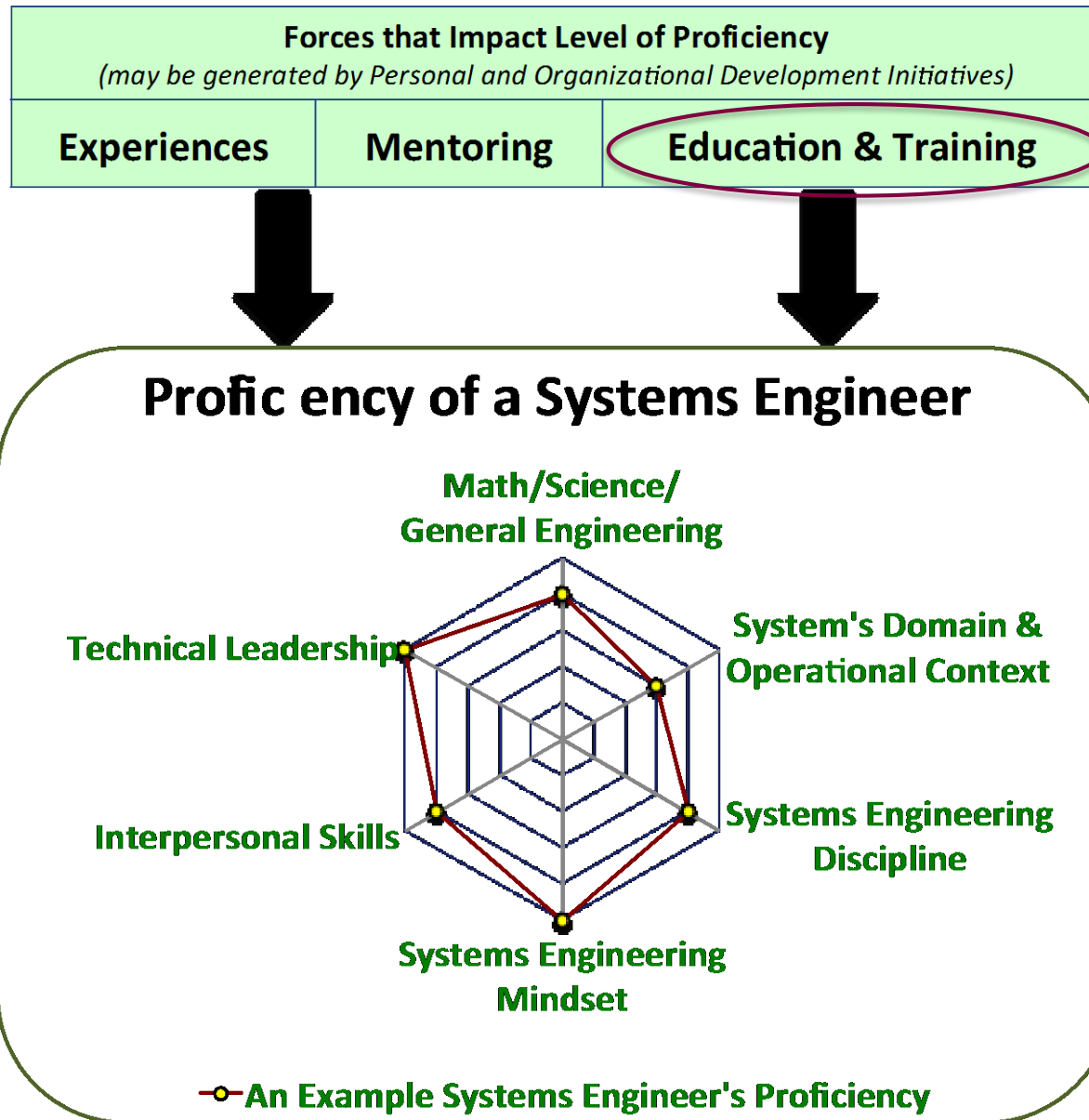






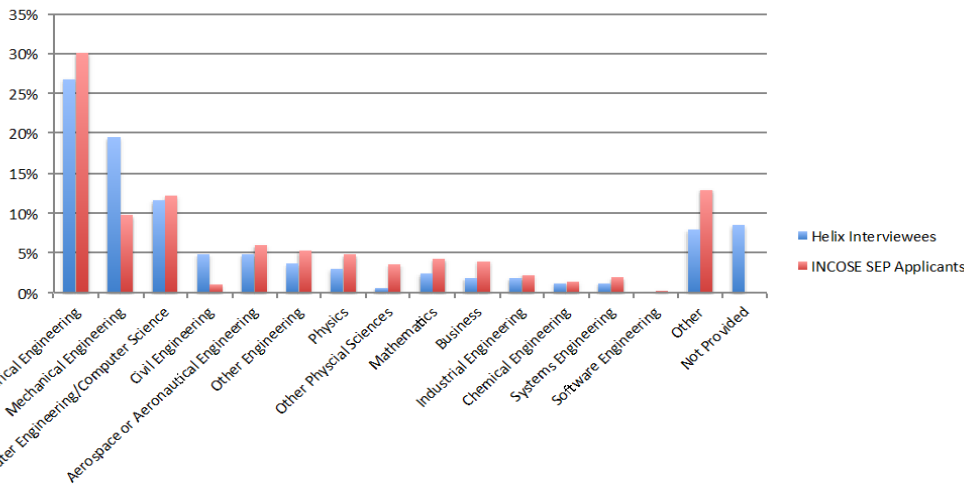
Topic	Formal Mentoring	Informal Mentoring
Visibility to Organization	Organizations tend to have full visibility into the mentoring arrangement and how it is working out for the mentor and the mentee.	Organizations are usually unable to keep track of a mentoring arrangement, and may even be unaware that such arrangements exist.
Mentor-Mentee Pairing	Organizations enable the mentor-mentee pairing: in some cases, it is forced; and in some cases, some flexibility in choice is given. There is the possibility of “wrong” selection or pairing that may not last long. In some cases, organizations enable mentors and mentees to establish a mentoring arrangement, but do not explicitly make the pairing.	Mentors and mentees tend to establish the relationship by themselves, usually upon the request of the mentee. These relationships tend to last longer, since the mentees have the flexibility to choose the mentor that they are comfortable with.
Mentor Engagement	Not all senior engineers are good mentors; and not all potentially good mentors are willing to be one. If they are forced into a relationship against their preference, they tend to be ineffective and unwilling. “Some mentors don’t interact at all,” said one interviewee.	Mentors usually enter into a mentoring relationship by their own choice and therefore tend to be more engaged.
Mentee Responsibility	The organization plays a part in establishing a mentoring arrangement, and this works for introverted mentees. However, it could also make mentees more passive than active.	The mentees must find a mentor and drive the relationship; “I think the mentee has to want it more than the mentor,” said one interviewee. More introverted mentees may find it difficult to seek a mentor and to ask them questions, while extroverted mentees find it easier to “go bug them and pick their brains”.
Goals and Objectives	The organization lays down expectations for a mentoring relationship and could also provide guidance on establishing goals and objectives. This is helpful to the mentee in particular, and tends to be more impactful.	There may be an informal understanding of some overall goals and objectives between the mentor and the mentee, but there is no requirement to establish them.
Mentoring Load	Mentoring can be burdensome, mechanical, and obligating. It is possible to “go through the motions” without any beneficial engagement.	Mentoring is usually a pleasure for both the mentor and the mentee since they both tend to be “willing and eager”. “If you try to formalize or institute a mentoring program, it feels awkward” said one interviewee.

Benefits to Mentees	Benefits to Mentors	Benefits to Organizations
<ul style="list-style-type: none">• Relationship with Mentor• Increased Effectiveness• Career Advancement• Valuable Lessons• Strong Networking	<ul style="list-style-type: none">• Professional Gratification• Organizational Recognition• Reduced Workload• Grooming Successor	<ul style="list-style-type: none">• Gain Effective Knowledge Transfer• Identify High-Potential Engineers• Reduce Orientation Time• Fill Workforce Gaps• Increase Employee Retention• Improve Organization Culture

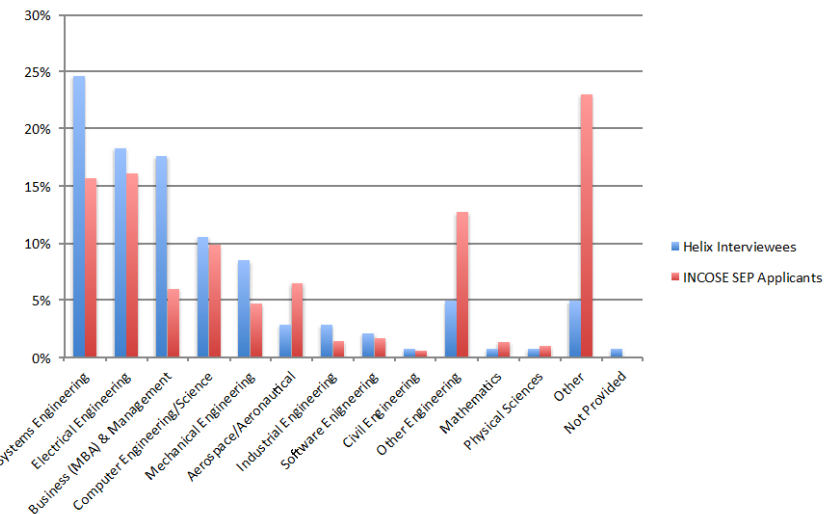


Degree Level	Helix Interview Data				INCOSE SEP Data
	Junior	Mid-level	Senior	All	
Associate's	0%	0%	0%	0%	<1%
Bachelor's	44%	23%	32%	33%	30%
Master's	56%	73%	56%	58%	61%
Doctorate	0%	5%	12%	9%	8%

Comparison of Bachelor's Degree Majors



Comparison of Master's Degree Majors

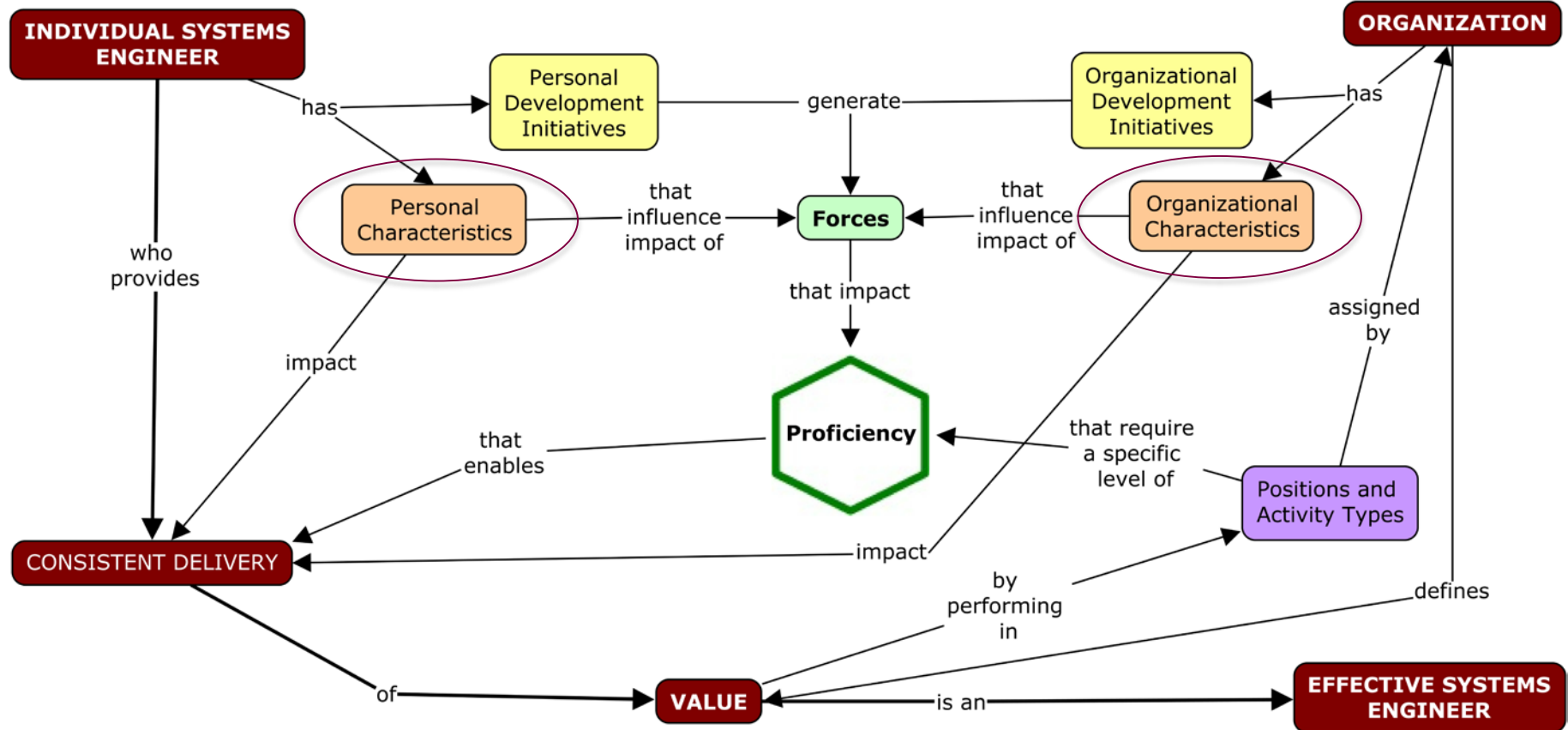


Training Subjects

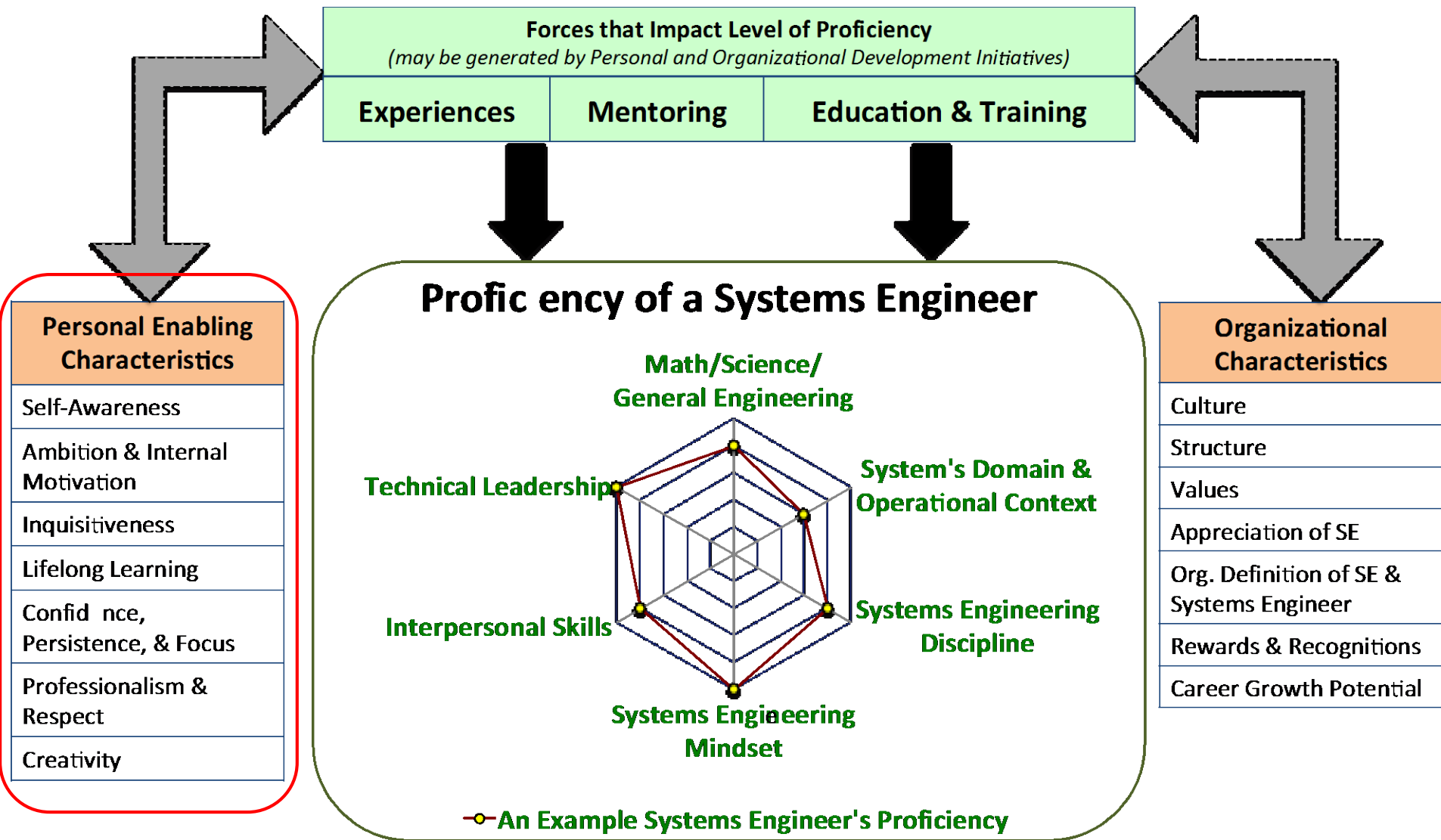
- **Systems Domain and Operational Context**
 - Engineering Disciplines
 - Relevant Technologies
- **Systems Engineering Discipline**
 - Foundations
 - Specific Topics
 - Tool-Specific Training
 - Systems Engineering Processes
- **Interpersonal Skills**
 - Communication
 - Teamwork
- **Technical Leadership**
 - Leadership training
 - Team building
 - Related Disciplines

Issues & Best Practices

- **Training must be “immediately” applied or lost.** Participants indicated training that could be applied on the job during or immediately after training was internalized and remembered much more effectively than training which occurred “in the classroom” only.
- **Access to training.** The most common issue was that even when training was mandatory or when it was optional but cited as a priority within the organization, it was often difficult to gain access to training. A few common causes: a lack of funding for training; a disconnect between organizational and project priority; and lack of managerial support.
- **Some anticipated risks can be addressed by training.** These included how organizations could become more agile, better incorporate and integrate COTS into design, and MBSE were topics that were mentioned.

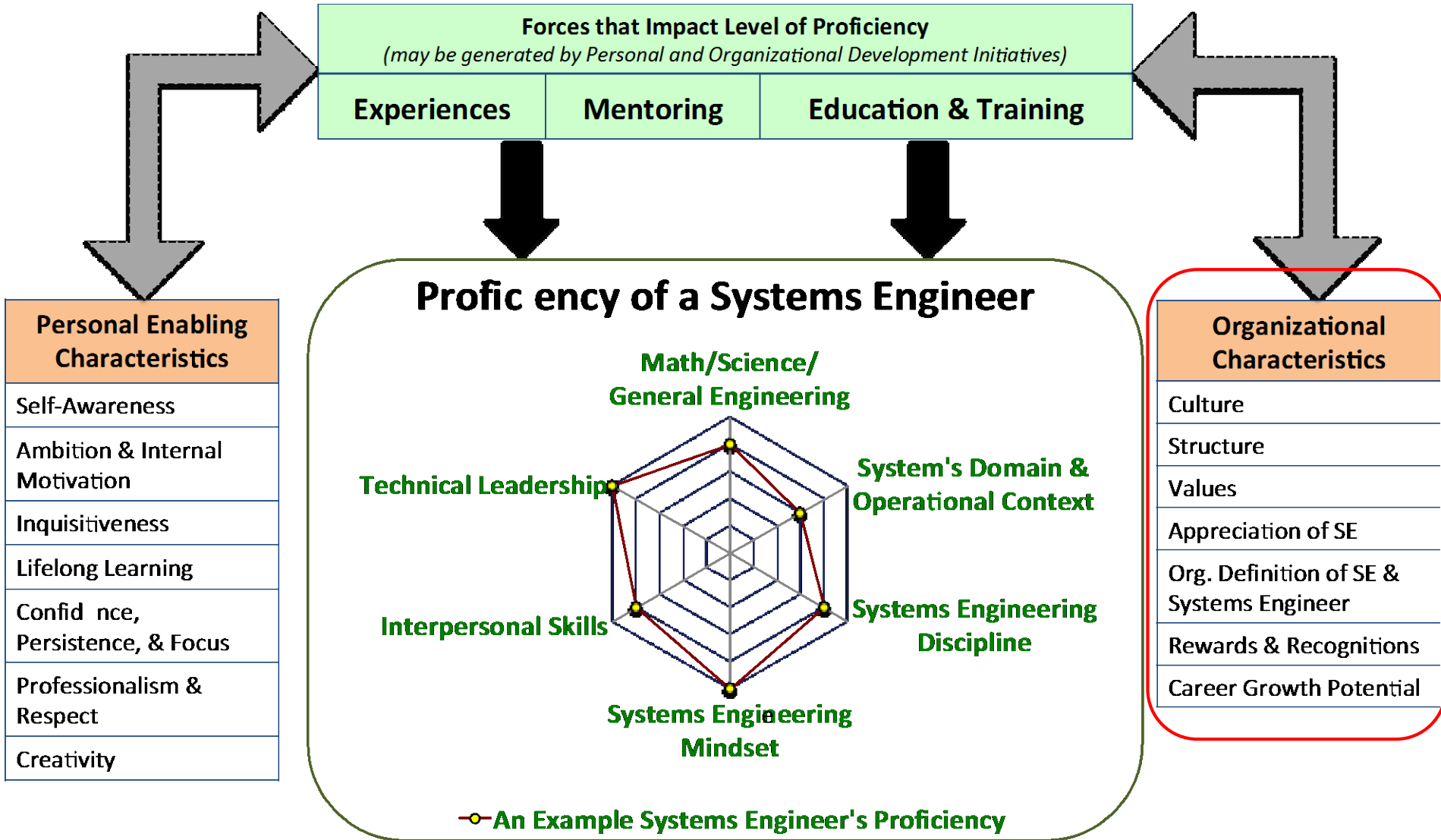


Atlas 1.0: Personal and Organizational Characteristics



- **Self-Awareness:** Described as a critically important characteristic for the development of *Big-Picture Thinking* (21%) and *Paradoxical Mindset* (21%).
- **Ambition and Internal Motivation:** Described as critical characteristics for the development of *Big Picture Thinking* (62%) and *Paradoxical Mindset* (15%).
- **Inquisitive:** About a third (31%) of individuals who discussed the importance for systems engineers to be inquisitive explained that courage was an important supporting characteristic; systems engineers who are too timid may not ask the necessary questions. Many indicated that inquisitiveness is critical to the development of proficiency in *Big-Picture Thinking* (40%).
- **Lifelong Learning:** Lifelong learning was commonly correlated with internal motivation (25%); the desire for growth and change is addressed by continual learning. A quarter of the excerpts on lifelong learning indicated that it was a critical characteristic for the development of *Big-Picture Thinking*.
- **Confidence, Persistence and Focus:** These characteristics were seen as critically important for the development of *Big-Picture Thinking* (33%), *Paradoxical Mindset* (7%), and effective *Communication* (33%).
- **Professionalism and Respect:** Interviewees viewed these attributes as critical to developing several proficiencies: *Building a Social Network* (50%), *Paradoxical Mindset* (13%), *Big-Picture Thinking* (9%), *Communication* (9%), and *Flexible Comfort Zone* (9%).
- **Creativity:** Individuals who discussed creativity indicated that it was critically important to the development of proficiency in *Big-Picture Thinking* (50%) and *Paradoxical Mindset* (50%).

Atlas 1.0: Personal and Organizational Characteristics



Organizational Characteristics

Culture

Structure

Values

Appreciation of SE

Org. Definition of SE &
Systems Engineer

Rewards & Recognitions

Career Growth Potential

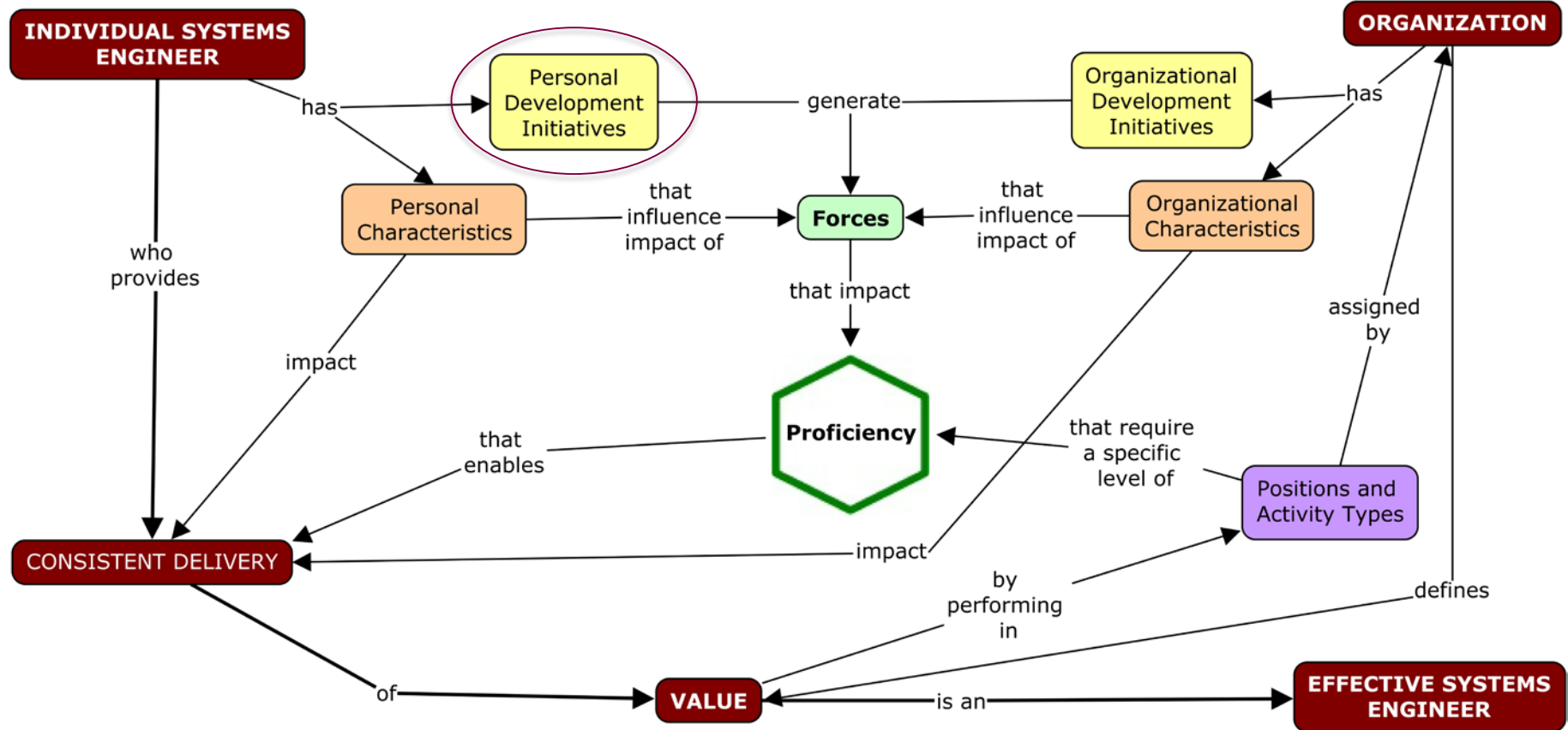
Corporate culture refers to the beliefs and behaviors that determine how a company's employees and management interact and handle outside business transactions. Often, corporate culture is implied, not expressly defined, and develops organically over time from the cumulative traits of the people the company hires.

There are several structural approaches to incorporating systems engineers – centralized, distributed/matrix, etc. – each with benefits and issues.

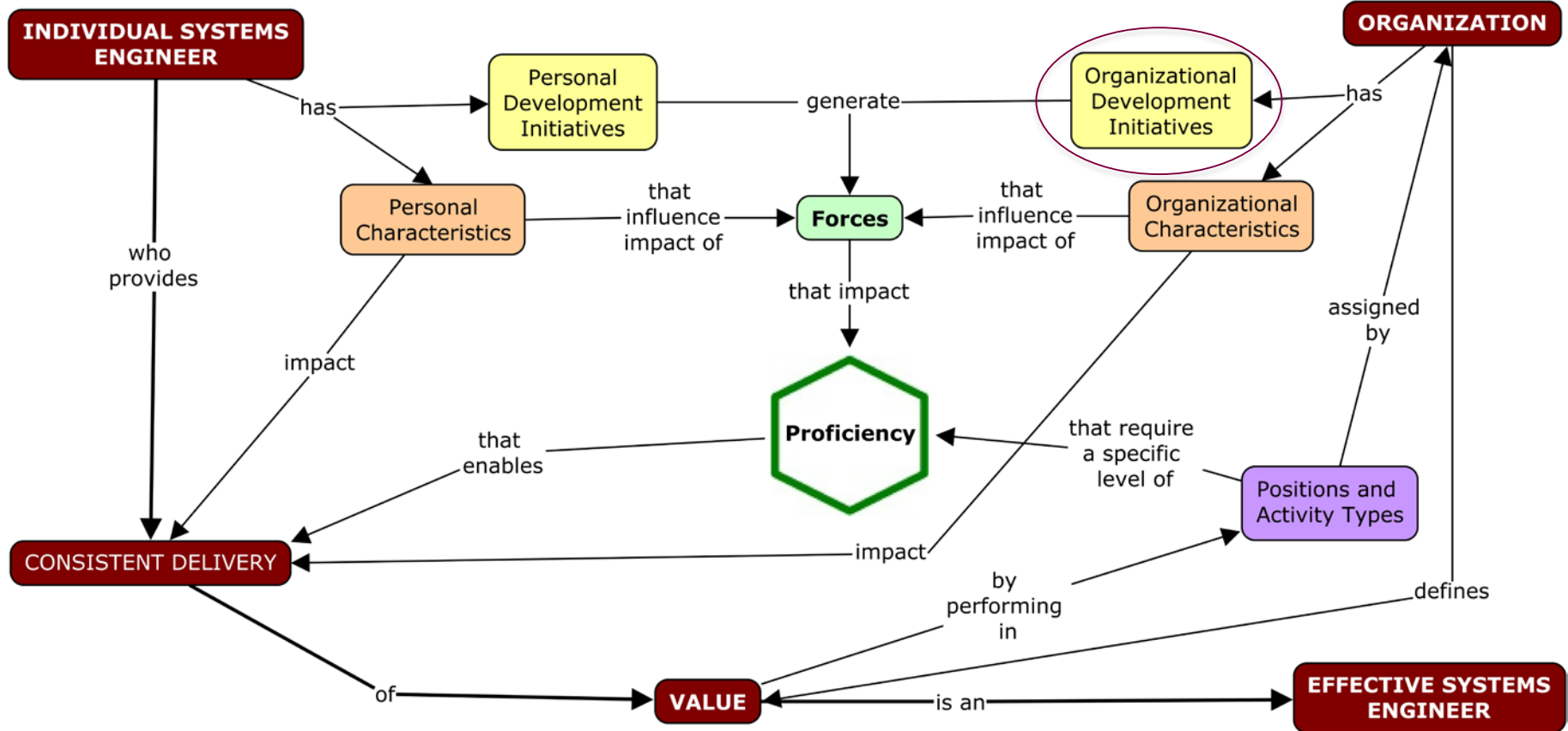
General corporate values can support or inhibit effectiveness – e.g. valuation of individuals over teams is less supportive of systems engineers.

Systems Engineering-Specific Organizational Characteristics:

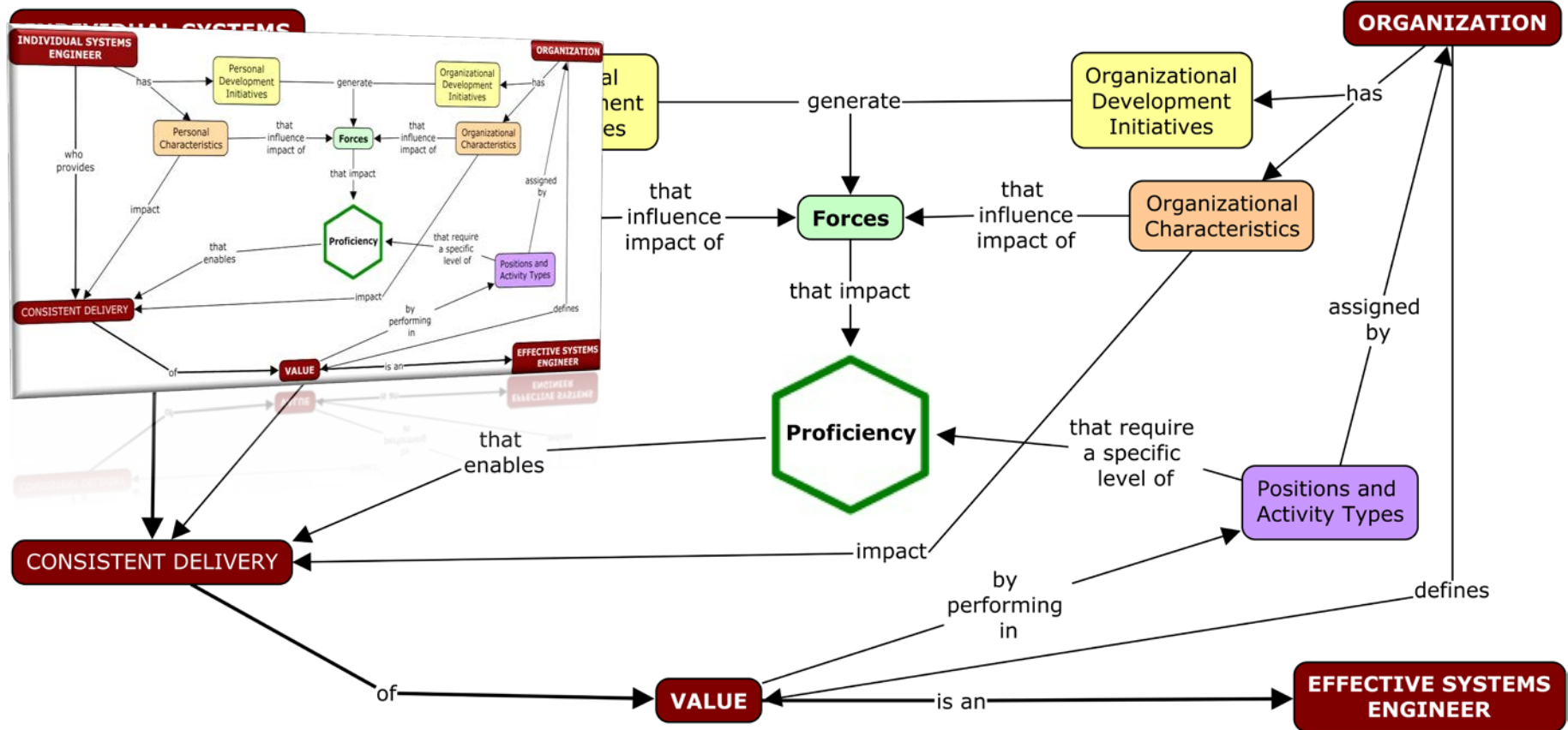
- How the organization values systems engineering as a discipline – both the official policy and the day-to-day realities.
- Whether/how an organization defines SE and identifies systems engineers.
- Incentives – monetary or otherwise – focused on systems engineers' performance.
- Whether/how an organization plans for the development and future positions of systems engineers.

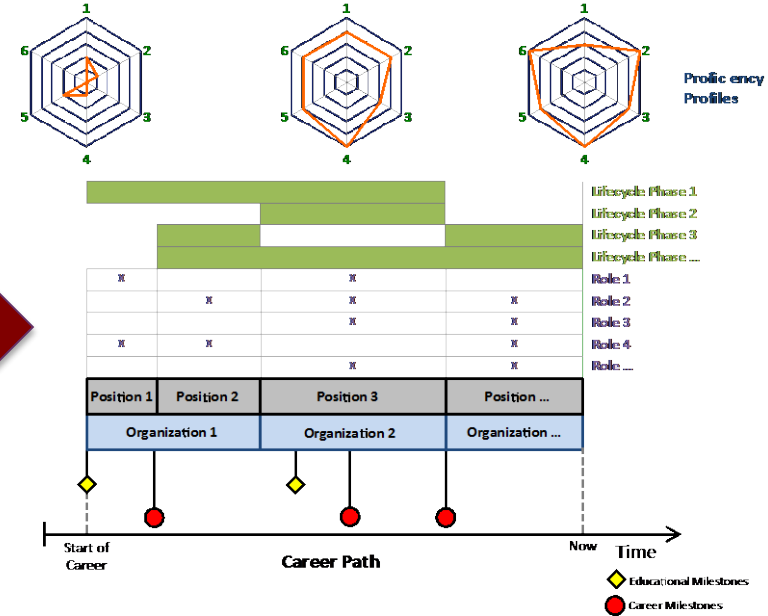
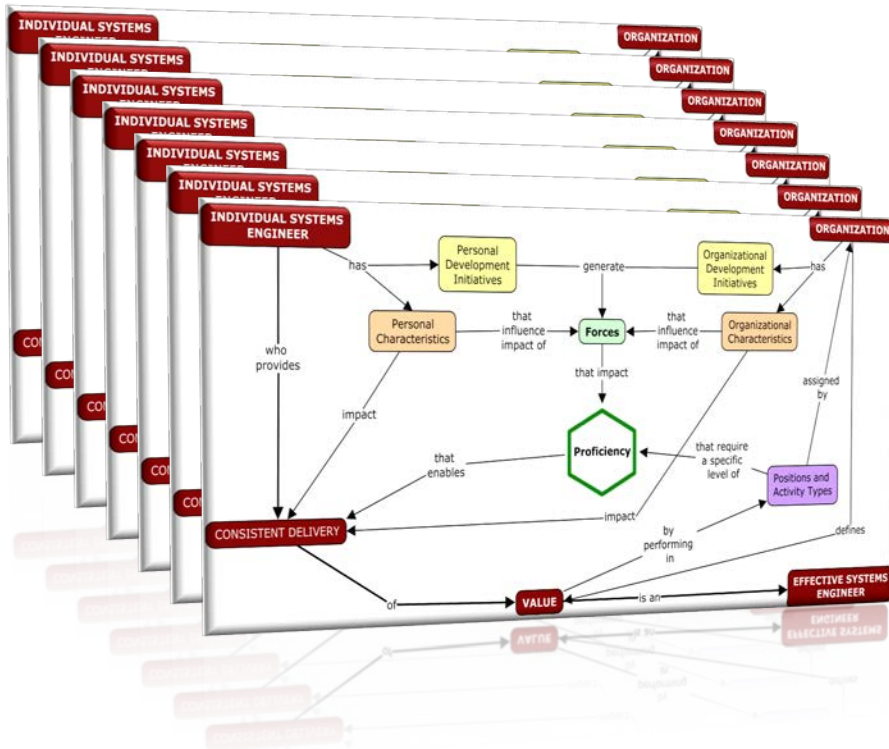


- **Individual Reading** – Journal articles, conference papers, trade publications, relevant news or magazine articles – usually around new technologies related to the systems the individual supported, classic engineering disciplines, relevant domains, or systems engineering itself. Books were more commonly around non-technical areas such as technical leadership, particularly business, or interpersonal skills, particularly communication.
- **Attending Conferences** – This could be a mix of domain-specific, classic engineering, systems engineering, or project management related.
- **Online Courses** – Not full academic courses for credit that could be counted towards a degree. Massive open online courses (MOOCs) or small, university-sponsored free courses on relevant topics.
- **Certification** – All of the DoD organizations required an engineering certification for all of their systems engineers. However, a few individuals have sought individual external certification. None of the organizations specifically sponsored external certification initiatives.



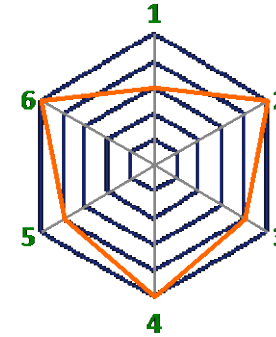
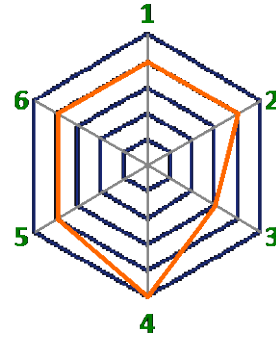
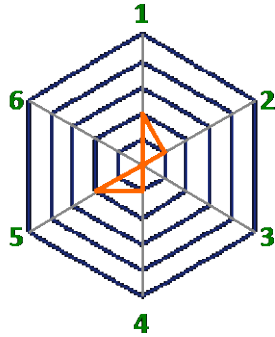
- **Distinction between initiatives and policies:** Helix considers it an initiative if the organization plays an active role in promoting, enabling, and supporting it for the benefit of its employees.
- **Scope of organizational initiatives:** Available to all employees versus targeted to systems engineers.
- **Influence of organizational initiatives on organizational characteristics:** While some organizational initiatives generate the forces that in turn improve the proficiency levels of individual systems engineers, some other organizational initiatives improve organizational characteristics – either directly or indirectly.
- **Formal and informal initiatives:** By definition, organizational initiatives are formally established and deployed. However, there also exist informal versions of those formal organizational initiatives, that could even co-exist with formal versions within the same organization. Some informal initiatives are also established by the organization.
- **Portfolio of initiatives:** Organizational initiatives rarely exist in isolation; typically, a portfolio of initiatives is available to employees. Organizations establish individual initiatives to address various needs; and in some cases, a higher level initiative leads to many lower level initiatives as well.



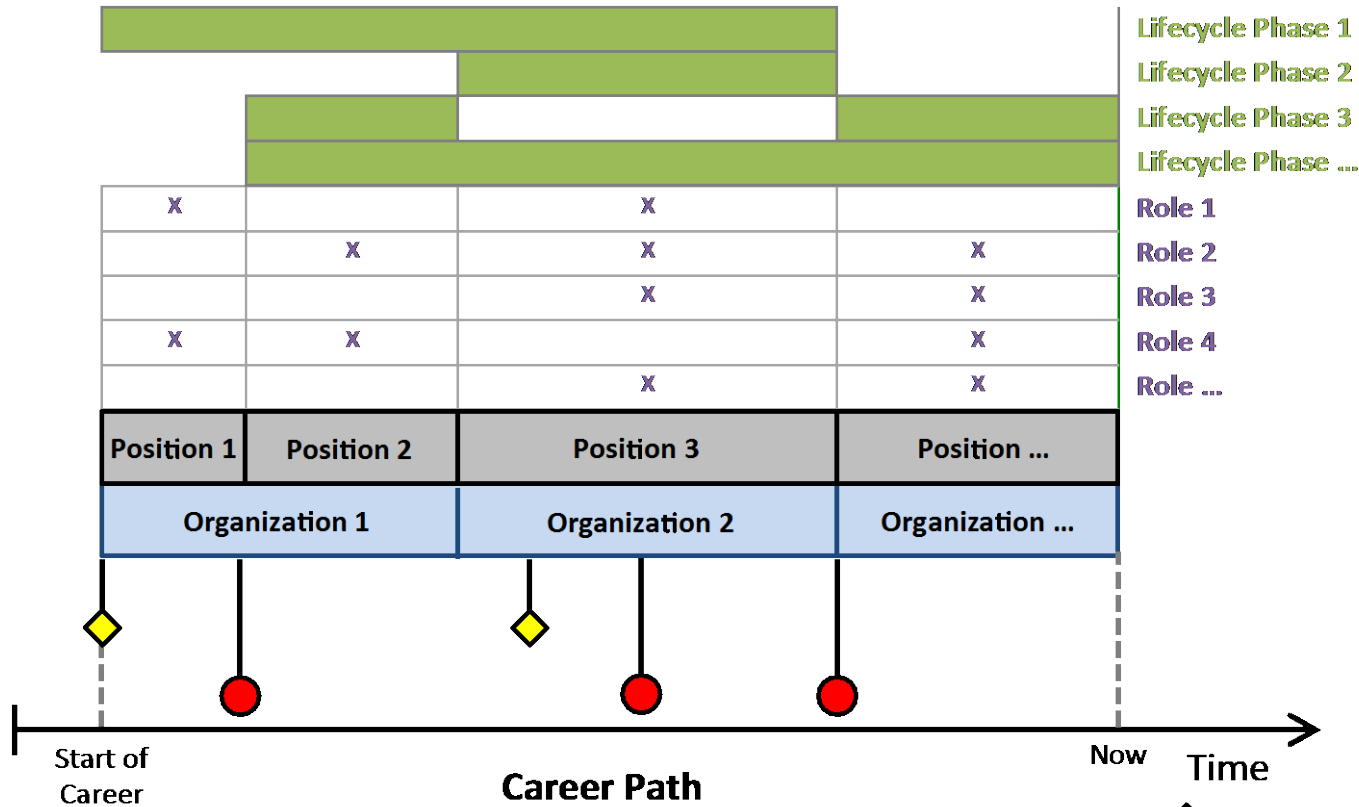


Multiple Snapshots throughout Career

Vector: Career Paths Over Time



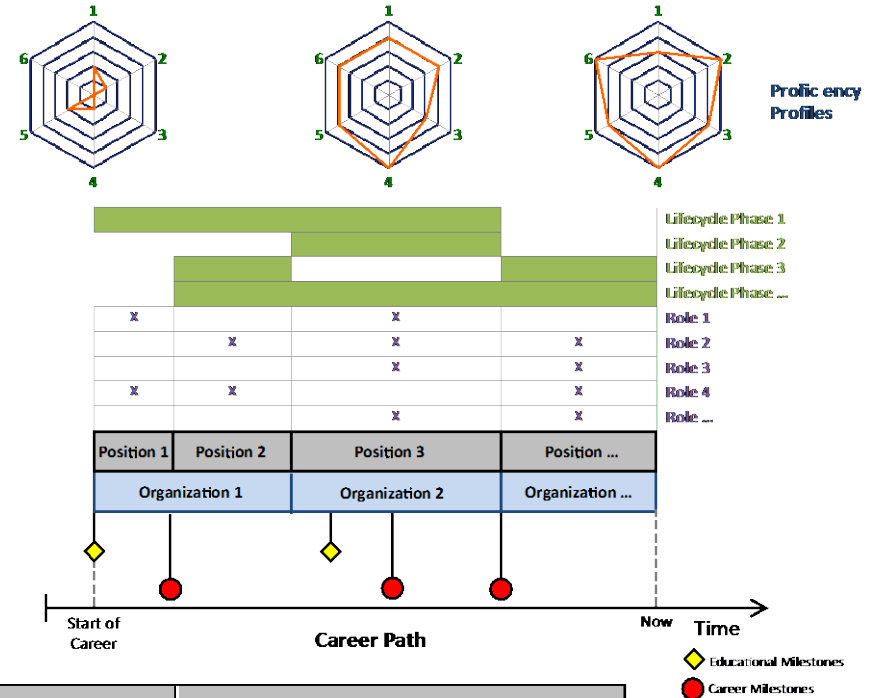
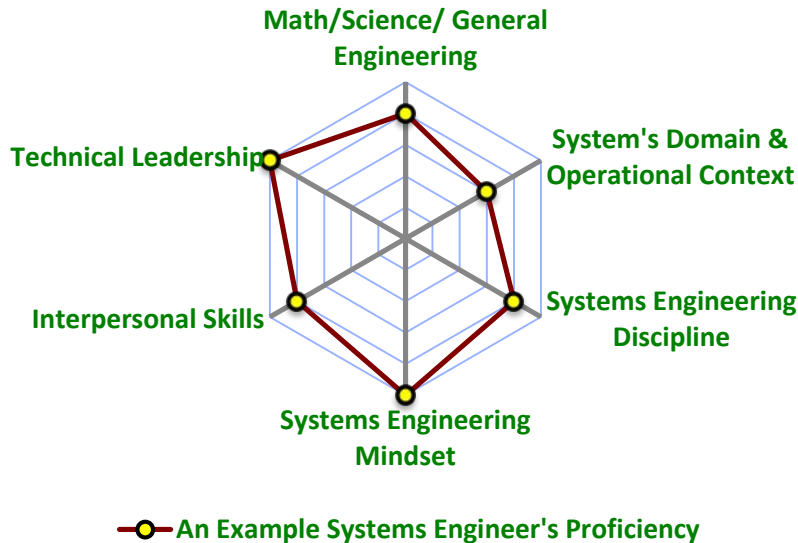
Proficiency Profiles



- Educational Milestones
- Career Milestones

1. What are the characteristics of systems engineers?

Proficiency of a Systems Engineer



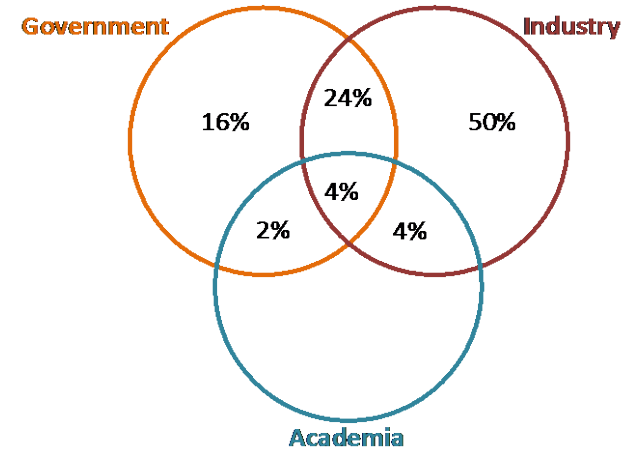
Personal Characteristics
Self-Awareness
Ambition & Internal Motivation
Inquisitiveness
Lifelong Learning
Confidence, Persistence, & Focus
Professionalism & Respect
Creativity

Role (Abbreviation)	Role (Abbreviation)
Requirements Owner [†]	Information Manager (IM) [†]
System Designer (SD) [†]	Process Engineer (PE) [†]
System Analyst (SA) [†]	Coordinator (CO) [†]
V&V Engineer (VV) [†]	Systems Engineering Evangelist (EV) ^{†††}
Logistics/ Operations Engineer (LO) [†]	Detailed Designer (DD) ^{††}
Glue (GL) [†]	Organizational/Functional Manager (MG) ^{††}
Customer Interface (CI) [†]	Instructor/Teacher (IN) ^{†††}
Technical Manager (TM) [†]	Program/Project Manager (PM) ^{††}

1. What are the characteristics of systems engineers?

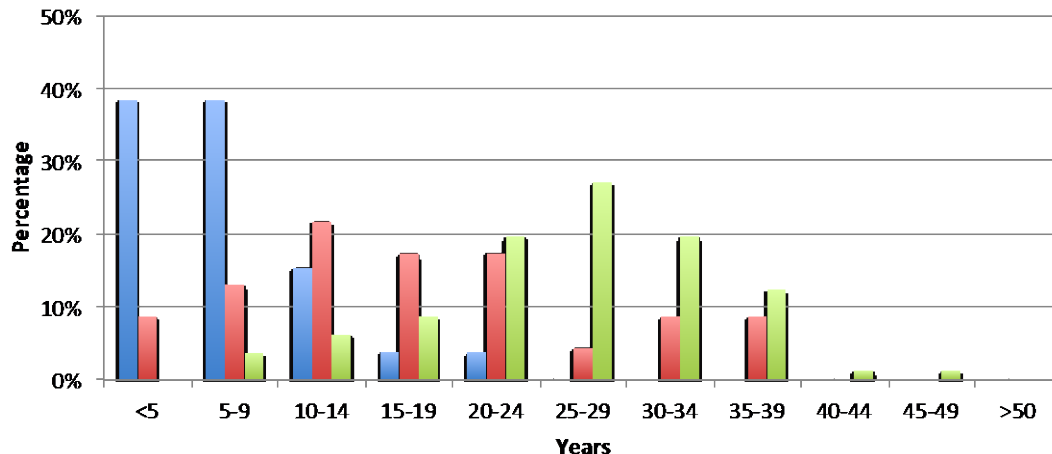
Criteria for Determining Seniority of Systems Engineers

	Junior	Mid-level	Senior
1.	Not more than 1 formal leadership position	At least 2 formal leadership positions	More than 2 formal leadership positions
2.	Experiences primarily in components	Experiences in components and subsystems, and perhaps in systems	Experiences in components, subsystems, systems, and perhaps in systems of systems
3.	Experiences in at least 2 aspects of the systems lifecycle	Experiences in at least 3 aspects of the systems lifecycle	Experiences in at least 4 aspects of the systems lifecycle



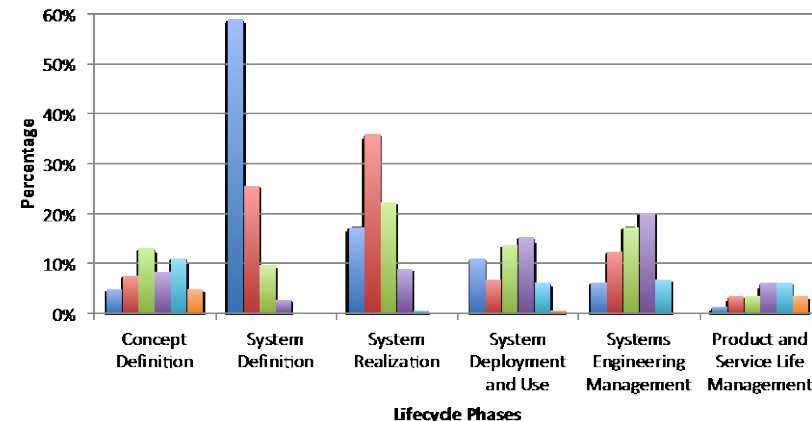
Experiences across Organization Sectors

■ Junior ■ Mid-level ■ Senior



Years of Relevant Experience, by Seniority

■ First ■ Second ■ Third ■ Fourth ■ Fifth ■ Sixth



Lifecycle Exposure (throughout Career)

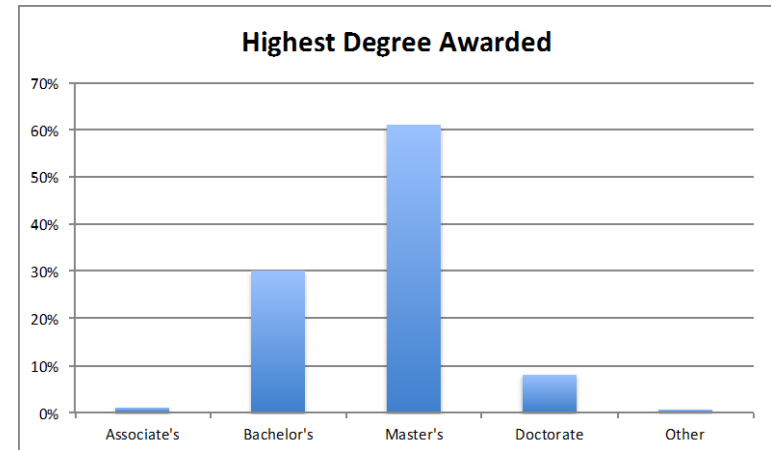
1. What are the characteristics of systems engineers?

Trends in popularity of Bachelor's degree majors:

Major	Before 1980	1980-89	1990-99	2000-09	2010-13
Electrical Engineering	77	168	112	106	5
Mechanical Engineering	17	62	56	63	7
Computer Science	7	47	38	53	5
Aerospace Engineering	8	32	25	32	1
Physics	23	30	25	9	0
Mathematics	27	26	9	15	0
Computer Engineering	2	6	9	33	2

Trends in popularity of Master's degree majors:

Major	Before 1980	1980-89	1990-99	2000-09	2010-13
Systems Engineering	5	5	17	124	87
Electrical Engineering	22	61	75	61	6
Computer Science	7	31	33	39	8
Mechanical Engineering	5	16	31	26	3
Business Administration	4	5	22	21	10
Engineering Management	0	5	22	22	9



Analysis of INCOSE Systems Engineering Professional Applications (n>2,000)

Degree Level	Interview Data				INCOSE Data
	% Junior SEs	% Mid-level SEs	% Senior SEs	% Total	
Associate's	0%	0%	0%	0%	<1%
Bachelor's	44.4%	22.7%	32.3%	33.1%	30%
Master's	55.6%	72.7%	55.6%	58.1%	61%
Doctorate	0%	4.5%	12.1%	8.8%	8%

Highest degree awarded

2. How effective are those who perform SE activities and why?

A systems engineer who consistently delivers value is effective.

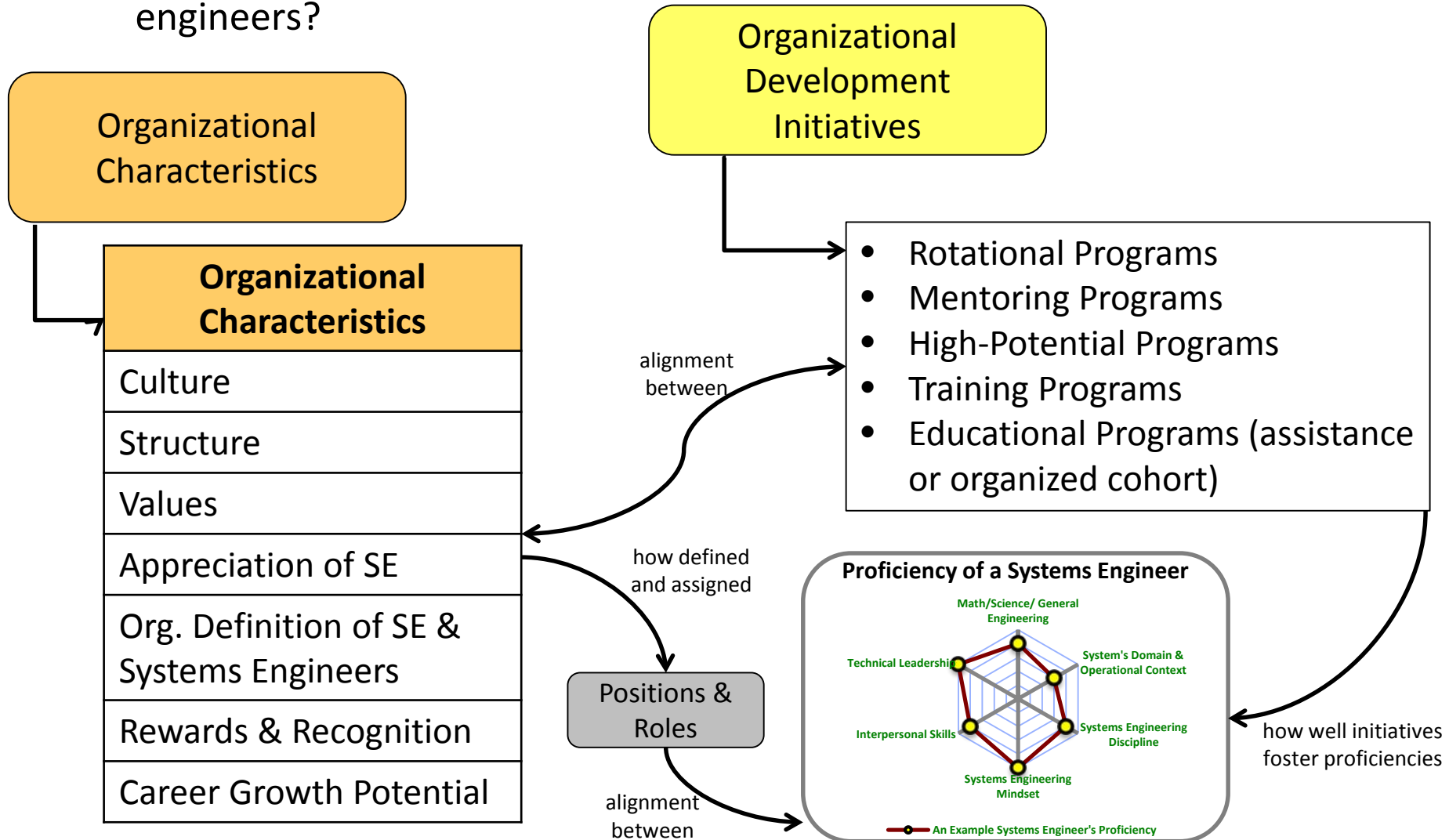
Primary Values Systems Engineers Provide*

- Keeping and maintaining the system vision (11%)
 - Enabling diverse teams to successfully develop systems. (10%)
 - Managing emergence in both the project and the system (7%)
 - Enabling good technical decisions at the system level (7%)
 - Supporting the business cases for systems (7%)
 - Translation of technical jargon into business or operational terms and vice versa (11%)
- Keeping and maintaining the system vision (11%) is enabled by:
 - Getting the “true” requirements from the customer and creating alignment between the customer and the project team. (39%)
 - Seeing relationships between the disciplines and helping team members understand and respect those relationships. (33%)
 - Balancing technical risks and opportunities with the desired end result. (36%)
 - Providing the big picture perspective for the system. (44%)

*Based on most common responses in interviews with systems engineers; validated by interviews with SE managers, program managers, classic engineers. (%) is total number of SEs stating this is a critical value.

(%) = percentage of individuals who spoke about keeping and maintaining the vision who described the enabling value.

3. What are employers doing to improve the effectiveness of systems engineers?



- December 2016
 - Atlas 1.0 & Technical Report
 - Excel-based tools for Proficiency and *Vector* analysis

- Plans for 2017
 - 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 systems engineering capability of an organization?
 - What critical factors, in addition to workforce effectiveness, are required to enable systems engineering capability?
 - Implementation
 - Utilization of *Atlas* in a handful of organizations (updates as necessary)
 - Understanding of organizational systems engineering capability
 - Transition to a more community-based infrastructure



- Keeping and maintaining the system vision (11%) is enabled by:
 - Getting the “true” requirements from the customer and creating alignment between the customer and the project team. (39%)
 - Seeing relationships between the disciplines and helping team members understand and respect those relationships. (33%)
 - Balancing technical risks and opportunities with the desired end result. (36%)
 - Providing the big picture perspective for the system. (44%)
- Enabling diverse teams to successfully develop systems. (10%)
 - Effectively understanding and communicating the system vision to the team, and ensuring that the team is aligned with this vision. (38%)
 - Helping the team to understand the big picture perspective and where they fit within the larger picture. (38%)
 - Identifying areas of concern for integration in advance. (13%)

- Managing emergence in both the project and the system (7%)
 - Projecting into the future (14%), which includes staying “above the noise” of day-to-day development issues and identifying pitfalls.
 - Technical problem-solving balanced with the big picture perspective. (43%)
- Enabling good technical decisions at the system level (7%)
 - The ability to see the vision for the system and communicate that vision clearly is a key enabler to helping teams make good technical decisions. (40%)
 - The big picture perspective is critical for understanding the system holistically and enabling system-level technical decisions, versus decisions made at the component or sub-system level. (22%)
 - A systems engineer’s solid grasp on the customer’s needs is also a critical enabler to ensuring that decisions made will keep the system on the correct technical path. (22%)
 - Being able to bring together a diverse team of engineers and subject matter experts is also critically important. (26%)
 - A systems engineer’s problem solving abilities – particularly the ability to focus on root versus proximal cause – is also a key enabler. (26%)

- Supporting the business cases for systems (7%)
 - Balancing traditional project management concerns of cost and schedule with technical requirements. (41%)
 - Understanding the position of a system within the organization or customer's portfolio and communicating this to the team. (59%)
- Translation of technical jargon into business or operational terms and vice versa (11%)
 - Translating highly technical information from subject matter experts into common language that other stakeholders can understand.
 - Translating operational concepts, customer needs, and customer desires into language that makes sense for engineers and program managers who do not have the same understanding of the systems' future operating environment.

- Inconsistent titles used for systems engineers
 - General engineer, systems engineer, architect, IT specialist for enterprise architecture, chief systems engineer
- Desired Capabilities
 - Responsible for **managing all technical aspects** of the program.
 - **Analyze customer needs** and **architect a solution** with **minimal guidance**.
 - Responsible for all internal activities and **product development**. Demonstrates **expertise in a variety of the field's concepts, practices, and procedures**.
 - **Manage systems engineering** and **integration/enterprise architecture** activities.
 - Provide comprehensive **technical leadership** in the development and **integration** of high-performance network communications systems.
 - The ideal candidate will have **strong interpersonal skills** and must be **comfortable working in different customer environments**.
 - **Define and develop policies and principles** to guide **technology decisions** for the enterprise architecture, synthesizing into solutions that deliver capabilities.

- Desired /Characteristics
 - A **wide degree of creativity** and **latitude** is expected. May report to an executive or a manager.
 - Leadership, self-motivation, time management, interpersonal, and **communication skills** are preferred.
- Required Background
 - Two to Five years of **directly related experience** in the field of systems engineering.
 - Expertise** with security software, and monitoring solutions.
 - Four-year college degree** or **related experience** in the field.
 - COTS Integration; Design Verification; Project Leadership; Supportability Test, Evaluation, Verification; System Performance Analysis; Systems Design and System Analysis; Systems Engineering.

- The system's domain – the primary area of application for the systems being worked on. The domain categories used for analysis were developed based on the data, but were also compared against the North American Industry Classification System to ensure that the categories were reasonable based on existing frameworks. (NAICS 2015)
- The types of systems worked on – the Helix team used the definitions provided in the SEBoK for **product**, **service**, and **enterprise** systems
- The level of systems for which an individual had responsibility – the Helix team again used the SEBoK definitions of **component/element**, **subsystem**; **system**, and **platform** or **system-of-systems** to define the primary levels of system worked on by an individual..
- The size of a system – in general this could be the size in terms of either total system cost or the number of individuals working on the system.

- **Concept Definition** - A set of core technical activities of SE in which the problem space and the needs of the stakeholders are closely examined. This consists of analysis of the problem space, business or mission analysis, and the definition of stakeholder needs for required services within it.
- **System Definition** - A set of core technical activities of SE, including the activities that are completed primarily in the front-end portion of the system design. This consists of the definition of system requirements, the design of one or more logical and physical architectures, and analysis and selection between possible solution options.
- **System Realization** - The activities required to build a system, integrate disparate system elements, and ensure that a system both meets the needs of stakeholders and aligns with the requirements identified in the system definition stage. This includes integration, verification, and validation (IV&V).

- **System Deployment and Use** - A set of core technical activities of SE to ensure that the developed system is operationally acceptable and that the responsibility for the effective, efficient, and safe operations of the system is transferred to the owner. Considerations for deployment and use must be included throughout the system life cycle. Activities within this stage include deployment, operation, maintenance, and logistics.
- **Product and Service Life Management** - Deals with the overall life cycle planning and support of a system. The life of a product or service spans a considerably longer period of time than the time required to design and develop the system. This stage includes service life extension, updates, upgrades, and modernization, and disposal and retirement. The organizations in the current sample are primarily concentrated on new development, so this is a very under-represented aspect of the life cycle.
- *Systems Engineering Management*, defined as managing the resources and assets allocated to perform SE activities. Activities include planning, assessment and control, risk management, measurement, decision management, configuration management, information management, and quality management.

- The types of programs an individual has worked on in terms of
 - Size in dollar value
 - Size in terms of people/team
 - Complexity
 - Formality (e.g. ACATI versus non-ACAT programs)
 - Type of program (government contract, commercial system, IR&D, etc.)
- **A common theme was that it was helpful to have experiences across different types of program contexts because each requires a different level of rigor/rigidity – or allows different flexibility – in the application and tailoring of processes**
- Smaller programs allow for more growth opportunities (“jack of all trades”) while larger programs may allow more specialization
- This data was provided very inconsistently

Timing of Graduate Education for Junior versus Senior Systems Engineers

0 Years of Career

