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Atlas 0.5: A Theory of Effective Systems Engineers

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What is Helix?

- ***Challenge:*** DoD, the Defense Industrial Base, and the broader community feel challenged to deploy an effective systems engineering workforce for the ever more technically challenging systems they need to build in an environment of increasing schedule and cost pressure.
- ***Knowledge Gap:*** There has never been a systematic understanding of what enables systems engineers to be *effective*; i.e., what enables them to consistently deliver value to their organizations.
- Helix is a research project that is attempting to close that knowledge gap by answering three questions:
  1. What are the characteristics of systems engineers?
  2. How effective are systems engineers and why?
  3. What are employers doing to improve the effectiveness of their systems engineers?

Progress to Date

1. Data has been collected through in-depth interviews with nearly 300 systems engineers and others from 21 organizations in the defense, aerospace, transportation, IT, and healthcare business sectors
2. Education data has been analyzed from applicants to the INCOSE Systems Engineering Professional program and experience data has been analyzed primarily from the applications of certified Expert Systems Engineering Professionals
3. *Atlas 0.50* has been published, articulating a theory of what enables systems engineers to be effective and why (*Atlas 0.25* was published in November 2014 and *Atlas 1.0* will be published in December 2016)
4. Several organizations have become early adopters of *Atlas* to better understand their systems engineers, how effective they are, and how to grow their effectiveness

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Research Methodology

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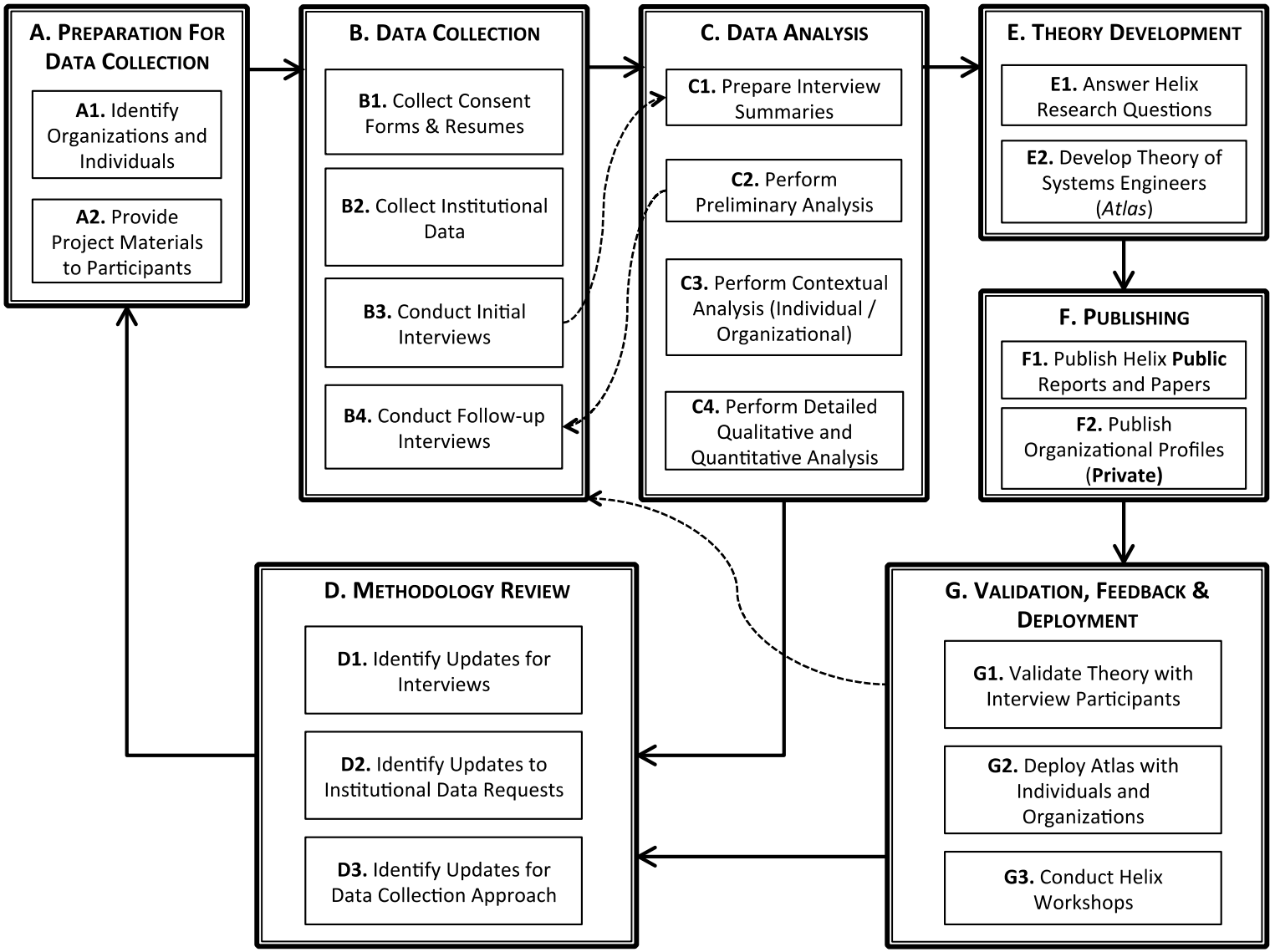
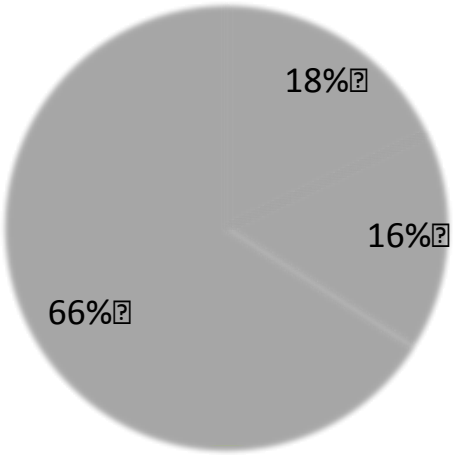


Sample Population

289 Interviewed



2504 INCOSE SEP Applicants

Rank	Country	# of Applicants	% of Total
1.	U.S.	1847	74%
2.	India	179	7%
3.	Germany	151	6%
4.	France	101	4%
5.	U.K.	49	2%
6.	Sweden	41	<2%
7.	Spain	36	1%
	Other	100	4%

Value Commonly Delivered by Systems Engineers

1. Keeping and maintaining the system vision (11% of excerpts) 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%)

2. 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%)

Value Commonly Delivered by Systems Engineers

3. 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%)

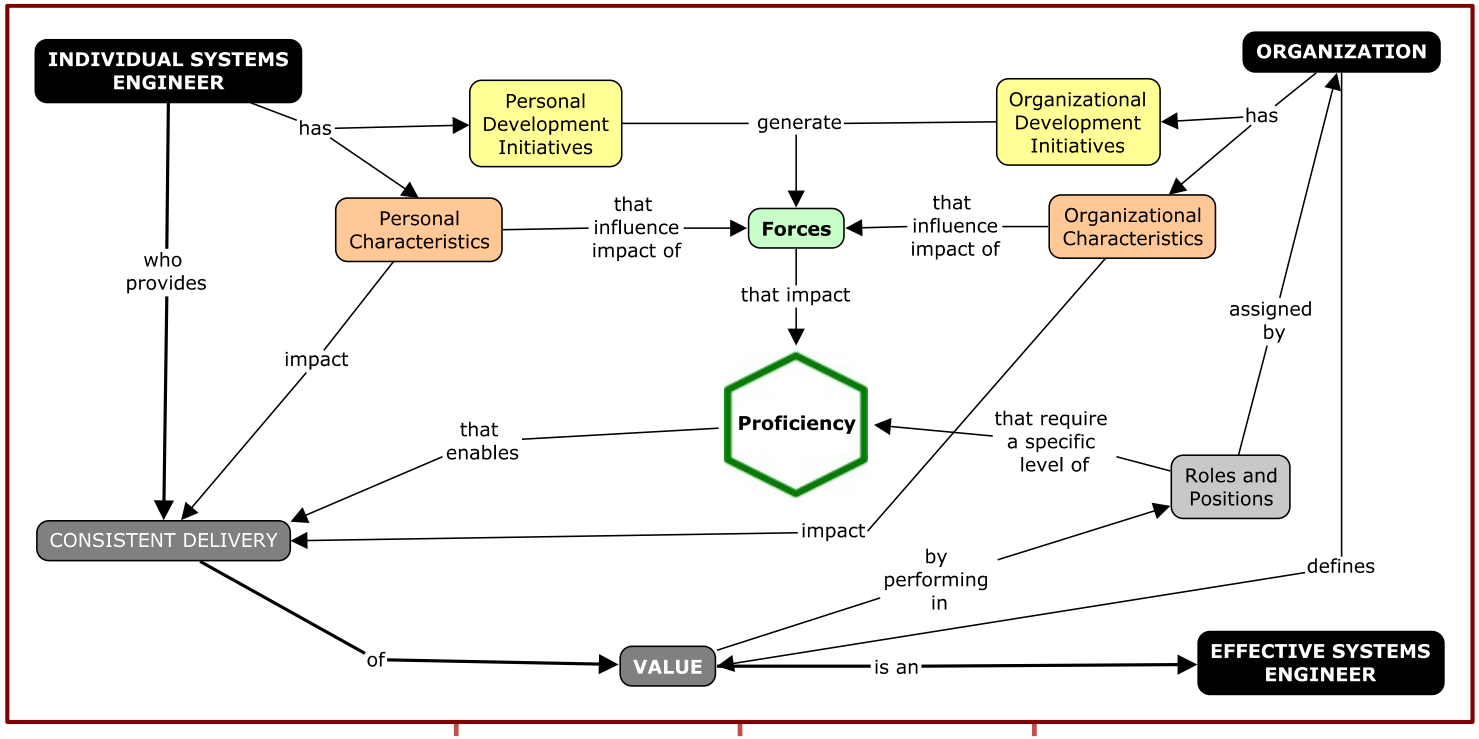
4. Enabling good technical decisions at the system level (7%)
   - The ability to see the vision for the system and communicate that vision clearly is a key enabler to helping teams make good technical decisions. (40%)
   - The big picture perspective is critical for understanding the system holistically 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%).

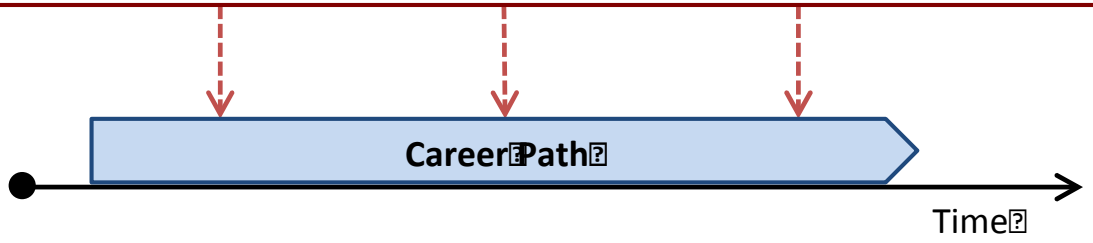
Value Commonly Delivered by Systems Engineers

5. 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%)

6. 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.

Becoming and Remaining An Effective Systems Engineer





A *career path* is the precise combination of experiences, mentoring, and education & training that an individual goes through during his or her career, particularly their characteristics, timing, and order

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Criteria for Seniority of Systems Engineers

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	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

- Note that years of experiences is not a direct criteria
- These are guidelines and there are always exceptions

Positions and Roles

- A ***position*** is equivalent to an individual's title. Organizations will define what roles and responsibilities each position contains and this may not translate across organizations.
  - An individual can work on more than one *project* in a position
- A ***role*** is a specific set of related systems engineering activities.
- Only ***relevant*** positions were considered – positions that specifically will help to grow systems engineering proficiencies

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Relevant Roles for Systems Engineers

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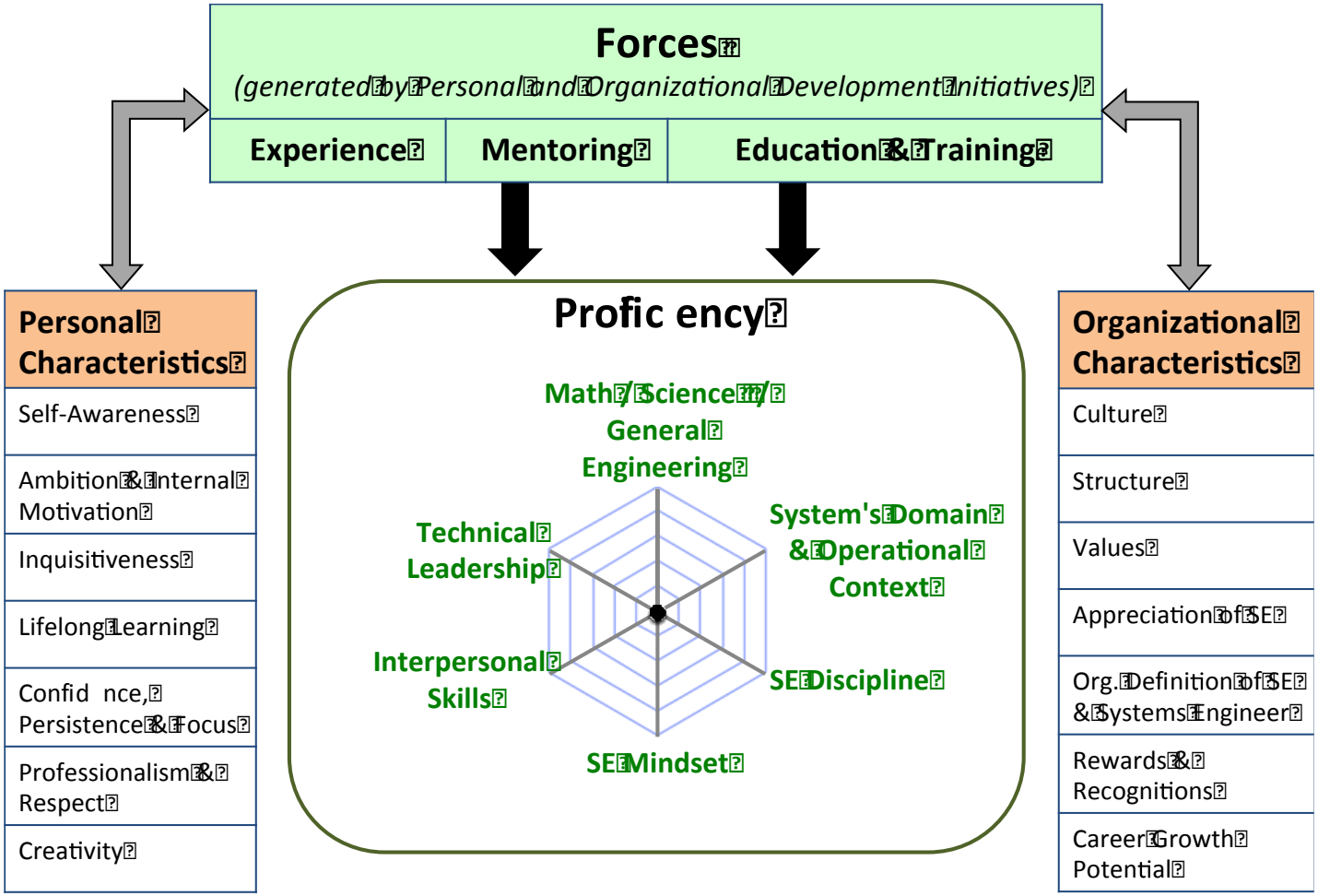
Role (Abbreviation)	Description
Requirements Owner (RO) +	Individual who is responsible for translating customer requirements to system or sub-system requirements; or for developing the functional architecture.
System Designer (SD) +	Individual who is responsible for owning or architecting the system; common titles may includes chief systems engineer or system architect.
System Analyst (SA) +	Individual who provides modeling or analysis support to system development activities, and helps to ensure that the system as designed meets he specification.
V&V Engineer (VV) +	Individual who plans and conducts verification and validation activities such as testing, demonstration, and simulation.
Logistics/ Operations Engineer (LO) +	Individual who performs the 'back end' of the SE lifecycle, who may operate the system, provide support during operation, provide guidance on maintenance, or help with disposal.
Glue (GL) +	Individual who is responsible for a holistic perspective of the system; this may be the 'technical conscience' or 'seeker of issues that fall *in the cracks*' – particularly, someone who is concerned with interfaces.
Customer Interface (CI) +	Individual who is responsible for coordinating with the customer, particularly for ensuring that the customer understands technical detail and that a customer's desires are, in turn, communicated to the technical team.
Technical Manager (TM) +	Individual who is responsible for controlling cost, schedule, and resources for the technical aspects of a system; often someone who works in coordination with an overall project or program manager.
Information Manager (IM) +	Individual who is responsible for the flow of information in a system development activity; specific activities may include configuration management, data management, or metrics.
Process Engineer (PE) +	Individual who is responsible for the systems engineering process as a whole; who also likely has direct ties into the business.
Coordinator (CO) +	Individual who is responsible for coordination amongst a broad set of individuals or groups who help to resolve systems related issues.
Systems Engineering Evangelist (EV) +++	Individual who promotes the value of systems engineering to individuals outside of the SE community - to project managers, other engineers, or management.
Detailed Designer (DD) ++	Individual who provides technical designs that match the system architecture; an individual contributor in any engineering discipline who provides part of the design for the overall system.
Organizational/ Functional Manager (MG) ++	Individual who is responsible for the personnel management of systems engineers or other technical personnel in a business – not a project or program – setting.
Instructor/ Teacher (IN) +++	Individual who is responsible for providing or overseeing instruction of SE discipline, practices, processes, etc.
Program/Project Manager (PM) ++	Individual who performs program or project management activities; who is not directly responsible for the technical content of a program, but works closely with technical experts and other systems engineers .

Proficiency Model



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Proficiency Areas and Categories

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Area	Category
1. Math / Science / General Engineering	1.1. Natural Science Foundations
	1.2. Engineering Fundamentals
	1.3. Probability & Statistics
	1.4. Calculus & Analytical Geometry
	1.5. Computing Fundamentals
2. Systems' Domain & Operational Context	2.1. Relevant Domains
	2.2. Relevant Technologies & Systems
	2.3. Relevant Disciplines
	2.4. Familiarity with System's CONOPS
3. Systems Engineering Discipline	3.1. Lifecycle
	3.2. SE Management
	3.3. SE Methods, Processes, & Tools
	3.4. System Complexity
4. Systems Engineering Mindset	4.1. 'Big Picture' Thinking
	4.2. Paradoxical Mindset
	4.3. Flexible Comfort Zone
	4.4. Abstraction
	4.5. Foresight & Vision
5. Interpersonal Skills	5.1. Communication
	5.2. Listening & Comprehension
	5.3. Working In a Team
	5.4. Influence, Persuasion & Negotiation
	5.5. Building a Social Network
6. Technical Leadership	6.1. Building & 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 & Project Management Skills

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Many Demographic Slices

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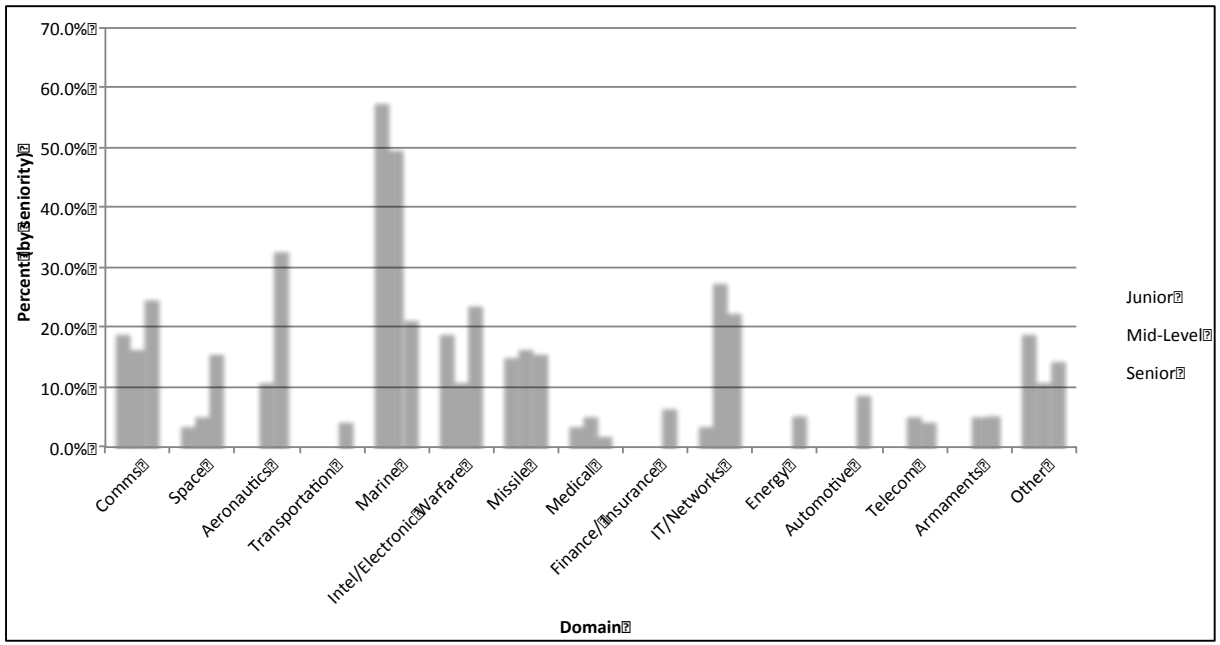


Domains in Which Systems Engineers Have Experience Divided by Seniority

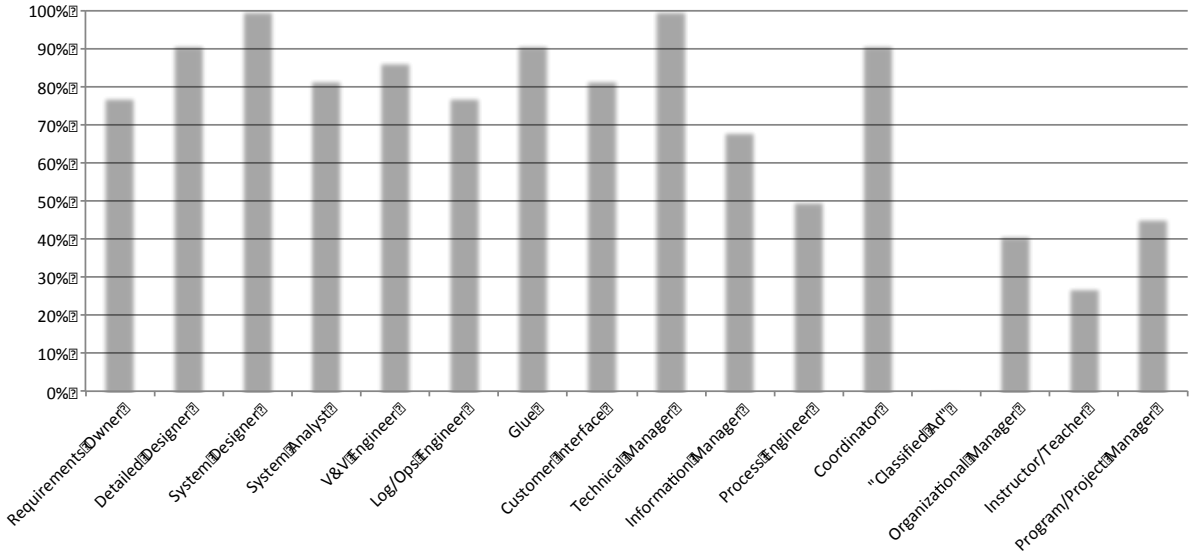
	Helix Interview Data				INCOSE SEP Data
Degree Level	**Junior**	**Mid-level**	**Senior**	**All**	
Associate's	0%	0%	0%	0%	<1%
Bachelor's	44%	23%	32%	33%	30%
Master's	56%	73%	56%	58%	61%
Doctorate	0%	5%	12%	9%	8%

Highest Degree Attained Divided by Seniority

Two examples of the many different demographic analyses performed on the sample population

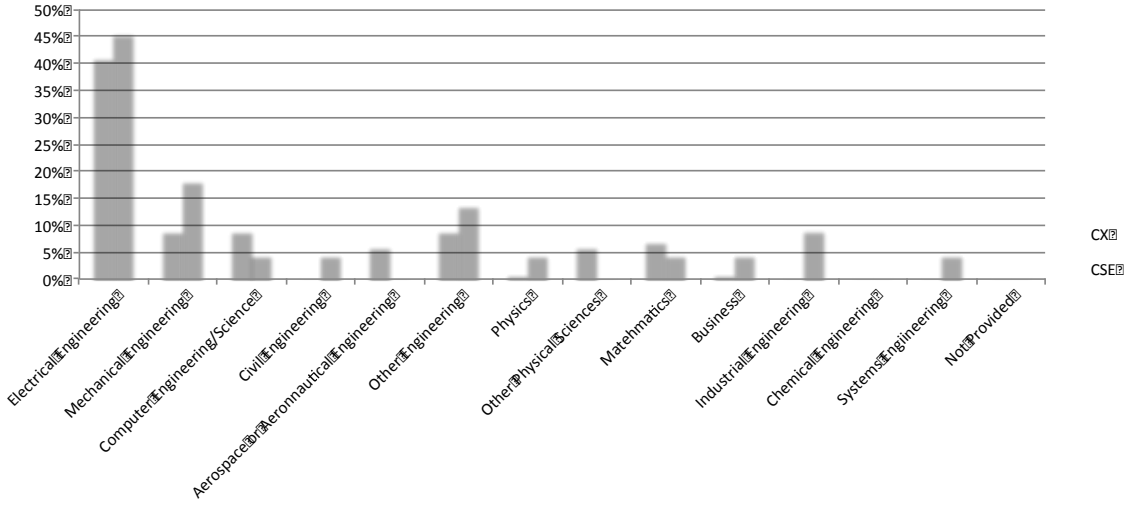
Deeper Dive for Chief Systems Engineers and ChiefXs

Role Played by Interviewed CSEs Prior to Their First CSE Position



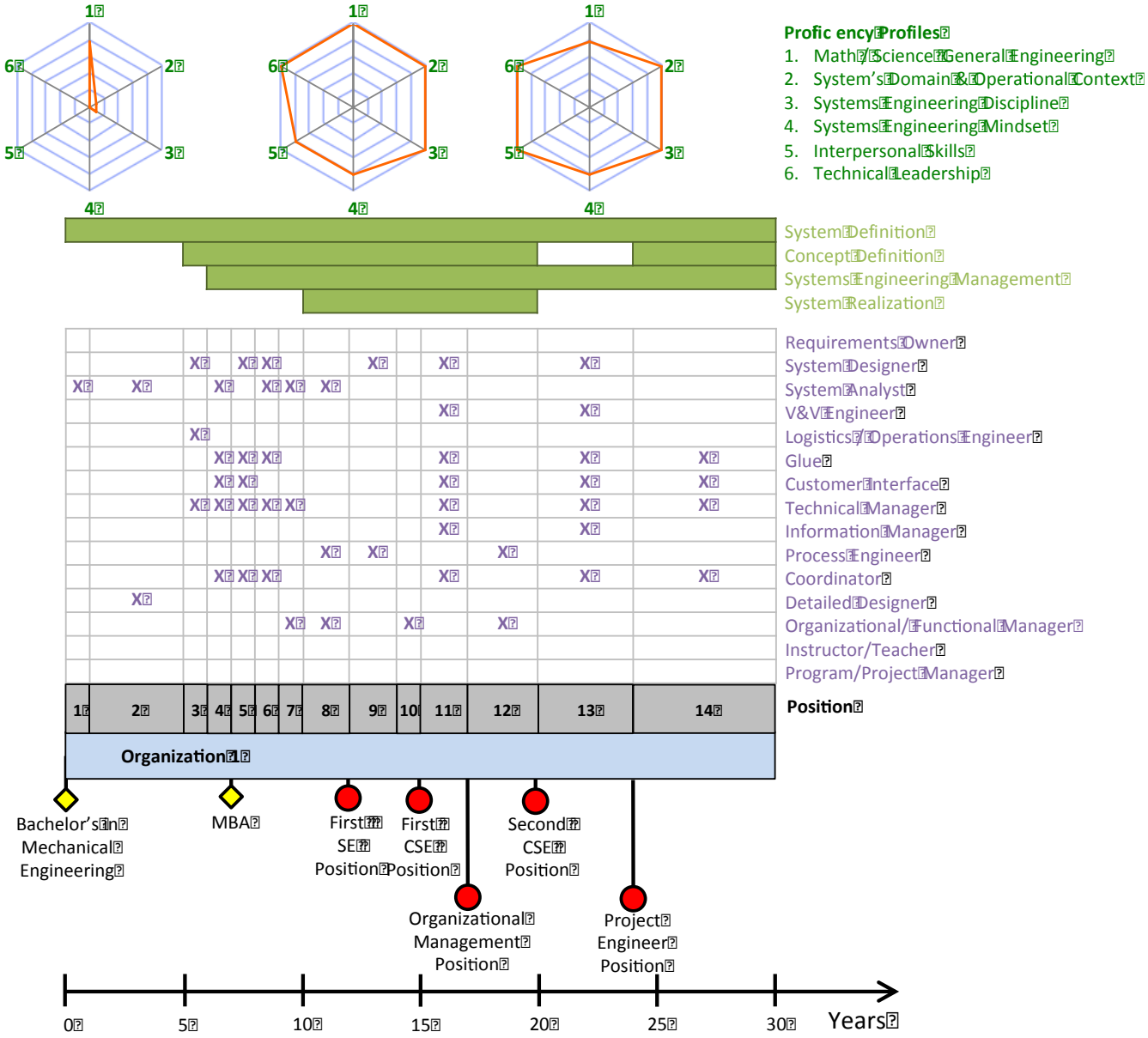
A **Chief Systems Engineer (CSE)** is one who has formal responsibility to oversee and shepherd the technical correctness and to maintain a consistent vision for a system, often coordinating with many other systems engineers who have smaller scopes of responsibility.

Comparison of Bachelor's Degree Majors Between Interviewed CSEs and INCOSE Applicant ChiefXs (CSE, Chief Engineer, Chief Architect, Chief Systems Architect, Chief Principal Engineer, and Chief of Systems Engineering)

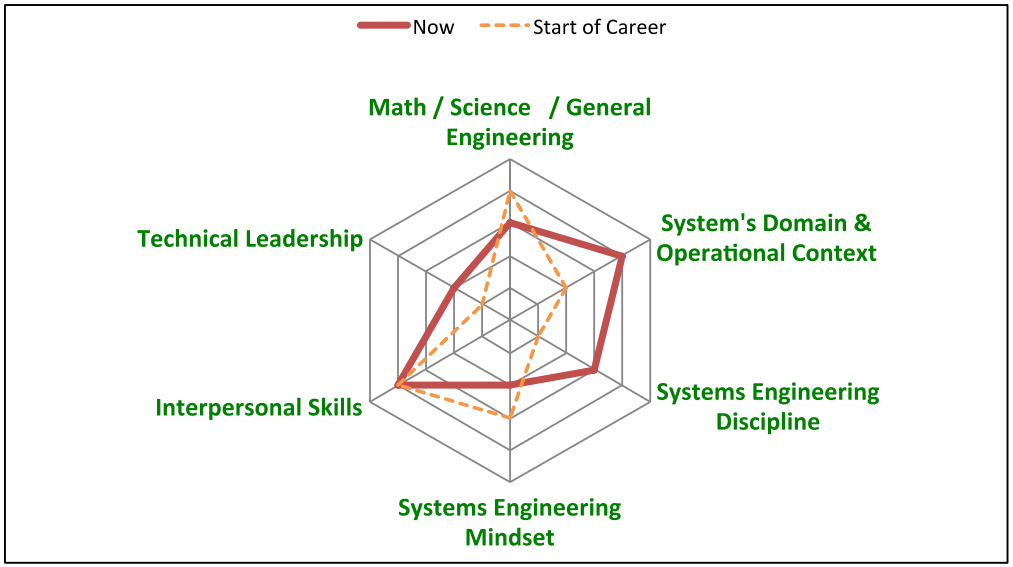


Two examples of the many different demographic analyses performed on the sample population

Career Path of CSE "Athena"

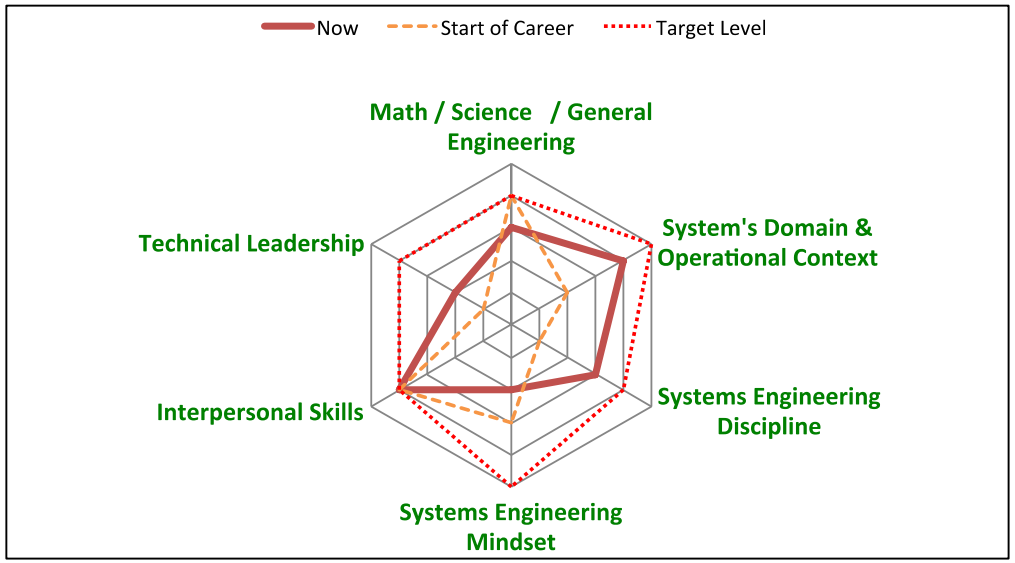


How Could *Atlas* Be Deployed?



Profile of An Individual

Proficiency Profile with Target Levels



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Understanding Changes in Proficiency Levels Over Time

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	Math/Science/General Engineering	System Domain	Systems Engineering Discipline	Systems Engineering Mindset	Interpersonal Skills	Technical Leadership
#1	2	6	3	-1	2	2
#2	1	5	3	0	2	3
#3	-2	5	6	6	5	7
#4	-4	9	8	4	6	8
#5	2	5	5	6	3	6
#6	-2	6	6	2	2	2
#7	-2	4	6	4	2	4
#8	-1	4	6	0	1	3
#9	0	7	9	0	5	6
#10	1	2	5	2	3	3
#11	-2	4	8	0	2	2
#12	2	6	6	5	4	6
#13	1	3	6	3	3	5
#14	-1	6	7	4	2	6
#15	-1	8	7	3	4	5
#16	2	8	6	3	2	5
#17	1	5	5	3	3	5
#18	-5	5	5	4	4	5
#19	1	5	7	2	3	4
#20	-2	6	5	2	2	7

Change in Proficiency Levels of Individuals

Scale
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
-5

Strongest and Weakest Proficiencies of Individuals

	Math/Science/General Engineering	System Domain	Systems Engineering Discipline	Systems Engineering Mindset	Interpersonal Skills	Technical Leadership
#1	8	8	7	7	7	7
#2	6	6	4	8	7	7
#3	4	7	7	8	9	9
#4	5	10	8	9	7	8
#5	7	7	5	9	8	6
#6	4	8	8	9	8	8
#7	6	6	8	6	6	6
#8	7	8	8	9	8	9
#9	8	8	9	9	8	7
#10	5	8	9	9	9	8
#11	4	6	8	6	6	6
#12	6	8	8	8	8	8
#13	8	9	8	10	7	7
#14	7	8	8	8	7	6
#15	6	9	8	9	7	8
#16	6	9	7	9	8	7
#17	8	7	8	7	7	8
#18	4	8	7	9	8	8
#19	7	7	9	6	8	9
#20	6	8	9	8	9	9

What's Next?

1. Develop and publish *Atlas 1.0*
2. Continue to validate *Atlas* with early adopters who are seeking to improve their systems engineering workforce
3. Develop greater automation to understand and apply *Atlas*
4. Continue to build the *Atlas* user community and increase awareness of *Atlas*