

The Education Background of INCOSE Systems Engineering Professional Certification Program Applicants

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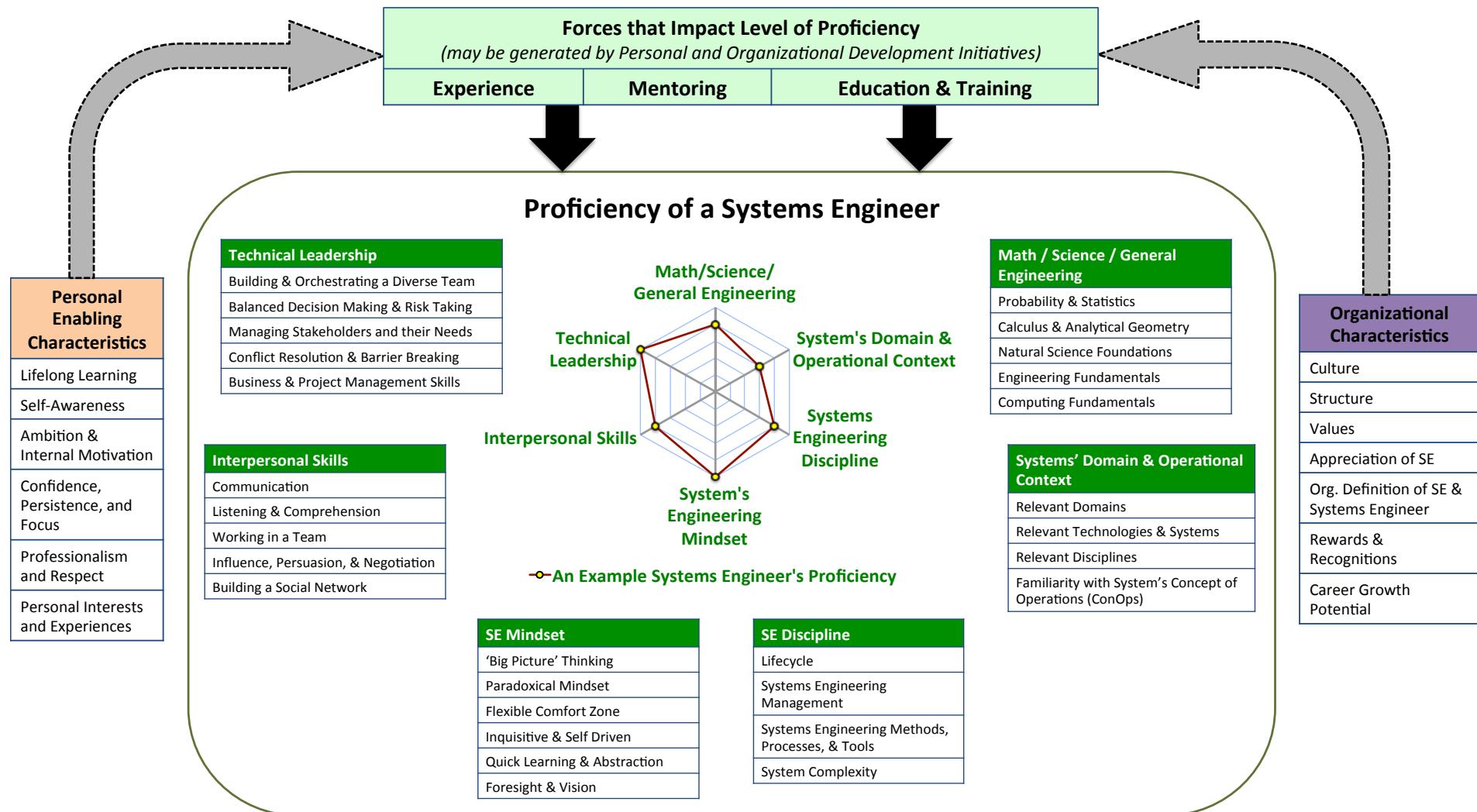
**Presented by Barboza and Hutchison
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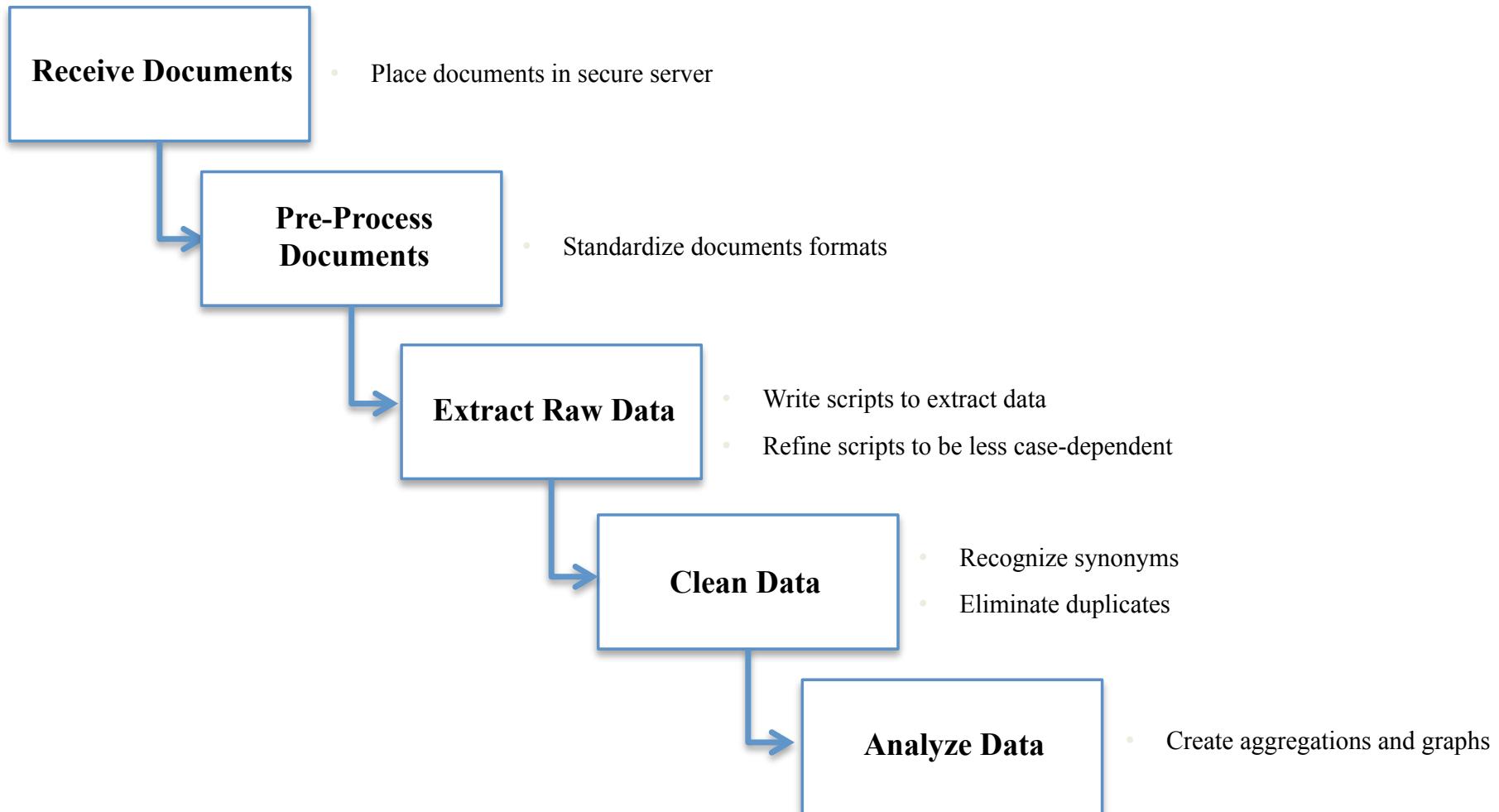
- Background on the Helix Project
- Methodology
- INCOSE Data Set
- Education Insights on INCOSE SEP Applicants
- Additional Insights on Experiences of INCOSE SEP Applicants

- 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 and by examining SEP applications
- Scope now includes those who perform SE activities but don't think of themselves primarily as systems engineers, and those organizations that perform systems engineering without calling it so
- Reporting is done in an aggregated anonymous manner that does not reveal the identities of participating individuals or organizations

- In-depth interviews to date
 - 224 individuals
 - 19 organizations
 - Follow up interviews with 75
- Detailed career analysis
 - 157
- Mixture of qualitative and quantitative analyses
- 2014 – *Atlas 0.25: Theory of Effective Systems Engineers*
- 2015:
 - INCOSE education and experience work
 - expanding outside of defense industry, into related disciplines, working on *Atlas 0.5*



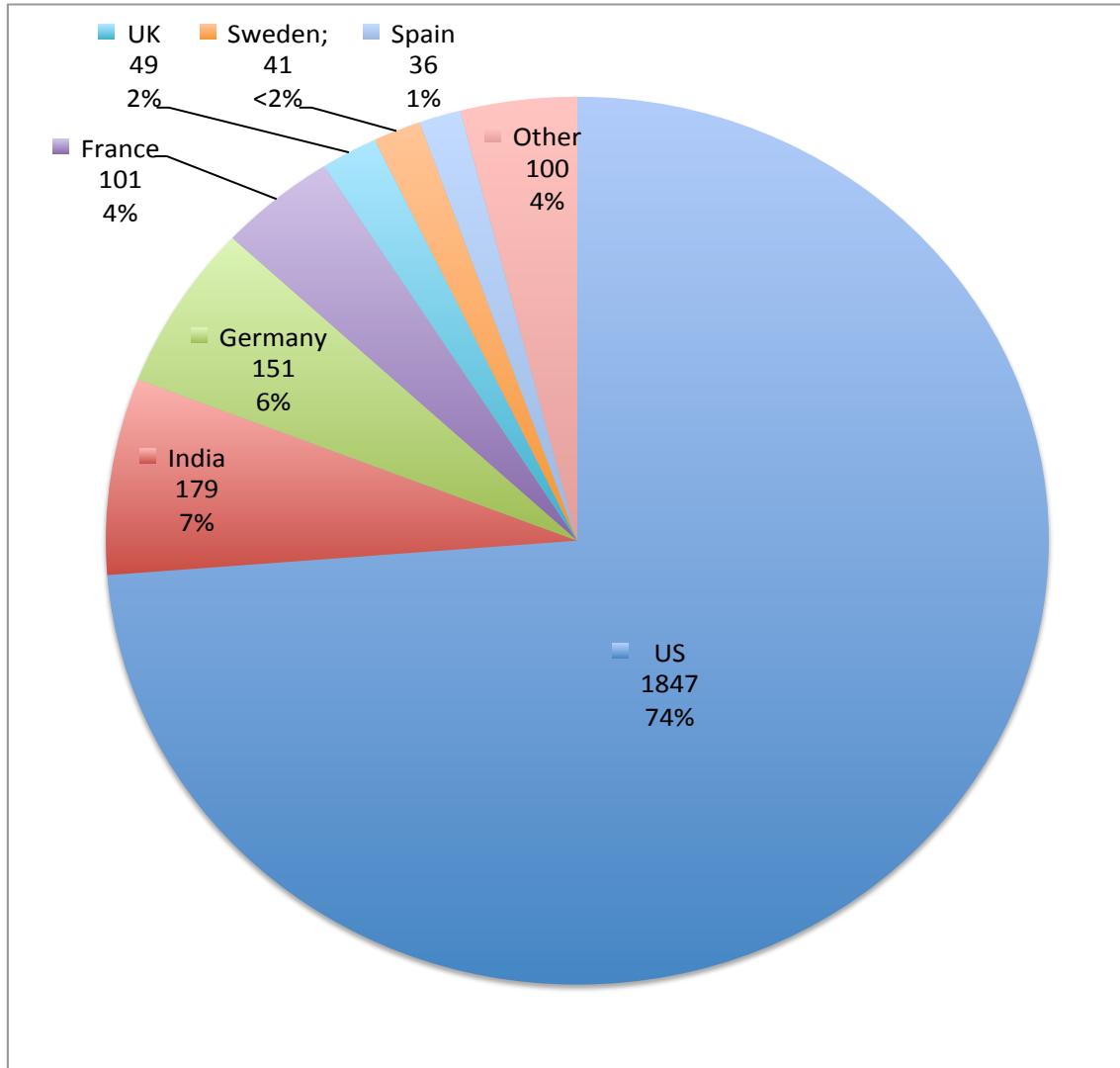
- Helix collaboration with the SEP Program Manager, Courtney Wright, and the INCOSE Certification Advisory Group
- April 2014 – Helix Team Signed Agreement with INCOSE to analyze SEP applications
- August 2014 – Helix team received
 - Over 2,500 applications
 - Applications cover 2004-2014
 - Almost a dozen different versions of application Form 1 (For ASEP / CSEP Certification) and Form 41 (ESEP Certification)
 - Fields changed and required different data, i.e. birthdate versus birthyear
 - Different file formats made data extraction difficult



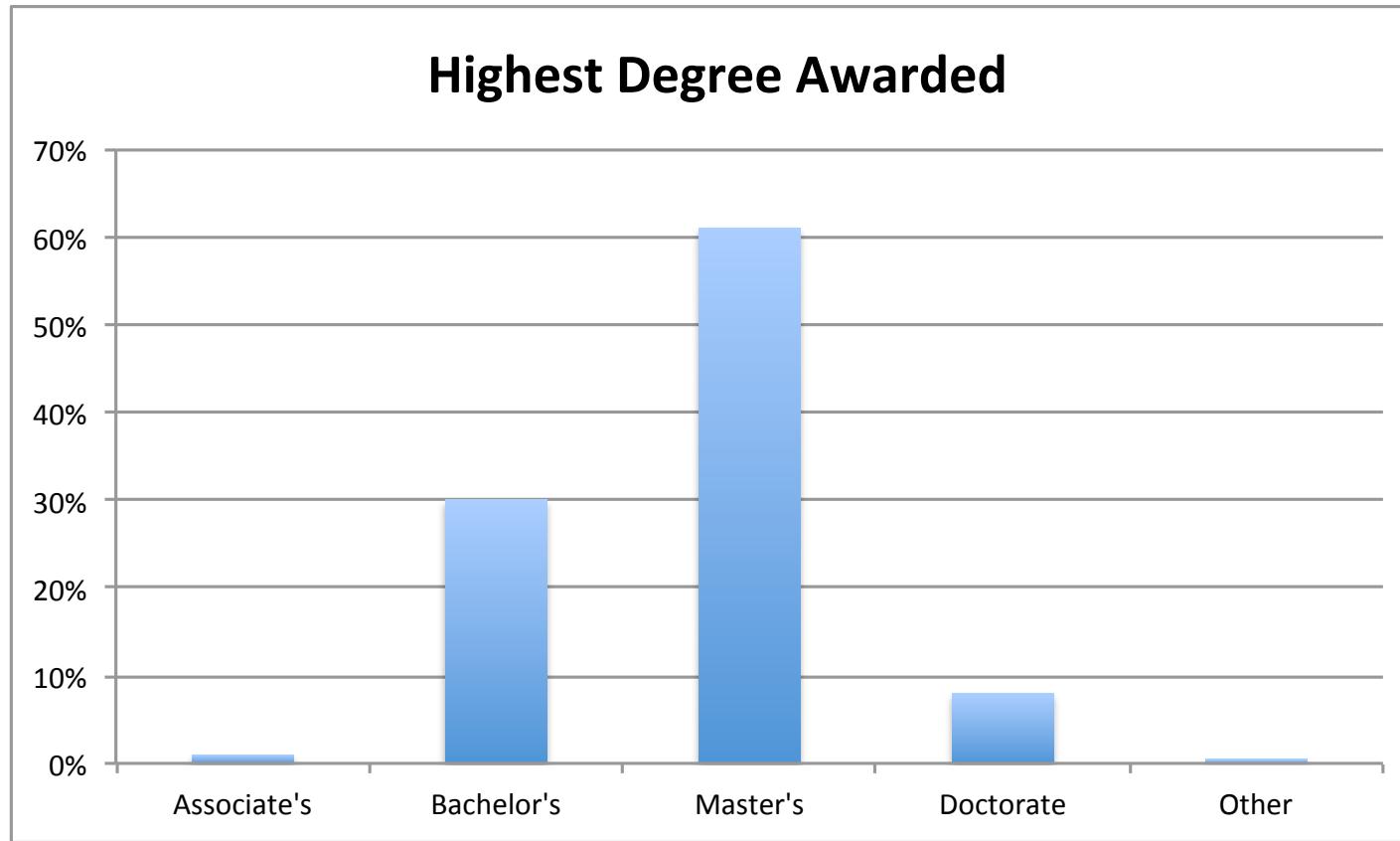
- Small percentage of fields had formatted data for data extraction or analysis
 - Fields included strings of text that had to be normalized
 - No guidelines were provided for entering university names, 'Stevens Institute of Technology' could be entered as 'Stevens', 'Stevens Institute', 'SIT', 'Stevens Inst. Of Tech.', or 'Stevens Institute of Technology'
 - Bachelor of Science is indicated in various ways, and in different countries is called a different degree
- After normalization, the number of applications with useful education data was 2,504 who collectively earned 4,963 college degrees

- Country Distribution

- Based on applicant mailing address



Sample – Highest Degree Awarded



- US terminology, normalized across the sample
 - Associate: Associate of Science, Diploma (India), Vordiplom (Germany)
 - Master's: Post Graduate Diploma (India), DEA (France)

Types of Bachelor's Degrees

Bachelor's Degree	# Applicants	% Total
Bachelor of Science	1813	77%
Bachelor of Engineering	316	13%
Bachelor of Arts	203	9%
Other	27	1%

Majors identified by 50+ people

Major	#	%
Electrical Engineering	468	18%
Mechanical Engineering	205	9%
Computer Science	150	6%
Aerospace Engineering	98	4%
Physics	87	4%
Mathematics	77	3%
Computer Engineering	52	2%

- Other includes:
 - Bachelor, Bachelor of Technology, Baccalaureate, etc.

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

Types of Master's Degrees

Master's Degree	# Applicants	% Total
Master of Science	1442	69%
Master of Engineering	337	16%
Master of Business Administration	196	9%
Master of Arts	70	3%
Master	24	1%
Other	26	1%

Majors identified by 50+ people

Major	#	%
Systems Engineering	238	11%
Electrical Engineering	225	11%
Computer Science	118	6%
Mechanical Engineering	81	4%
Business Administration	62	3%
Engineering Management	58	3%

- Other includes:
 - Diplom, Master of Public Administration/Technology, Management, etc.

Trend 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

Types of Doctorate Degrees

Doctorate Degree	# Applicants	% Total
Doctor of Philosophy	189	95%
Juris Doctor	6	3%
Doctor of Science	2	1%
Other	3	1%

- Other includes:
 - Doctor of Engineering,
 - Doctor of Management

Majors identified by 50+ people

Engineering Major	%
Electrical Engineering	25%
Systems Engineering	23%
Aeronautical or Astronautical Engineering	13%
Mechanical Engineering	8%
Biomedical Engineering	5%
General Engineering	6%
Other Engineering	19%

- Other includes:
 - Nuclear, Telecommunications, and Interdisciplinary Engineering

- The applicants are very well educated, with almost 70% having an advanced college degree.
- At the bachelor level, classical engineering degrees dominate, but computer-related majors are becoming increasingly popular.
- Two of the most popular masters degrees earned since 2000 are the Master of Systems Engineering and the Master of Business Administration.

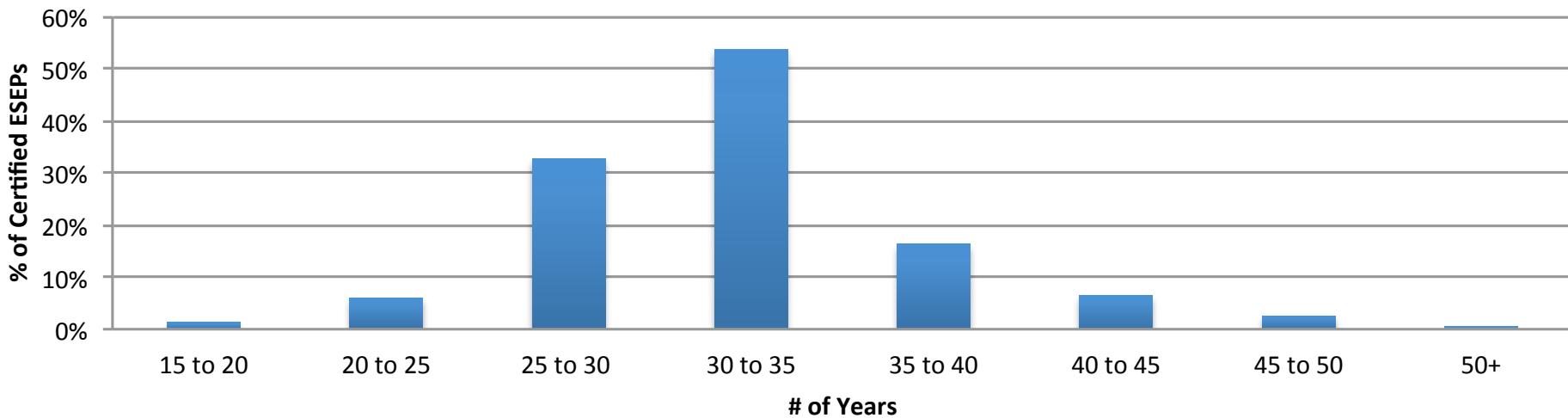
- Relevant System Engineering experiences are reported
 - Information provided ranged from none to 11 positions
 - ASEPs are not required to provide experience
 - CSEPs must provide a minimum of 5 years of experience*
 - *(or a minimum of 10 years without a technical bachelors, or a minimum of 15 years without any bachelors)
 - ESEPs must provide a minimum of 25 years of experience *
 - *(or a minimum of 30 years without a technical bachelors, or a minimum of 35 years without any bachelors)
- Extremely Dirty Dataset
 - 644 Applications were individually cleaned
 - Cleaned all (233) ESEP Applications
 - Dataset includes applications from 2008 to 2014
 - Random Selection of 411 CSEP and ASEPs Applications
 - Dataset includes applications from 2004-2011

Applicant Age at Time of Application

AGE	CERTIFICATION TYPE		
	ASEP	CSEP	ESEP
20-25	15%	1%	0%
25-30	26%	3%	0%
30-35	21%	16%	0%
35-40	13%	15%	0%
40-45	15%	15%	1%
45-50	0%	18%	11%
50-55	4%	16%	33%
55-60	2%	9%	26%
60-65	4%	5%	17%
65-75	0%	2%	11%
75-90	0%	0%	1%

- Average Age was consistent year by year
 - 47% of ASEPs are between 25 and 35 years old
 - 80% of CSEPs are between 30 and 55 years old
 - 76% of ESEPs are between 50 and 65 years old

Years of Experience at Time of Application

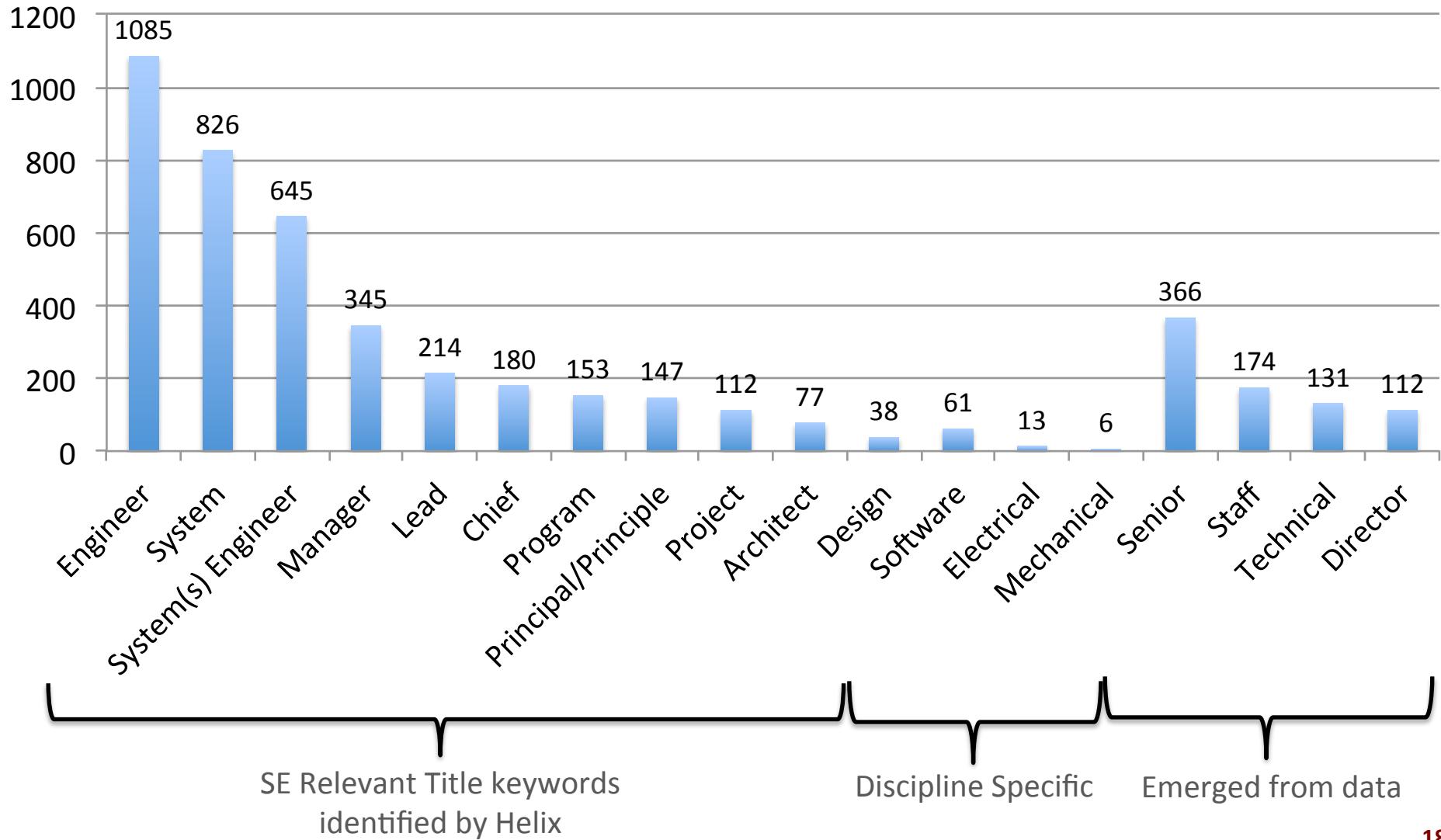


The average across all years is 31 years of experience at the time of application.

Years of Experience at Time of Application



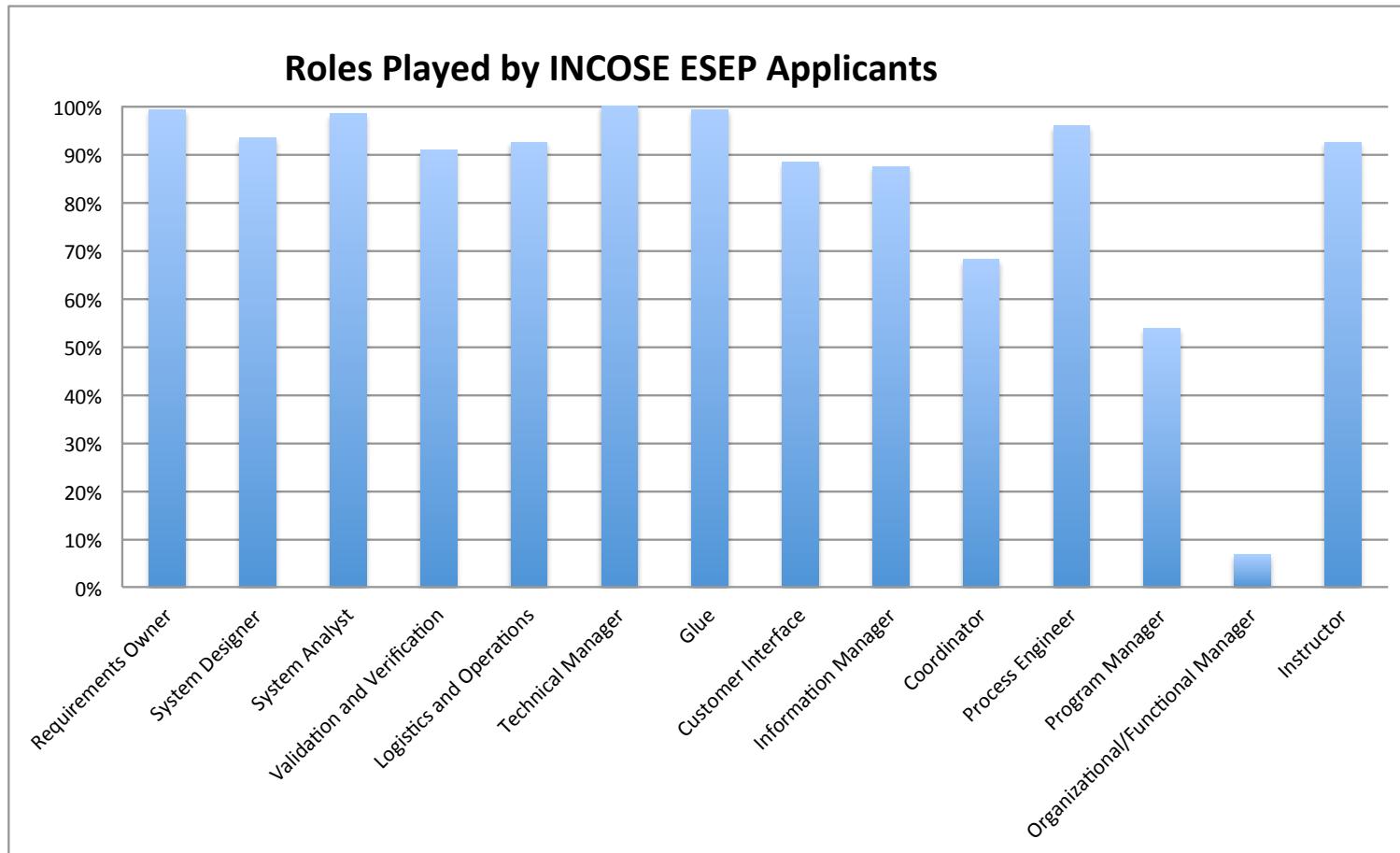
Analysis of Keywords in Position Titles



- 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. (Hutchison and Pyster 2015)
- A *role* is a specific set of related systems engineering activities. (Hutchison and Pyster 2015) The Helix team uses an expanded set of Sheard's "Twelve Systems Engineering Roles". (1996)
 - Keywords were used to uncover roles described in application position descriptions, see examples below:

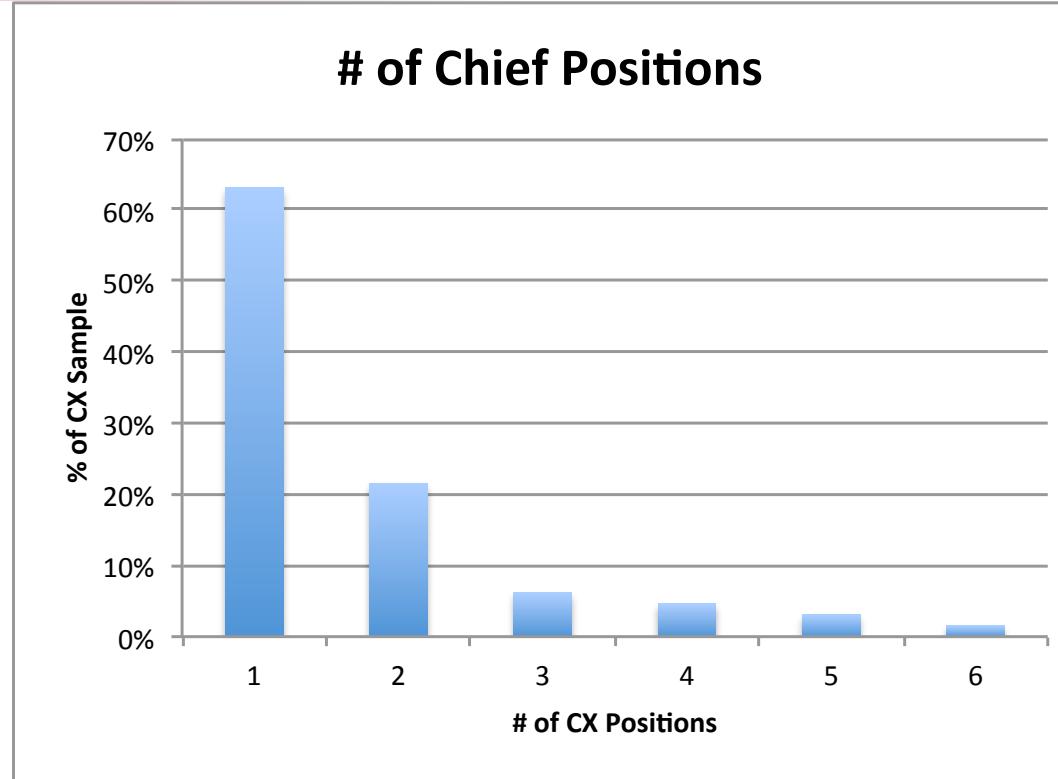
Role (Abbreviation)	Requirements Owner (RO)	System Designer (SD)	System Analyst (SA)	V&V Engineer (VV)	Logistics/ Operations Engineer (LO)	Glue (GL)	Customer Interface (CI)
Keywords	"*create/ed/ing Requirement*" "*Generate/ed/ing Requirement*" "*develop/e/ed/ing Requirement*" "*Requirement*" "*manage/ed/ing Requirement*" "*requirement database*" "*requirements database*" "*Requirement manage*" "*Requirements manage*" "*Requirement develop*" "*Requirements develop*"	"*system Design*" "*architect*"	*Analy* "*system model*" "*model*" "*simulat*"	"*verif*" "*validat*" "test"	"*logistic*" "*operat*" "*site support*"	"*integrat*" "*system interface*" "*design interface*"	"*customer coordinat*" "*customer*" "*coordinat*with customer*" "*customer interface*"

- Keywords were defined for each role – **position descriptions** were **searched** using **keywords**.
- Starting Point: Sheard's 12 SE Roles (1996)
- Full set of roles defined by Helix team based on Helix analysis (some modifications, additions from Sheard's original 12)

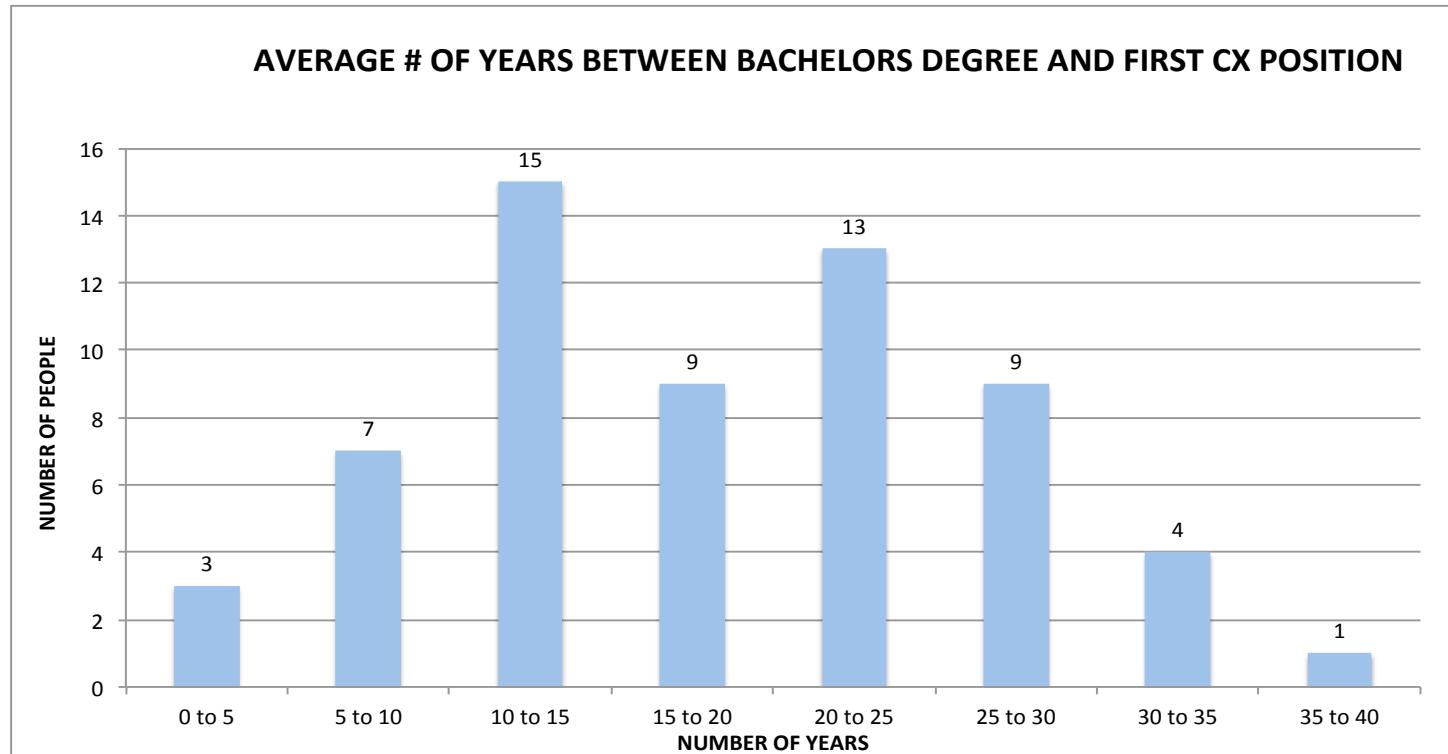


- Further investigation into experience and education background of people who have had the following “Chief” titles and were certified as ESEPs:
 - Chief Engineer,
 - Chief Systems Engineer,
 - Chief Architect,
 - Chief Systems Architect,
 - Chief Principal Engineer, and
 - Chief of Systems Engineering
- 65 “Chief X’s” exist in the dataset – they held a total of 108 “Chief X” titles

A chief systems engineer (CSE) is someone who has formal responsibility to oversee and shepherd the technical correctness of a system, often coordinating with many other systems engineers who have smaller scopes of responsibility.
(Hutchison and Pyster 2015)



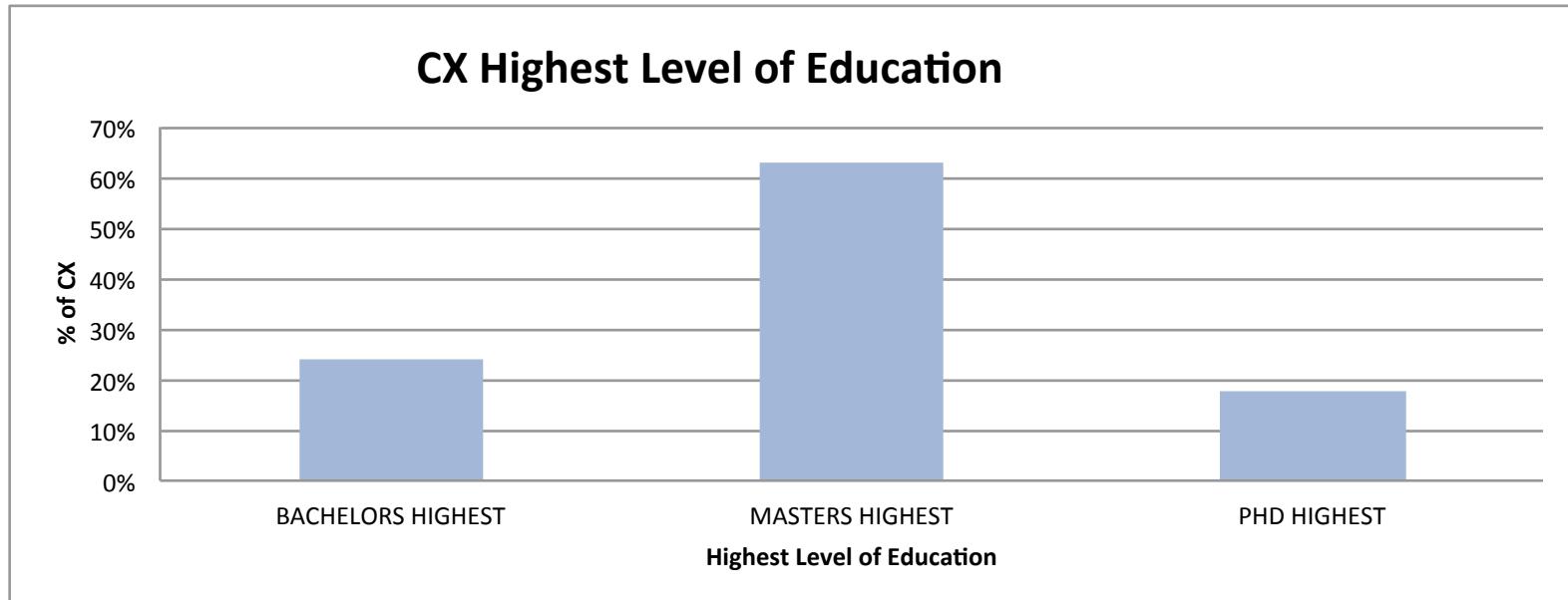
- 35% were in a “Chief X” (CX) position when they applied to become an ESEP
- Most people obtain a CX title during the 3 most recent positions reported
- Very few report being CX during their oldest 3 positions.



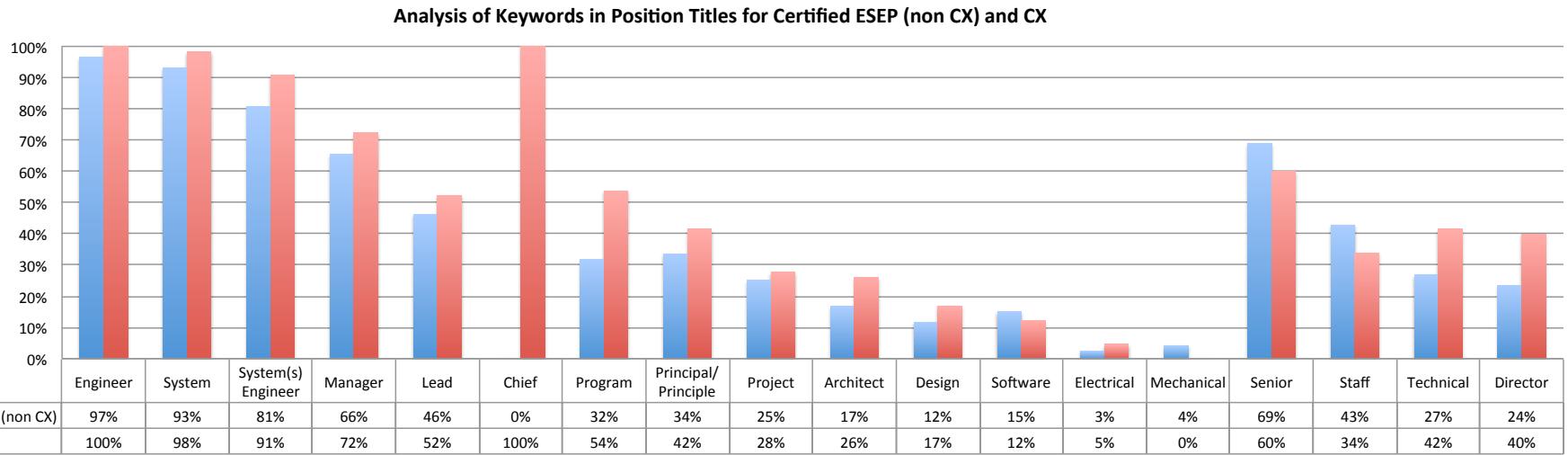
Major	Total
Electrical Engineering	36%
Mechanical Engineering	9%
Computer Engineering/Computer Science/Computer and Information Sciences	7%
Mathematics	7%
Aerospace Engineering	6%
Chemistry/Graduate Chemistry	6%
Engineering/Engineering Science	4%

- 50 People attained 62 Masters degrees
(12 people attained 2 Masters degrees)

MAJORS	Total
Management Variations and MBA Variations	22%
Electrical Engineering	21%
Systems Engineering	14%
Computer Science/Computer Science and Management	12%



Position Titles Comparative Analysis

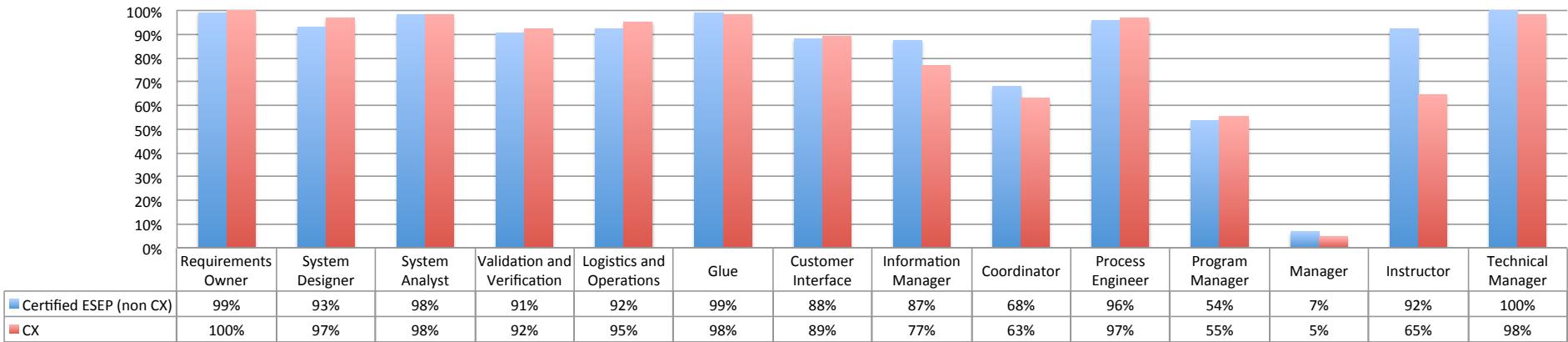


SE Relevant Title keywords
identified by Helix

Discipline Specific

Emerged
from data

Analysis of Roles in Position Descriptions for Certified ESEP (non CX) and CX



- Keywords were defined for each role – **position descriptions were searched using keywords**
- Observations
 - No major differences in roles – CX does have more exposure in 8 of the roles
 - Biggest difference seen in Instructor and Information Manager roles

- A larger percentage of the CX subset have PhDs as their highest degree when compared to the general INCOSE Applicant
- The CX's have had a breadth of position titles, this is apparent in the comparison with certified ESEPs
 - Except for Software, Mechanical, Senior and Staff
- No major differences were found in the roles analysis for both certified ESEPs and CXs

Contact the Helix team at:

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Systems Engineering Research Center

www.sercuarc.org

Grouped Bachelor's Degree Majors

Major Group	%
Electrical Engineering	30%
Mechanical Engineering	10%
Computer Engineering/Computer Science	12%
Aerospace or Aeronautical Engineering	6%
Industrial Engineering	2%
Systems Engineering	2%
Other Engineering	7%
Physics	5%
Mathematics	4%
Other Physical Sciences	4%
Business or Management	4%
Other	13%

Grouped Master's Degree Majors

Major Category	%
Electrical Engineering	16%
Systems Engineering	16%
Computer Engineering/Computer Science	10%
Mechanical Engineering	5%
Aerospace or Aeronautical Engineering	6%
Software Engineering	2%
Other Engineering	16%
Physics	2%
Other Physical Sciences	1%
Mathematics	1%
Business or Management	1%
Other	24%