Investigating the DNA of the Systems Engineering Workforce

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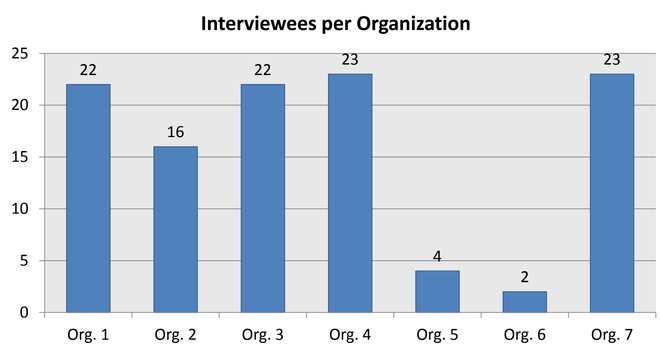
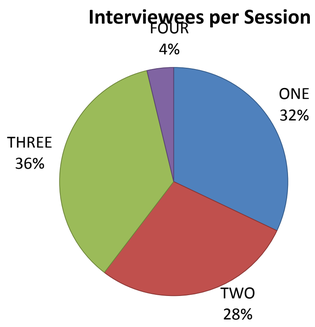
The Helix Project

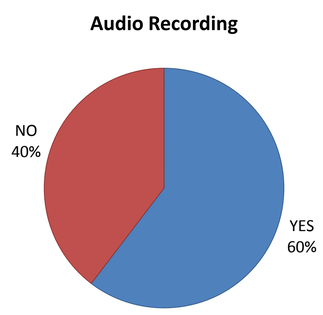
- Helix is a multi-year longitudinal study designed to build an understanding of the systems engineering workforce in the U.S. Department of Defense (DoD) and the Defense Industrial Base (DIB)
- Helix is focusing on three main research questions:
  1. What are the characteristics of systems engineers?
  2. How effective are systems engineers and why?
  3. What are employers doing to improve the effectiveness of their systems engineers?
- Data collection is primarily 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

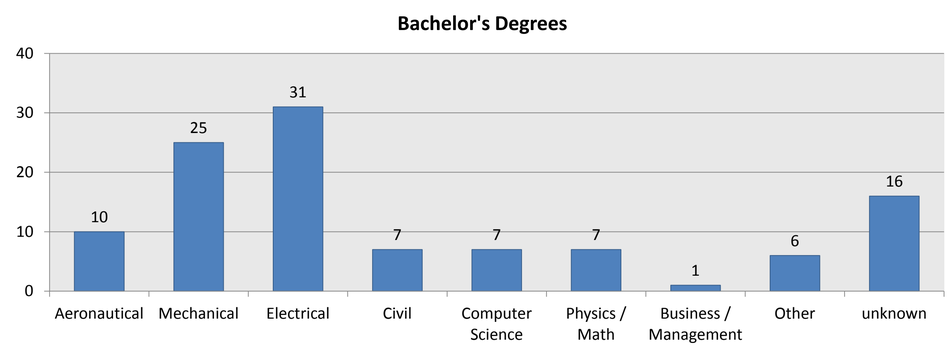
Systems Engineers Interviewed in 2013

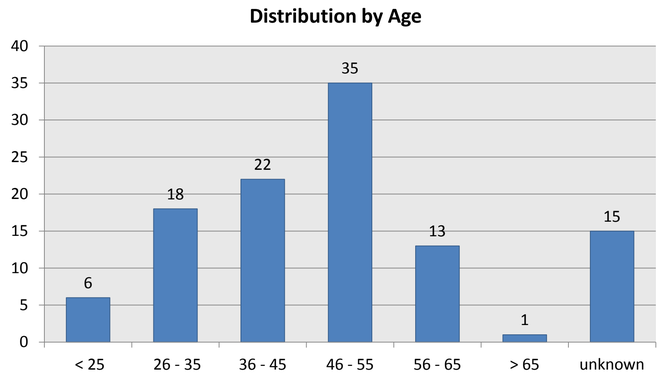
- In 2013, the Helix team interviewed **110** systems engineers from **7** organizations

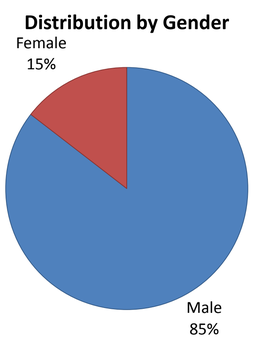


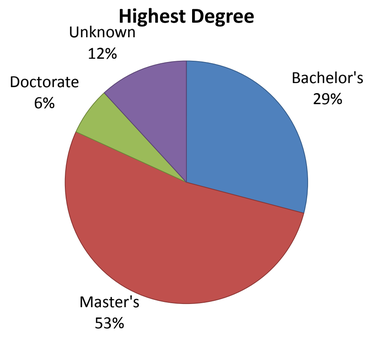


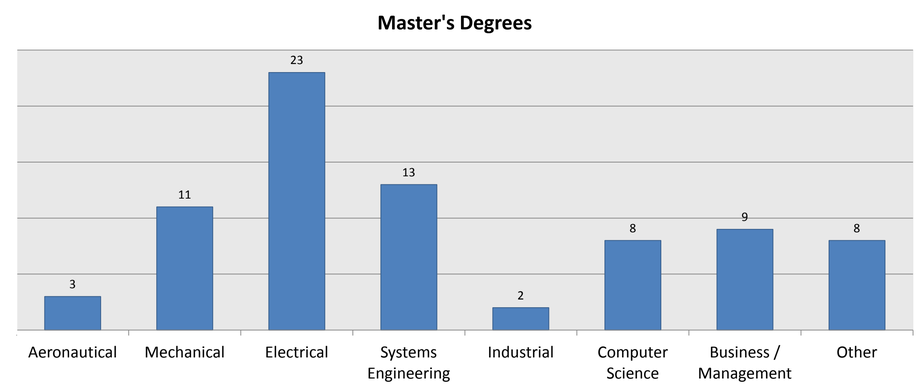












Initial Findings

- Qualitative and quantitative research methods were applied on the interview data, based on a modified grounded-theory approach

Important CHARACTERISTICS of Effective Systems Engineers

1. **Paradoxical Mindset**
   - Big Picture Thinking *and* Attention to Detail
   - Strategic *and* Tactical
   - Analytic *and* Synthetic
   - Courageous *and* Humble
   - Methodical *and* Creative
2. **Effective Communication**
   - Modes *(oral and written; good speakers and listeners)*
   - Audience *(bridge between problem domain and solution domain)*
   - Content *(social, managerial, technical)*
   - Purpose *(understanding needs, negotiation, information brokering, technical arbitration, driving consensus)*
3. **Flexible Comfort Zone**
   - Open Minded
   - Rational Risk Taking
   - Multidisciplinary
   - Enjoys Challenges
4. **Smart Leadership**
   - Quick Learning and Abstraction
   - Knowing when to stop
   - Focused on 'Vision' for System
   - Ability to Connect the Dots
   - Patience
5. **Self Starter**
   - Curiosity
   - Passionate and Motivated
   - Eager to Learn

Greatest CONTRIBUTIONS of Systems Engineers

- Translating highly technical information from subject matter experts (SMEs) into common language that other stakeholders can understand
- Balancing traditional project management concerns of cost and schedule with technical requirements
- Asking the right questions
- Seeing relationships between the disciplines
- Staying "above the noise" and identifying pitfalls
- Managing emergence in both the project and the system
- Projecting into the future
- Getting the "true" requirements from the customer

What Makes Systems Engineers MOST Effective

- "Effectiveness" to be defined
- Diverse Experiences
  - Different parts of the SE life cycle
  - Different types of life cycles
  - Different aspects of a system (part, component, subsystem, system)
  - Different critical orthogonal attributes of the system (e.g. weight, size, etc.)
- Mentoring
- Value of Systems Engineering – understood and desired

Important TECHNICAL COMPETENCIES of Effective Systems Engineers

- Types of Competencies: General Engineering and Systems Engineering Competencies
- **At Present:** More Breadth than Depth
  - To be familiar with technical language
  - To appreciate the expertise and value of technical experts
  - To understand and integrate the various disciplines related to the system
  - To understand the needs of the customers and constraints of the disciplinary experts, and to evaluate technical feasibility
- **In the Past:** Depth in One (or more) Disciplines
  - To appreciate the value of disciplinary analysis and design, and to understand the time, effort, and resources required
  - To evaluate the validity of responses provided by disciplinary experts
  - To appreciate aspects of sub-system level optimization and the need for system level optimization
  - For credibility and respect within the team and among stakeholders

Perceived RISKS to the Systems Engineering Workforce

- High Percentage of Senior Systems Engineers
  - Mixed reactions:
    - Bath-tub curve does not exist in all organizations
    - Some organizations have formal succession plans
    - Some interviewees said "good riddance!"
- Shifting Environment
  - Shift from war-time to peace-time posture
  - Decreased need for QRCs
  - Smaller and fewer programs expected
- Expectations of Young Systems Engineers
  - To become "senior" systems engineers quickly (in 5 – 10 years)
  - Moving to organizations, looking for upward mobility

What Makes Systems Engineers LEAST Effective

- Ambiguous Definition of Systems Engineering
- Unclear Use of "Systems Engineer" Title
- Limited Value of Systems Engineering in Organizational Culture
- Lack of Systems Engineering Tools
- Greater Visibility of Failures than Successes
- Valuing *Process* over Critical Thinking
- Younger Systems Engineers Fail to Recognize the Importance of Process
- Inadequate Knowledge Management

Future Plans

- To interview non-systems engineers and others who interact with systems engineers
- To interview individual systems engineers not currently affiliated with an organization
- To analyze INCOSE certification applications and information from DoD's Data Mart, to obtain further insights into demographics and career paths of systems engineers
- To expand scope, to include commercial organizations and other countries

Contact

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