SYSTEMS ENGINEERING
Research Center

HELIX

Helix

"DNA" of Systems Engineers

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5th Annual SERC Sponsor Research Review

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Washington, DC

www.sercuarc.org

Outline

- Overview of Helix Project
- Helix in 2013
- Initial Findings
- Plans for 2014 and Beyond

Helix Project Overview

- Helix is a multi-year longitudinal study designed to build an understanding of the systems engineering workforce in the DoD and the Defense Industrial Base (DIB) *(that scope may expand)*
- 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 has primarily been 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

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Helix in 2013

HELIX

- **7** DoD and DIB organizations participated in Helix interviews
- **110** systems engineers interviewed
- Over **1000** pages of raw data
- Qualitative and quantitative research methods applied, based on a modified grounded-theory approach
- Early findings reported in December 2013
- Interactions with additional DoD and DIB organizations for potential participation in 2014

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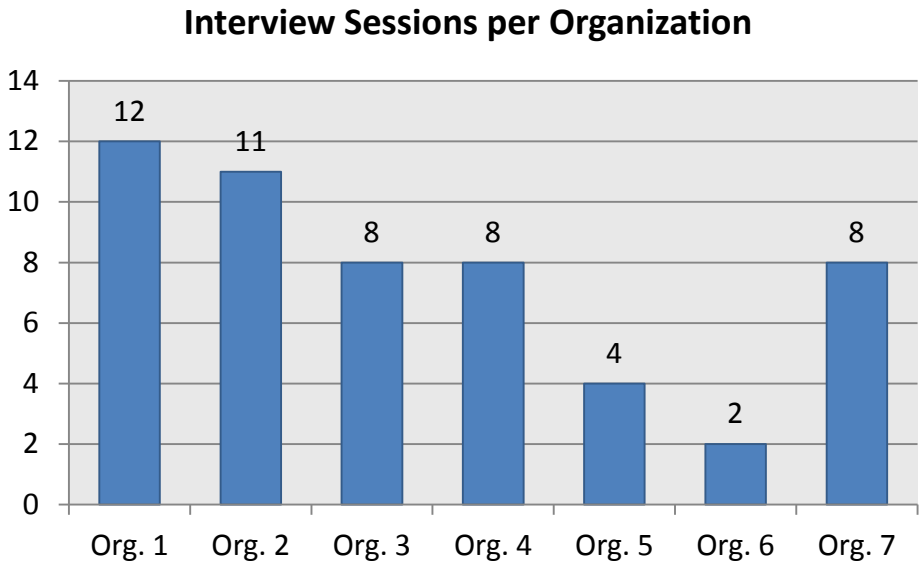
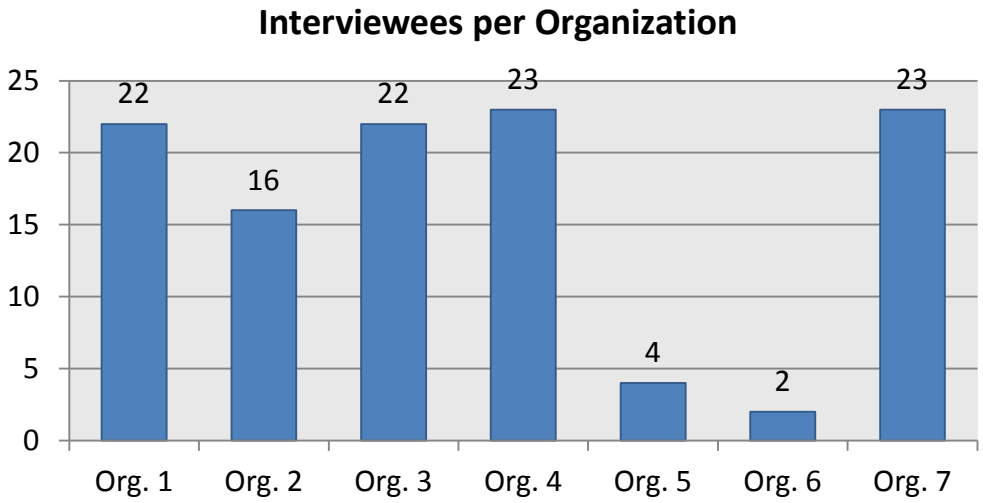
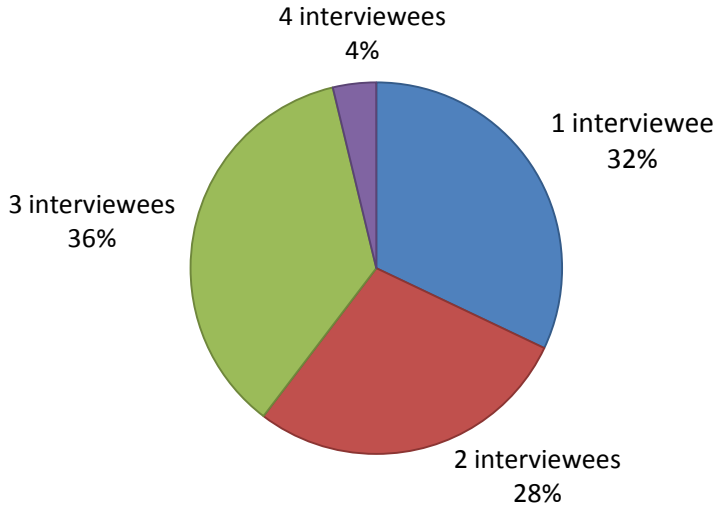
Participating Organizations



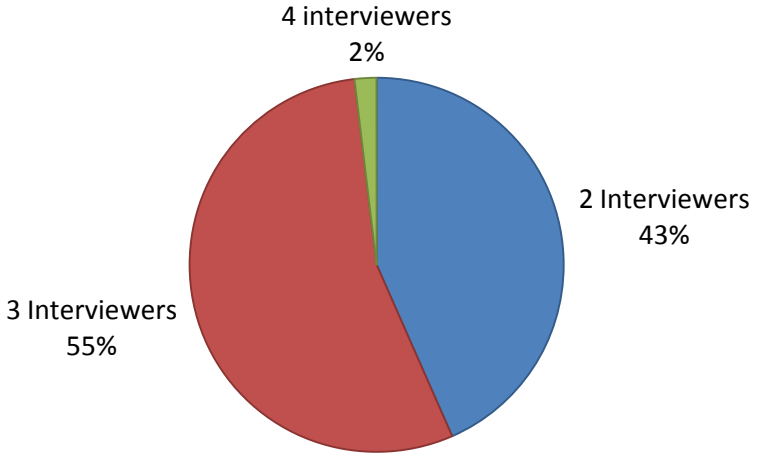


Helix Interviews

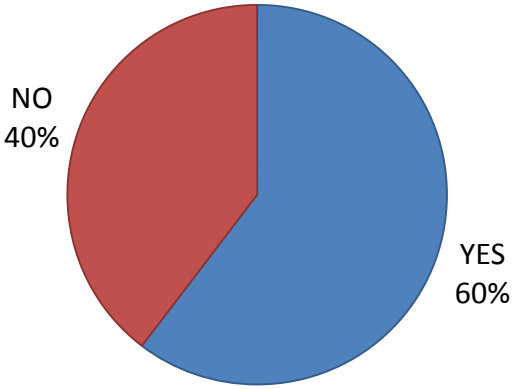
Interviewees per Session



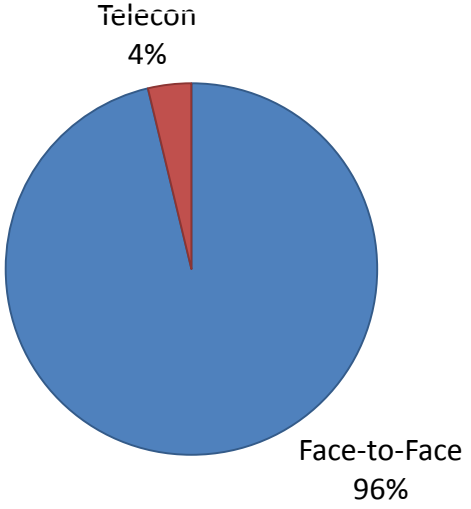
Size of Interview Team per Session



Audio Recording

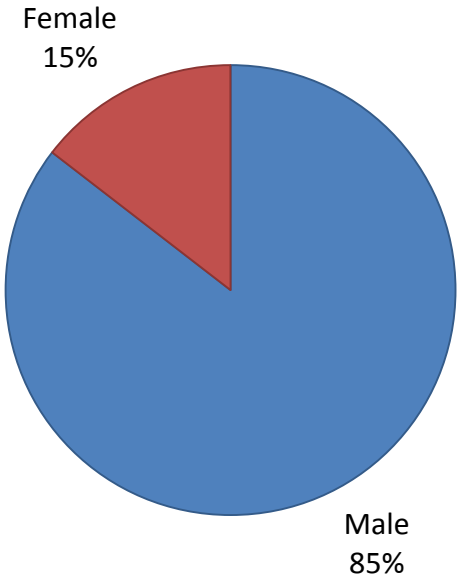


Interview Mode

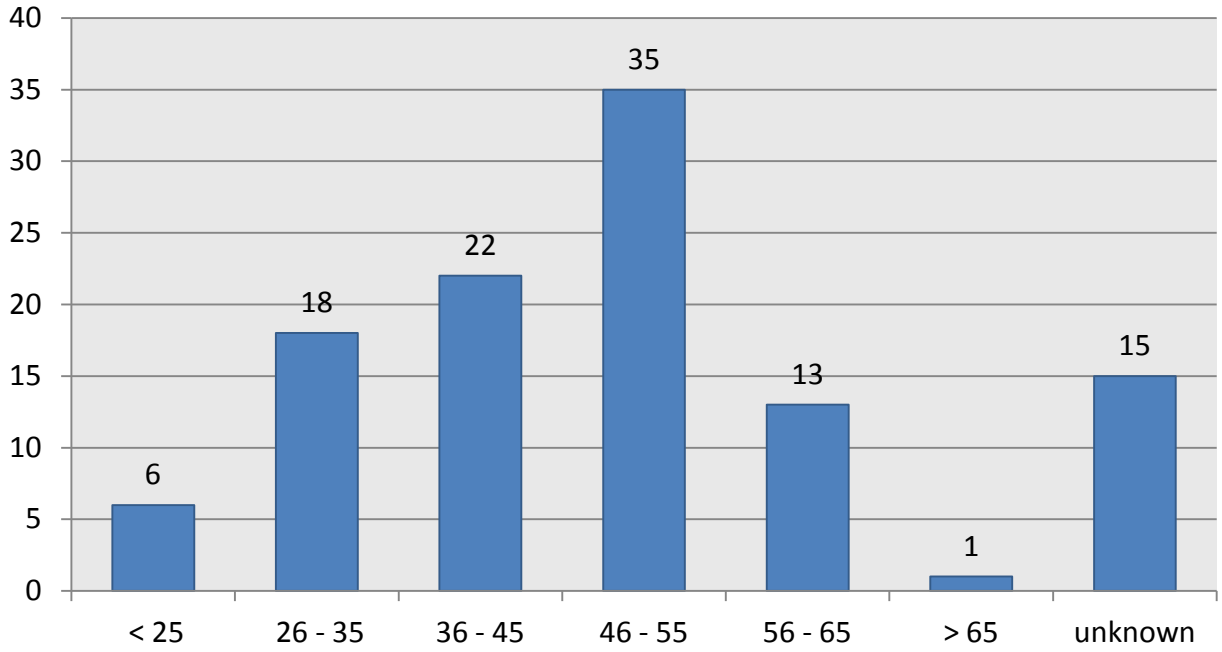


Interview Population - Distribution

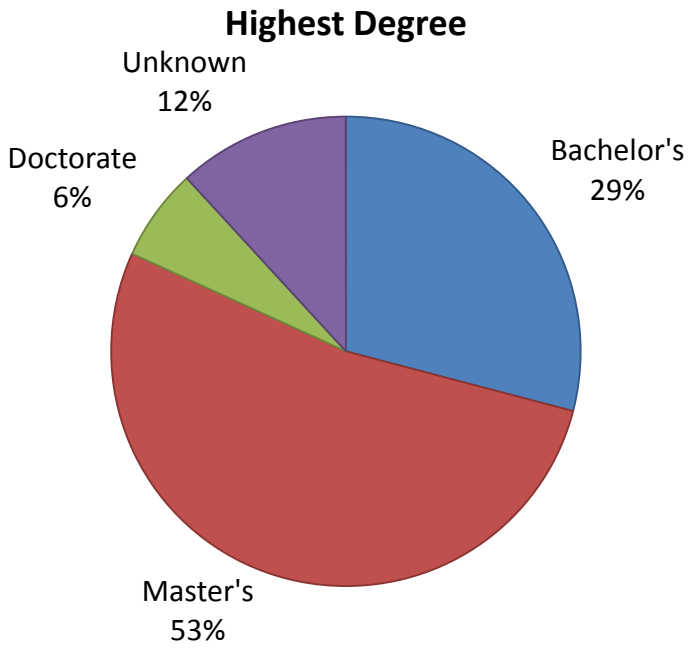
Distribution by Gender

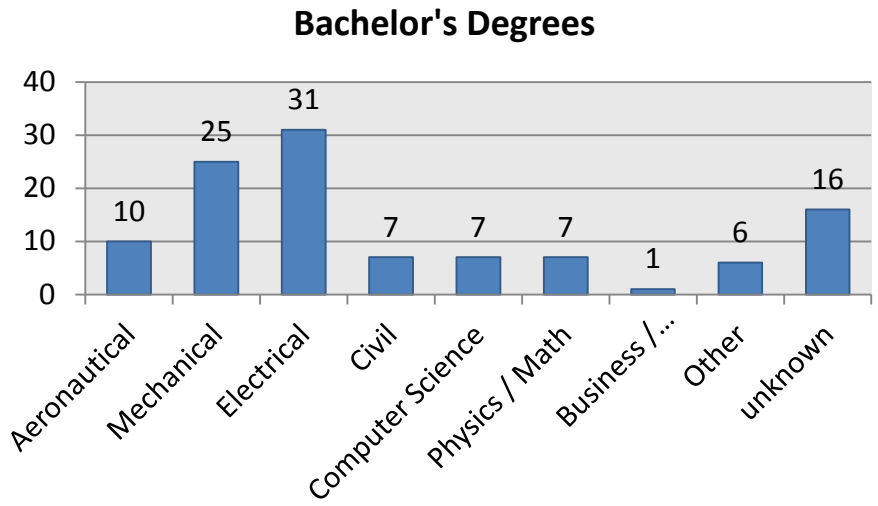


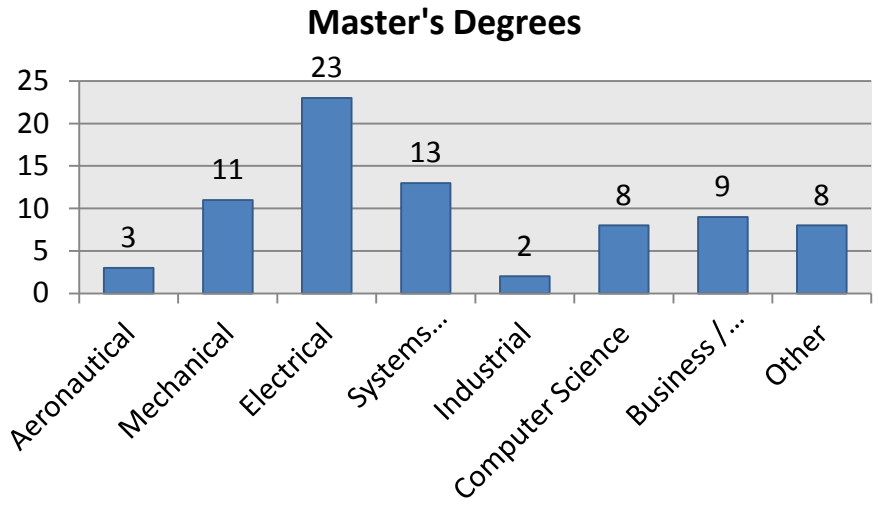
Distribution by Age



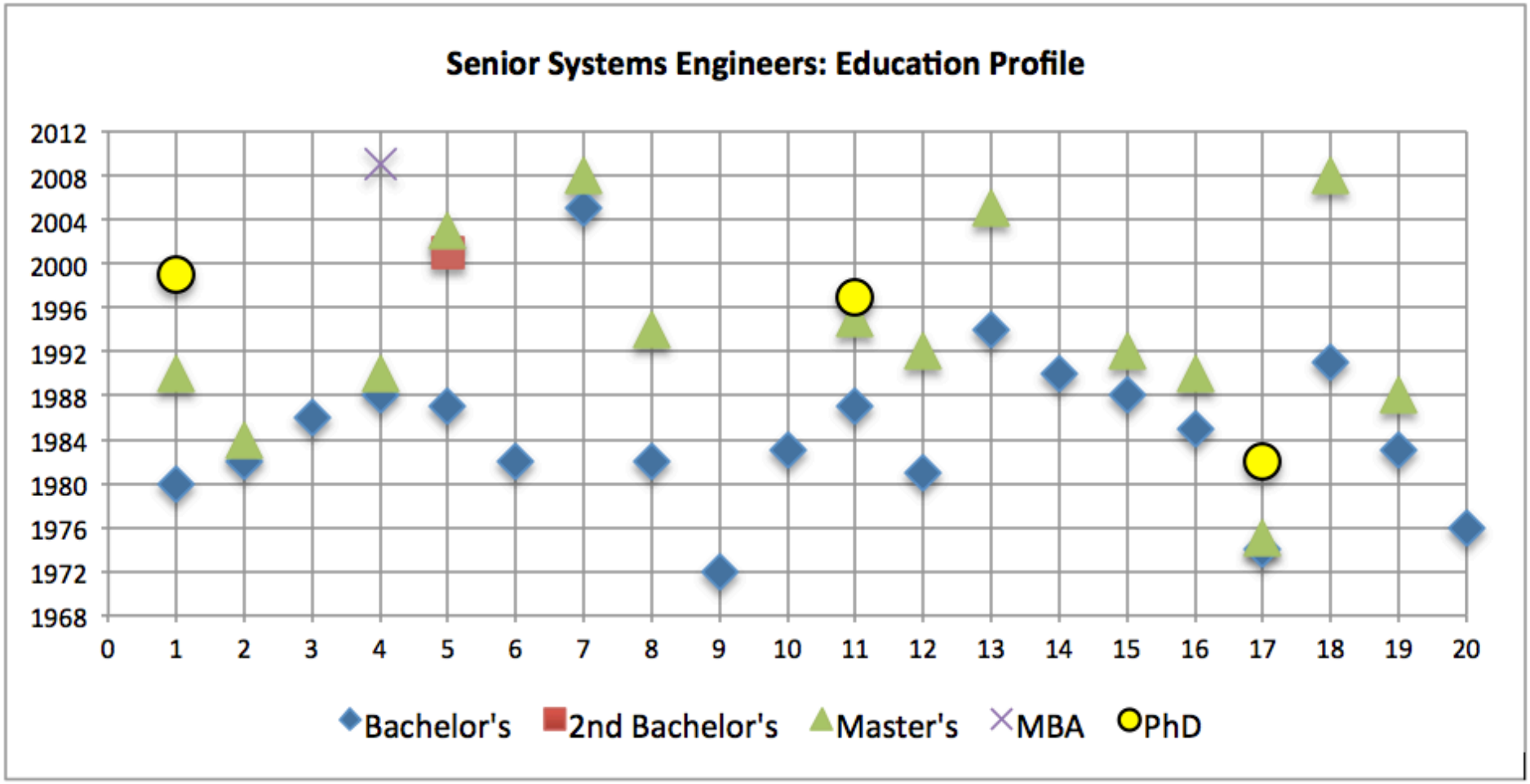
Interview Population - Education







First Look at Senior Systems Engineers



Initial Findings - Categories

1. The most important characteristics and competencies of effective systems engineers
2. The greatest contributions of systems engineers
3. What makes systems engineers most effective
4. What makes systems engineers least effective
5. Perceived risks to the systems engineering workforce

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Important CHARACTERISTICS of Effective Systems Engineers

HELIX

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

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

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

(Baseline definition of "Effectiveness" is established)

- 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

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

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

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Proposed Data Collection in 2014

- Continue data collection from DoD and DIB
  (include non-systems engineers: other engineers, managers, customers of systems engineering, etc.)

- Conduct interviews with individual systems engineers not currently affiliated with an organization

Other Plans for 2014

- Refine research methodology and initial findings
- Build early version of “Theory of Systems Engineers”
- Analyze INCOSE certification applications
- Analyze data from AT&L DAW Data Mart
- Hold Helix workshop (details to be planned)
- Publish 3 reports; write 2 journal papers
- Provide individual feedback to participating organizations
- Lay foundation for longer-term plans

Plans for 2015 and Beyond

- Satellite Research Teams
  - Established in other countries within universities, sponsored by INCOSE
  - Independently staffed and funded
  - Helix team will offer training in data collection, data handling, and research methodology
  - Satellite Research Teams report data at country level; Helix team aggregates data for global perspective
- Enrich and validate “Theory of Systems Engineers”
- Analyze commercial SE workforce in the US