SYSTEMS ENGINEERING
Research Center

HELIX

Summary of Findings from the Helix Project (2013-14)

- An Investigation of the DNA of the Systems Engineering Workforce-

Presenter

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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)
- 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 conducted at DoD and DIB organizations
- Reporting is done in an aggregated anonymous manner that does not reveal the identities of participating individuals or organizations

Data Collection and Analysis

- 10 DoD and DIB organizations have participated in Helix interviews + a number of independent consultants
- **165** participants interviewed
- Over **2000** pages of raw data
- Research based on a modified Grounded Theory approach; Qualitative and Quantitative analysis techniques used
- Initial version of model explaining the development of effective systems engineers; towards developing theory of systems engineers.
- Early findings reported in December 2013 and April 2014; Next report to be published in November 2014

Helix Findings

Initial Findings [December 2013]

1. The most important characteristics and technical 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

Additional Analysis [April 2014]

1. Career Path Analysis
2. Mentoring

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

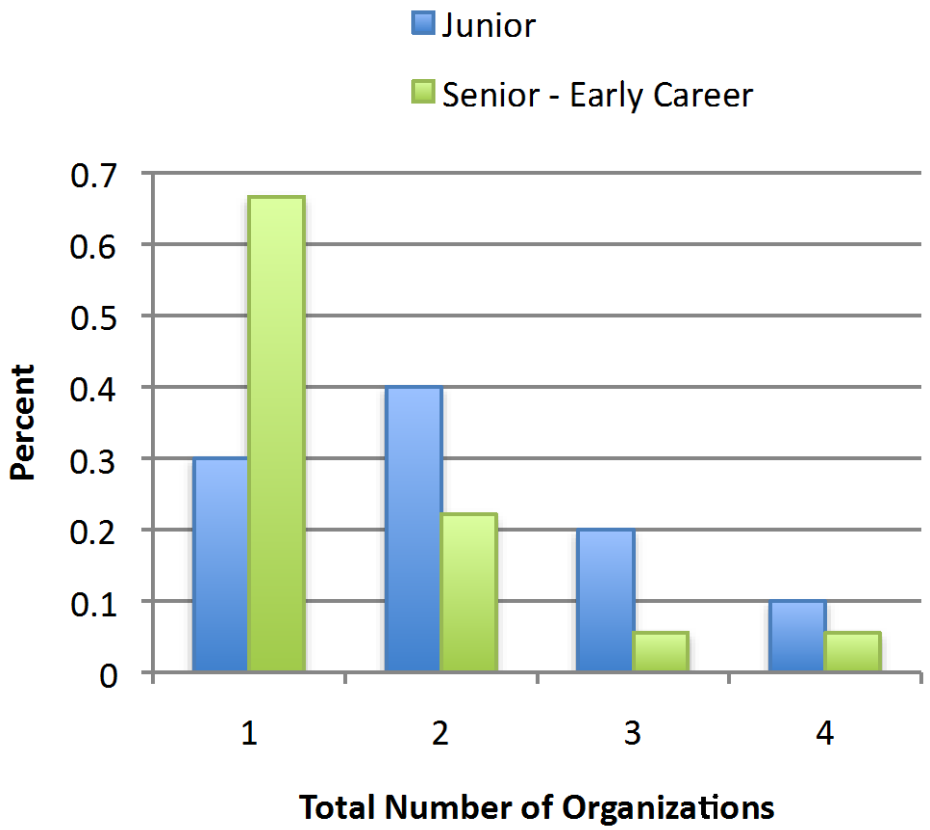
5. Self Starter

- 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

Early Career – Organizational Variety

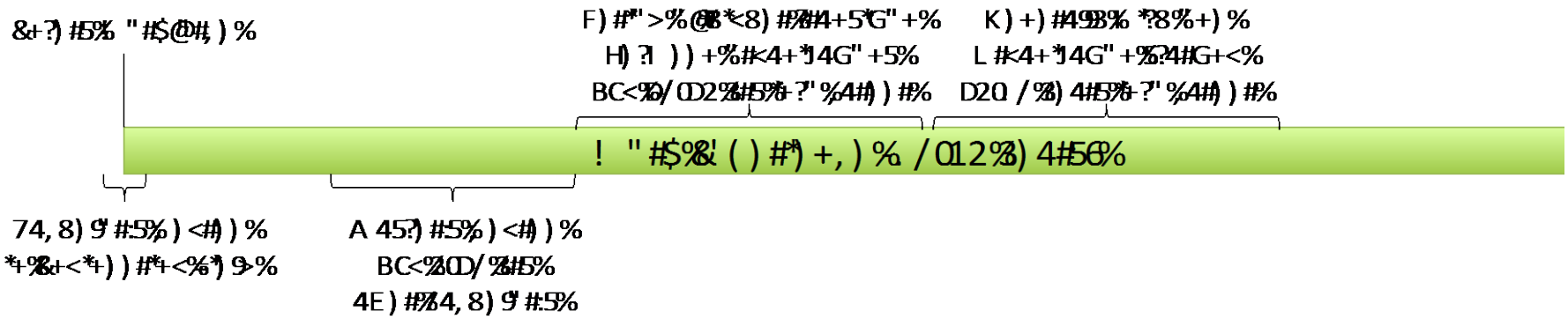


Today, more mobility is observed in the early career of systems engineers due to:

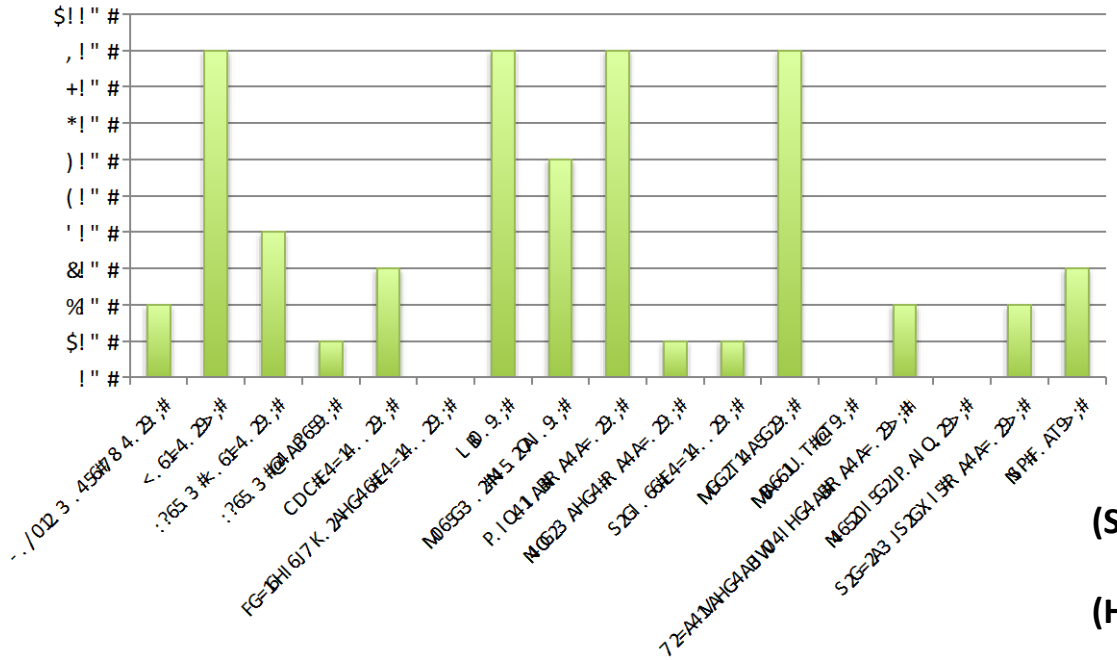
- Positional Impatience
- Positional Stagnation
- Work-Life Balance

Chief Systems Engineers

Typical CAREER PATH of Chief Systems Engineers



Typical ROLES of Chief Systems Engineers



(S): Sheard's 12 Systems Engineering Roles
(H): Helix

Mentoring

- Types of mentoring arrangements
- Formal vs. Informal mentoring
- Benefits of mentoring to: mentees, mentors, and organization
- Importance of mentoring for systems engineers
- Critical factors for success with mentoring

Importance of Mentoring for Systems Engineers

- **Systems Engineers Can be a Rare Commodity**: In some organizations, there are not enough systems engineers to perform the required SE activities.
- **Identifying and Recruiting SE talent**: In many organizations recruitment directly into the SE division or into a systems engineer's role does not happen.
- **Support for New Systems Engineers**: "It isn't rare and it isn't uncommon to end up doing SE if you were not a systems engineer before". Mentoring plays a key role in equipping non-systems engineers to be effective systems engineers.
- **Changing Face of Systems Engineers**: Systems engineers used to be "greybeards" who "floated up to the top and had all the experience". But today, depending on organizational policies and practices, engineers may become systems engineers without a lot of experience.
- **Nature of Systems Engineering**: Due to the nature of systems engineering, and particularly how it is performed in the organization, there is much to be learned hands-on that cannot be learned before entering the organization.

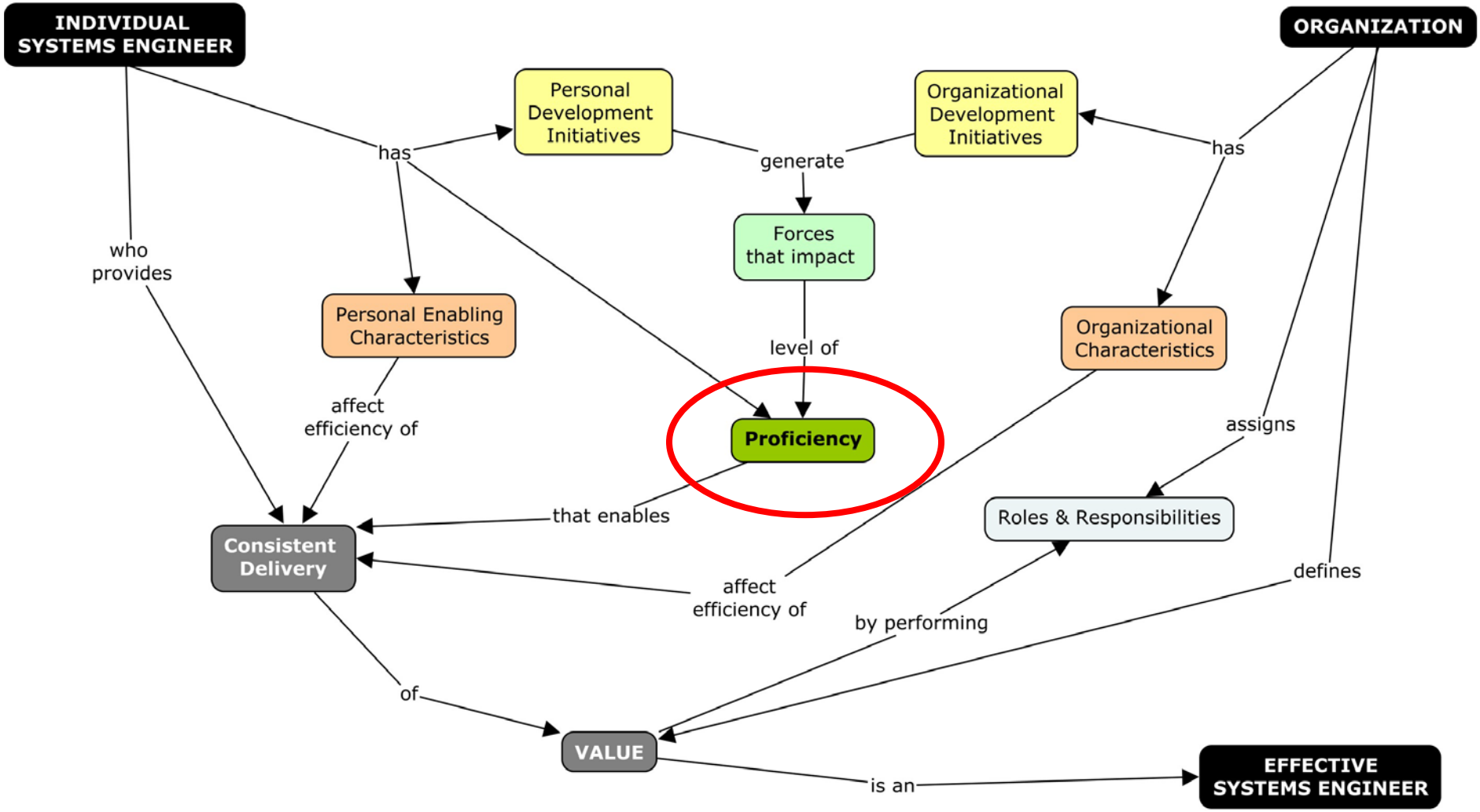
What is "Effectiveness"?

- Helix 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?

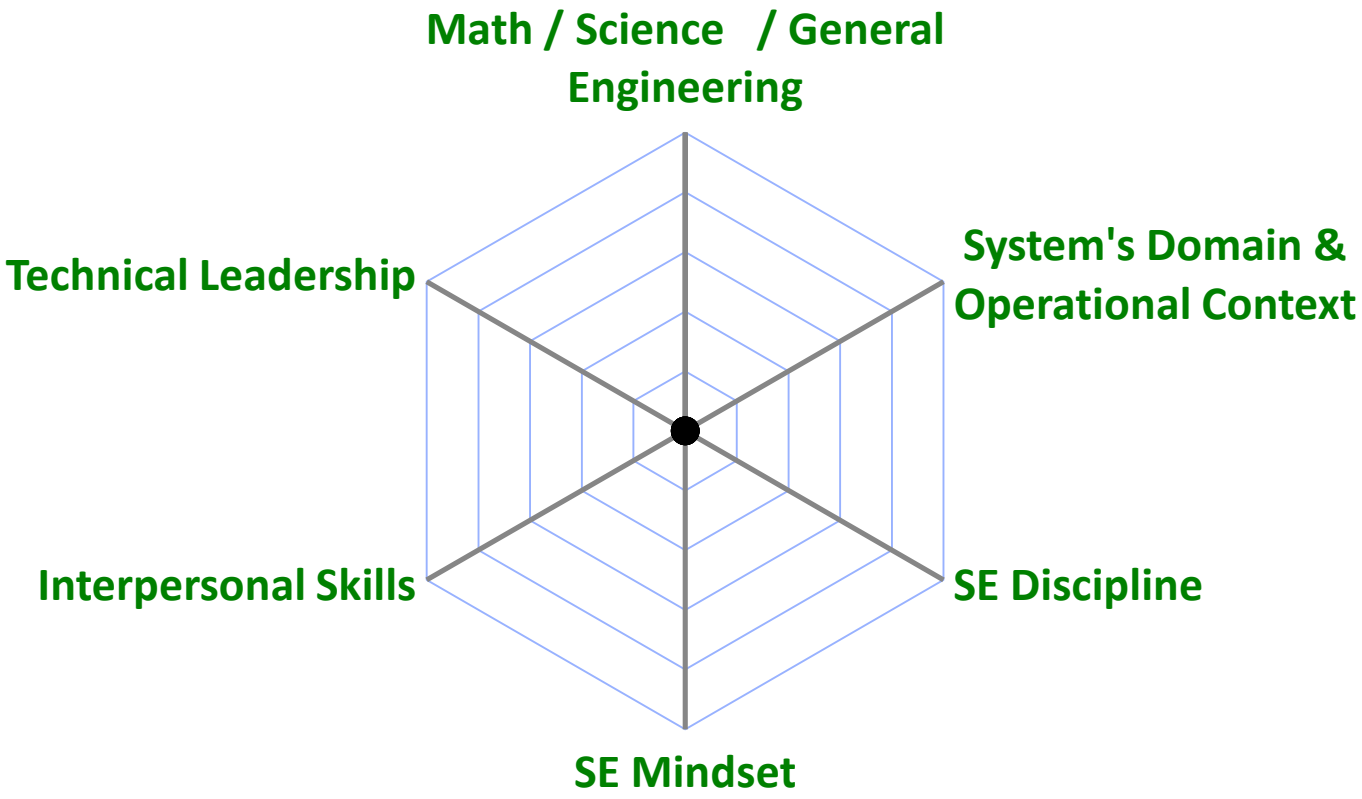
- Less insightful response: *Effectiveness is delivering within cost and schedule with intended quality*

- Helix working definition:
  - A **systems engineer** is "effective" when he or she consistently delivers the most important value to his or her organization.
  - The **systems engineering workforce** is "effective" when they collectively consistently deliver the most important value to their organization.

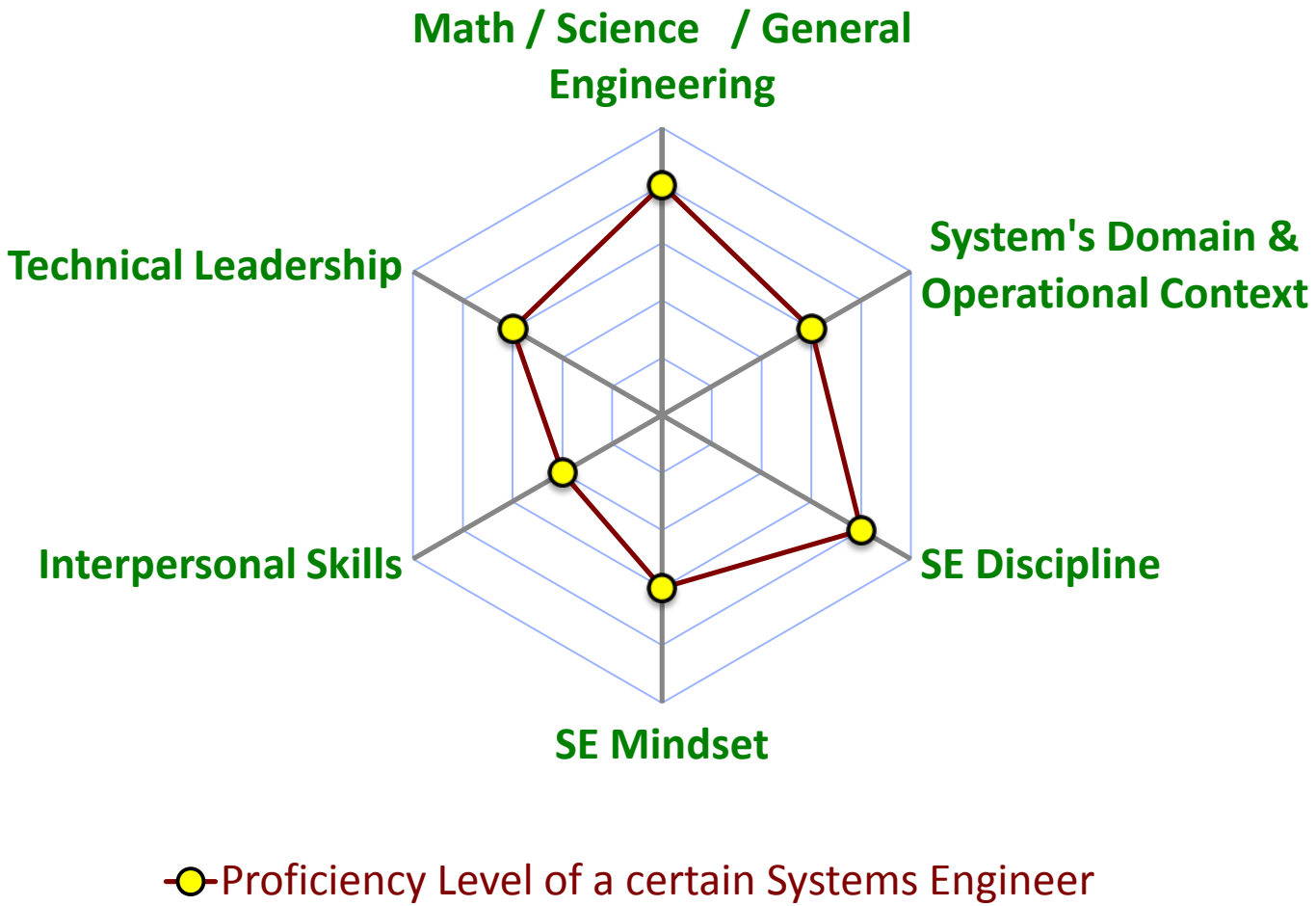
Effective Systems Engineers



Proficiency of a Systems Engineer



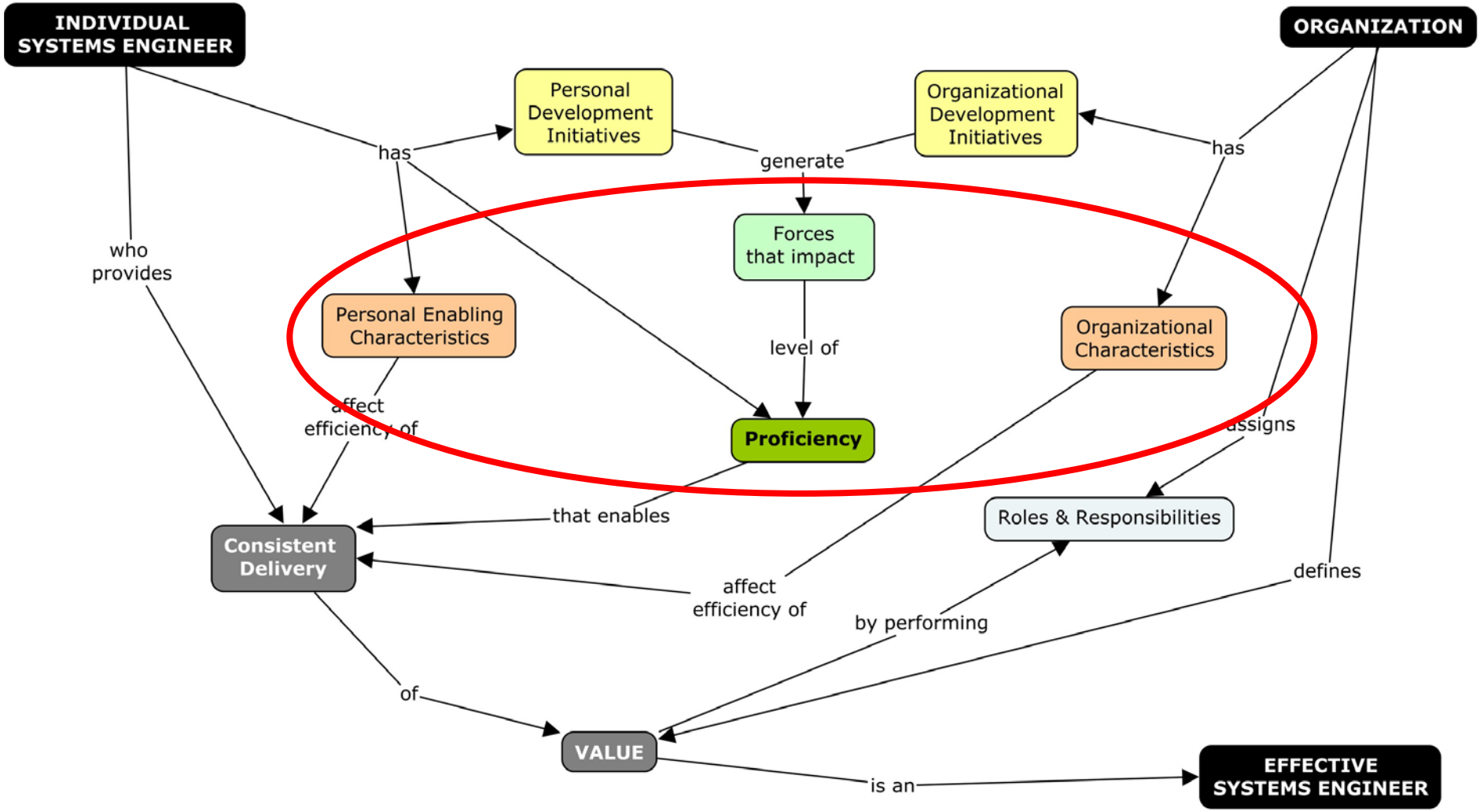
Proficiency of a Systems Engineer



Proficiency Areas

1. **Math/Science/General Engineering:** Foundational concepts from mathematics, physical sciences, and general engineering
2. **System's Domain & Operational Context:** Relevant domains, disciplines, and technologies for a given system and its operation
3. **Systems Engineering Discipline:** Foundation of systems science and systems engineering knowledge
4. **Systems Engineering Mindset:** Skills, behaviors, and cognition associated with being a systems engineer
5. **Interpersonal Skills:** Skills and behaviors associated with the ability to work effectively in a team environment and to coordinate across the problem domain and solution domain
6. **Technical Leadership**: Skills and behaviors associated with the ability to guide a diverse team of experts toward a specific technical goal

Effective Systems Engineers



Forces and Characteristics

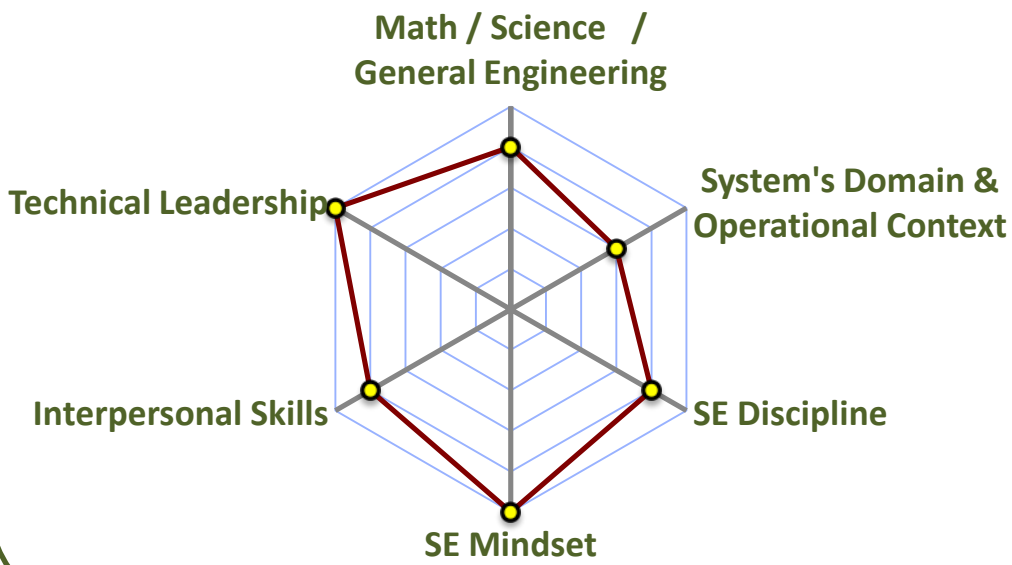
Forces that impact level of Proficiency

(generated by Personal and Organizational Development Initiatives)

Experience | **Mentoring** | **Education & Training**

Personal Enabling Characteristics
Learning Ability
Ethics & Morality
Professionalism
Curiosity
Motivation
Self awareness
Diligence

Proficiency of a Systems Engineer



Organizational Characteristics
Culture
Structure
Values
Appreciation of SE
Org. Dffinition of SE & Systems Engineer
Rewards & Recognitions
Career Growth Potential

Plans for rest of 2014 and 2015

- Continue to evolve and validate model for developing effective systems engineers
- Explore how the characteristics and roles of systems engineers vary in several different domains and different lifecycles *(Expand beyond DoD and DIB organizations)*
- Compare characteristics and value of systems engineers, to project/program managers and specialty engineers including electrical, software, and mechanical engineers *(Expand beyond Systems Engineers)*
- Analyze INCOSE certification applications

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The Helix Project

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