Challenges and Opportunities for the New Generation of Systems Engineering Leaders

Muhammad F Islam, Ph.D., CSEP[(1)]
mislam@mitre.org

Subash Kafle, Ph.D. [(1)]
skafle@mitre.org

Al Wong, D.Sc. [(1)]
alwong@mitre.org

Gina Guillaume-Joseph, Ph.D. [(1)]
gingj@mitre.org

DeAnthony Heart, M.S. [(1)]
dheart@mitre.org

(1) *The authors' affiliation with The MITRE Corporation is provided for identification purposes only, and is not intended to convey or imply MITRE's concurrence with, or support for, the positions, opinions or viewpoints expressed by the authors.*

Introduction

- Advancement in Technologies and Innovations – Need for components of the society to change, adapt and evolve

- Socio-technical relationships and interactions are challenging to comprehend

- Need for leaders with systems thinking abilities

Image Credit: Cordless Consultants http://www.cordlessconsultants.com/images/pages/technologychange.jpg

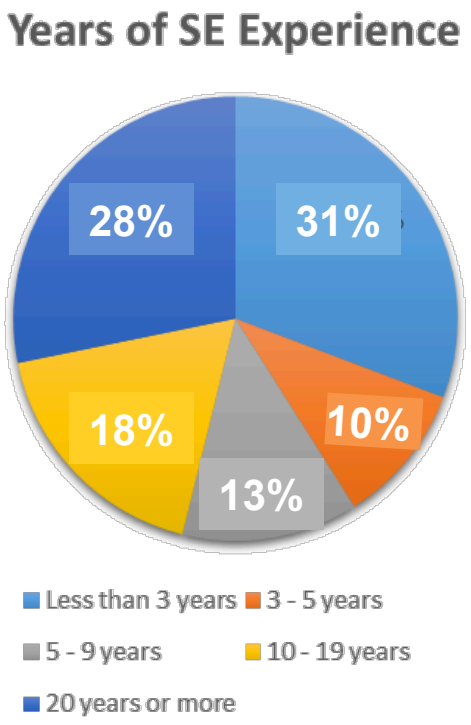
Icon Finder https://cdn2.iconfinder.com/data/icons/business-set-2/512/Icon_15-512.png

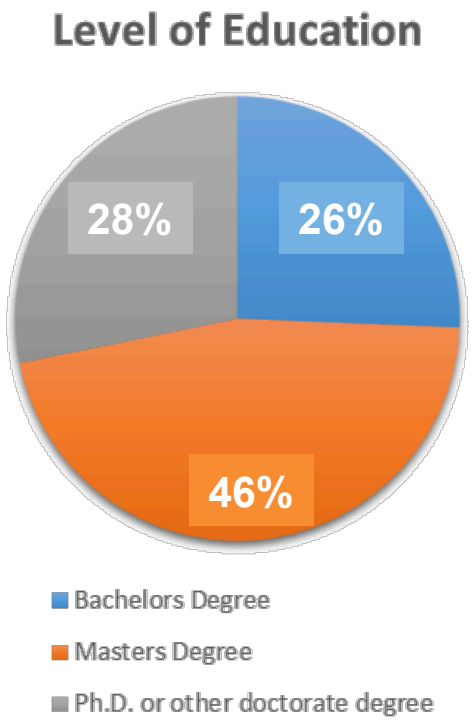
Challenge and Opportunity

Image Credit: University of Lincoln http://research.blogs.lincoln.ac.uk/files/2011/04/Puzzle-Solution-by-Idea-go.jpg

Challenge and Opportunity

- To understand the challenges and opportunities for a new generation of SE leaders, we identified a focus group of 39 SE practitioners
  - Experience ranged from fewer than three years to more than 20 years as systems engineers





Challenge and Opportunity

Years of experience in SE	SE Career Challenges	SE Career Opportunities
Fewer than 3 years	• Other engineering education streams at universities lack SE perspective and vice versa • SE major is offered by smaller number of universities for both undergraduate and graduate degree programs • Some industries still exist where SE is not applied • Not enough formal SE education or training available	• Ability to take more leadership roles • Uniquely positioned to mentor others • Systems engineers can bring a holistic systems perspective and act as “facilitators” between technical and business streams • Due to the unique qualities systems engineers bring, they are always in demand

Challenge and Opportunity

Years of experience in SE	SE Career Challenges	SE Career Opportunities
3 to 9 years	• Proving the value of SE certification • SE perceived as a project management practice • SE not widely recognized as a unique engineering discipline • Limitation of continuing education, skills, and techniques that mature systems engineers over time • Lack of leadership opportunity for technical systems engineers • Lack of clear and common understanding of the SE field • Senior leaders and project managers are unable to understand and manage technical SE (need for technical SE leader in a team)	• An increasing demand for systems engineers to oversee and perform integration across initiatives • Uniquely positioned to build network and professional connections that are helpful for a successful career • Demand for SE leaders in oversight and management of large systems development effort roles • Systems engineering helps one to become a critical thinker

Challenge and Opportunity

Years of experience in SE	SE Career Challenges	SE Career Opportunities
10 to 19 years	• Women engineers are less represented in the overall science and engineering fields, including SE which is less diverse • Lack of awareness and motivation to get certified in SE • Most challenges are not technical, but are related to people, process, and culture • Maintaining consistency in SE practice	• Ability to see SE spanning other fields such as security engineering (holistic view) • Opportunity for growth when systems engineers lead facilitation between engineering and management aspects of a project • Systems thinking approach helps projects avoid failure • Systems engineers can be technical leaders and domain specialists • Empowering future systems engineers through SE education has huge opportunity

Challenge and Opportunity

Years of experience in SE	SE Career Challenges	SE Career Opportunities
More than 20 years	• The field of SE is still evolving • Challenge for SE professional to make customer appreciate SE benefits • Helping clients understand value of SE and SE certification • Challenges in getting others to use SE standards and processes • Understanding the value of continuous training and certifications • Difficulty in differentiating SE from project management	• Opportunity to lead • Opportunity to work on a great variety of projects and initiatives (technical and non-technical) • Systems engineers work more effectively with others • Opportunity to interface with program managers • Help decision makers identify risks and mitigate risks

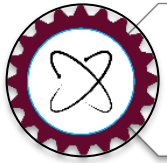
Challenge and Opportunity

- Based on the responses from the participants, the challenges and opportunities can be clustered into four major areas

SE Academic Environment

SE Certification

SE Technical Leadership



STEM and SE

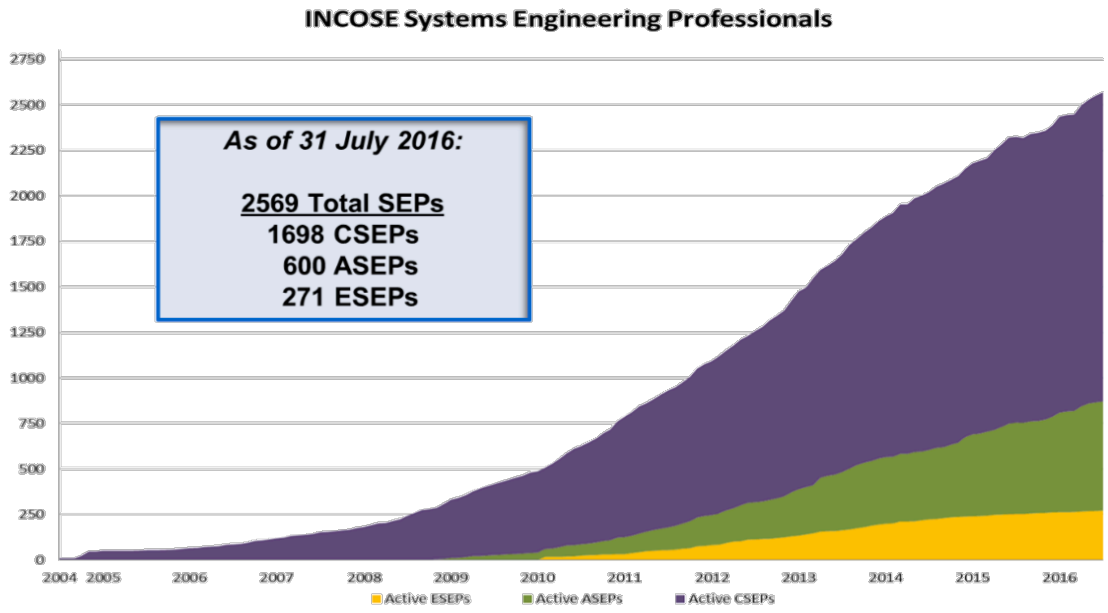
SE Academic Environment

World Region	Number of Universities Offering Systems Engineering and Closely Related Programs
North America	160
Europe	51
Asia	49
South and Central America	24
Africa	6
Australia	2

- SE requires both basic levels of knowledge, achieved through education, and advanced levels of knowledge, obtained through experience (Hutchison et al., 2016).
- Complementing SE programs with internships can provide future SE practitioners the exposure necessary to apply SE methodologies and the practical experience to address complex challenges (Tetenbaum, 1989).
- SE programs must be interdisciplinary to support the engineering of today's complex systems and must provide both classroom-based education and practical experience (Kossiakoff & Sweet, 2011).

SE Certification

- Defense Acquisition University (DAU)
  - Levels I, II and III
- INCOSE
  - ASEP, CSEP and ESEP



- INCOSE needs to create effective learning paths for SE that are interdisciplinary in nature and address today's complex systems
  - More research is needed to measure the return on investment on certifications

Image Credit: INCOSE SEP Statistics http://www.incose.org/docs/default-source/certification/incose-sep-statistics.pptx?sfvrsn=4

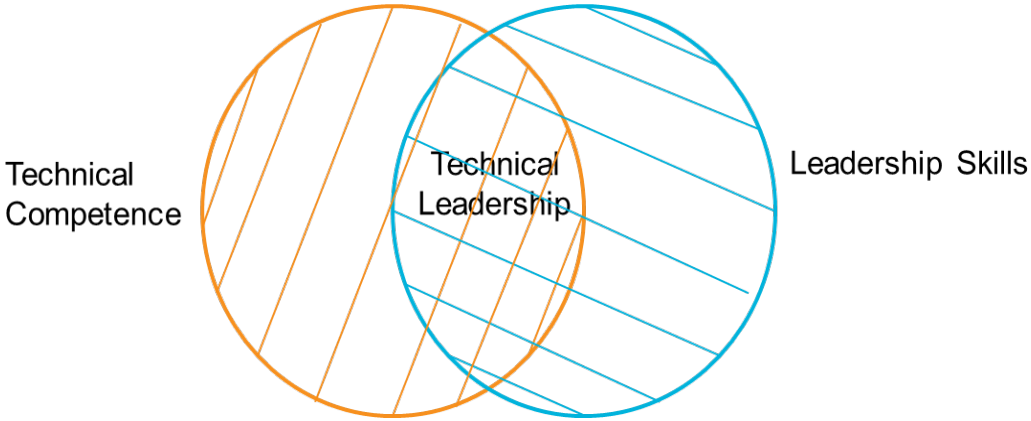
SE Technical Leadership

- In 2009, the DAU funded SERC to provide insights into creating a future generation of leaders in SE. The intent of the technical leadership program was to provide leadership insights into SE activities.
- INCOSE formed a Technical Leadership Institute based on the SERC case-based learning model for technical leaders.

Image Credit: DAU www.dau.mil

SERC http://www.sercuarc.org

SE Technical Leadership



- Technical leadership is a combination of skills and behaviors that guides a diverse team of experts toward a specific technical goal (Hutchison et al., 2016).
  - Requires ability to hold a vision and to develop enterprise technology strategies in support of the organizational and business visions and objectives (Gavito et al., 2012, Godfrey, 2016).

SE Technical Leadership

- Growing dependency on technology and science
  - Leaders require strong insight into engineering to tackle problems from all areas of people, process, technology, and governance.
- Increasingly, technology is playing a greater role in process automation by reducing or replacing the need for humans in certain activities.
  - Manufacturing quality assurance
- A technical leader will rely on the skills and expertise of team members
  - Non-verbal communication, emotional intelligence and story telling

SE and STEM

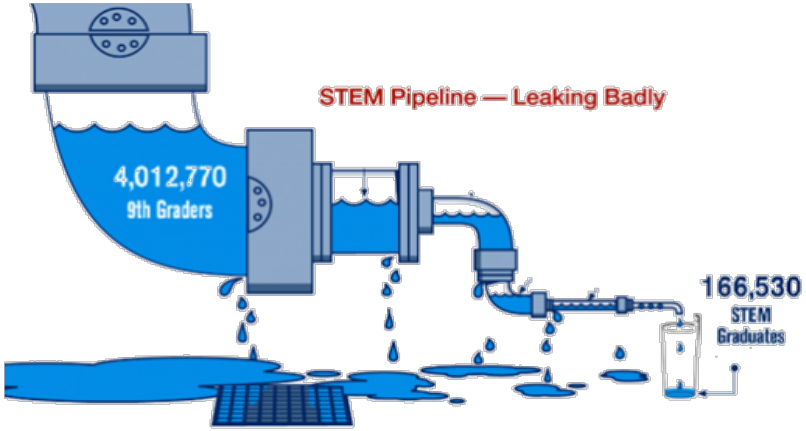


Image Source: Digest of Education Statistics, 2008

- Advancing the field of STEM is critical to the future of the SE profession
  - Foundational to the complex challenges of today's changing world
- INCOSE is uniquely positioned and outfitted with industry experts across the STEM spectrum to support these leaders

SE and STEM

- Help foster the youth's passion for STEM and thirst for knowledge
- Encourage governmental and industrial support for research and educational programs to improve SE process and practice
- STEM abandonment is more common among students with weaker math and science backgrounds
- With a projected growth of over 9 million STEM jobs over the next six years, the need for qualified candidates increases daily

Overcoming Challenges for the New Generation of Leaders

- Strategies for innovation, growth, adoption, or change
- Human capital professional development
- Technical leadership skills
- Increase number of women professionals in STEM
- A more cooperative ethos

Next Steps

- Expand SE challenges and opportunities focus group to consider SE practitioners and leaders from a diverse range of generations, industries, educational backgrounds, and geographical regions
  - Additional research and empirical data on SE practices, practitioners, and leaders
- Industry and professional organizations working in SE and SE leaders have greater responsibilities
  - Amplify the opportunities and bring awareness to the challenges
- The goal of SE is to make the world a better place
  - Understand what systems engineers can do to make positive impacts every day is crucial to achieving the goal

References

- ABET (2017). Accreditation Board for Engineering and Technology. Retrieved from: http://www.abet.org/
- Blanchard, B. S., & Fabrycky, W. J. (2011). Systems Engineering and Analysis (5th ed.). Boston: Prentice Hall.
- Brown, R. (2013). Managing the “S” curves of innovation. Journal of Consumer Marketing.
- Bowman, J. S., West, J., P., Berman, E. M., Wart, M. V. (2016). The Professional Edge; Competencies in Public Service. New York: Routledge Taylor and Francis Group.
- Chen, C. (2013). STEM Attrition: College Students’ Paths Into and Out of STEM Fields: Statistical Analysis Report.
- Defense Acquisition University (2017), The Defense Acquisition University Systems Engineering Certification Guide Level I. Retrieved from: https://dap.dau.mil/career/sys/Pages/Certification.aspx
- Synder, Thomas (2009). U.S Department of Education: Digest of Education Statistics 2008 (NCES). Retrieved from https://nces.ed.gov/pubs2009/2009020.pdf
- Government Accountability Office (2016). Strategies to Address Representation of Women Include Federal Disclosure Requirements.
- Gavito, V., et al. (2012). Systems Engineering Technical Leadership Development Program (No. SERC-2012-TR-013-3). Hoboken, NJ: Systems Engineering Research Center.

References

- Godfrey, P. (2016). Building a Technical Leadership Model. 26th Annual INCOSE International Symposium.
- INCOSE. (2016). 2016 Worldwide Directory of Systems Engineering and Industrial Engineering Academic Programs. Retrieved from: http://www.incose.org/docs/default-source/aboutse/se-academic-program-directory0231BA07E0A3.pdf?sfvrsn=18
- INCOSE Handbook (2015). INCOSE Systems Engineering Handbook - A Guide for System Life Cycle Processes and Activities, version 4.
- Hutchison, N., Henry, D., Verma, D., Clifford, & M., Pyster, A. (2016). Atlas: The Theory of Effective Systems Engineers, version 1.0. Hoboken, NJ: Systems Engineering Research Center.
- Kossiakoff, A., & Sweet, W. N. (2011). Systems Engineering Principles and Practice. Hoboken, NJ: John Wiley and Sons Inc.
- Mella, P. (2012). Systems Thinking: Intelligence in Action. Heidelberg: Springer.
- Minister of State for Universities, Science and Cities by Command of Her Majesty. Department for Business Innovation & Skill (2014). UK Government: Our Plan for Growth: Science and Innovation. Retrieved from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/387780/PU1719_HMT_Science_.pdf
- NSB (2016). National Science Board, Science & Engineering Indicators Digest 2016

References

- Özgen, S., Sánchez-Galofré, O., Alabart, J. R., Medir, M., & Giralt, F. (2013). Assessment of engineering students' leadership competencies. Leadership and Management in Engineering, 13(2), 65-75.
- Pollack, E. (2016). The Only Woman in the Room: Why Science Is Still a Boys' Club, 252.
- Rottmann, C., Sacks, R., & Reeve, D. (2015). Engineering leadership: Grounding leadership theory in engineers' professional identities. Leadership, 11(3), 351-373.
- Reid, K. (2014). Our Nation Needs to Fix the Breach in the STEM Pipeline. Retrieved from: http://www.nsbe.org/News-Media/Blogs/Karl-Reid/August-2014/Our-Nation-Needs-to-Fix-the-Breach-in-the-STEM-Pip.aspx#.WCDHLS0rKUk
- Soderholm, D. H., & Huttner, E. (2013). The Gordon-MIT Engineering Leadership Program: Relationship to CDIO Syllabus v2. In: Proceedings of the 9th International CDIO Conference.
- Tetenbaum, S. (1989). Curriculum for a Bachelor of Science degree with a major in information systems engineering. IEEE Transactions on Education, 32(1), 56-58.
- The STEM Connector (2012). Annual Report: Where are the STEM Students. Executive Summary, 12.
- Vilorio, Dennis (2014). The U.S. Bureau of Labor Statistics. Career Outlook: STEM 101: Intro to Tomorrow's Jobs, 3.
- Wright, Courtney (2015). INCOSE Certification Program Knowledge Exam Update 2015. 25th Annual INCOSE International Symposium (IS 2015), 2015.