INCOSE Healthcare Working Group

5th Annual Systems Engineering in Healthcare Conference

May 1-2, 2019
Minneapolis, MN

Roundtable Session: Developing Systems Engineering and Systems Thinking Skills

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Developing Systems Engineering and Systems Thinking Skills
Chris Unger - Moderator's Introduction

- Effective SE individuals and teams combine **domain and technology** knowledge, SE **process** expertise, **leadership** skills, and **critical thinking** skills…multidimensional challenge
- SE **process** skills are relatively easy to train and develop.
- **Influencing and leadership** skills are harder to develop, but are critical to success and there are standard tools available.
- **Organizational** development and maturity takes even longer

Developing Systems Engineering and Systems Thinking Skills

Juan Fernandez de Castro

- **Problem:** How to build an systems engineering team with the right knowledge and skills to meet your organization's needs.

- **Obstacles (many):**
  - **Organizational:**
    - Different understanding of SE role within the organizational hierarchy
    - Depends on organizational maturity
  - **Focused vs General Roles:**
    - Systems group may include specific roles (and employees may have specific interests and goals)
  - **Hiring into the Systems Group:**
    - SE has less cross-industry standardization than other disciplines
    - Expected for SE team members (at least Sr) to have product/technology knowledge – normally is acquired either in the company or from competitor
    - Company employees from other disciplines hesitant to switch to SE team

Developing Systems Engineering and Systems Thinking Skills

Juan Fernandez de Castro

So, how to develop a Systems Engineering Team with Systems Thinking?

I don't have a complete answer to this question, but I can share ideas that can help.

Developing Systems Engineering and Systems Thinking Skills

Juan Fernandez de Castro

- **Proposed Solutions - Organizational Level Problem:**
  - **Standardize SE Role Industry and Organizations**
    - This is something that can be pursued in the INCOSE Healthcare (Medical Device) Working Group – Create a template for a Medical Device SE Job Description that can be adopted by industry HR departments and will create standardization in the industry
    - At the level of our organizations, work within our sphere of influence to push a unified vision and understanding of the SE role. Start by establishing and standardizing SE Job Descriptions in the organization.

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Proposed Solutions - Problem of Hiring in to the Systems Group

- **Scout internal talent and when assessing outside talent look for agility**
  - Creating an industry-wide SE job description (the previously mentioned standardization) will help
  - For outside hires, may have better success hiring at a lower level (3 – 5 year experience career band) and growing the associate in the role over time
  - If hiring from the outside at a more senior level, if there is an aptitude assessment available, look for high scores in agility and adaptability. Don't want someone stuck in how their previous employer did it, want somebody willing to learn how your organization does it.
  - During department talent assessments, pro-actively look at the entire organization to find individuals with an aptitude for systems engineering (leadership, understanding of the core technology, interest in the customer domain) – recruit them into the role.

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Proposed Solutions - Problem of Focused vs General Roles:

- **Accept responsibility for developing all members of the SE team, including those who don't fit the SE "generalist" role**
  - SE team will include a mix of competencies and talent; every team member does not need to be cross-trained in all the SE competencies.
  - SE Manager must assess this and provide development paths for all team members. Example: Team success may depend on a Test Scientist doing his or her job well; let's not focus on training that individual to be a Risk or Requirements Management practitioner, let's help that individual grow where he or she provides value.
  - Of course, the SE group requires a core with breadth that is capable of performing SE functions on any project (Requirements, Risk Management, Architecture, Human Factors, Reliability, etc.) The recommended path for training these roles is on-the-job training with mentoring from experienced team members or the manager.
  - Shorter duration post-commercialization design change or sustaining projects are good for training team members in less time and for developing leadership skills.

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Developing Systems Engineering and Systems Thinking Skills
Tom Fairlie

Developing good Systems Engineers is a subjective process that takes patience, but it can be very rewarding.

Think of and plan this process like a Systems Engineer: Understanding your goals and your current capabilities is vital, as is creating a practical plan of attack

However, the good news is that you can start small with a simple framework and get better as you go; the trick is to not try and boil the ocean at the onset

At Medtronic, I leveraged the work of researchers[1] and the INCOSE Competency Working Group to create an approach that allows us to assess individual and organizational capability

Over time, this assessment has been used for job assignments, training assignments, and strategic organizational planning

Furthermore, this process is shared with all employees to fully engage them in the process

(1) Accelerating the Development of Senior Systems Engineers, Heidi L. Davidz, Deborah J. Nightingale, Donna H. Rhodes. https://core.ac.uk/download/pdf/19879175.pdf

Developing Systems Engineering and Systems Thinking Skills

Tom Fairlie

Our original problems were common to most maturing organizations:

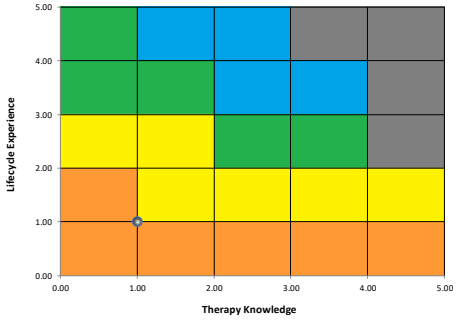
- How do we assess SE talent during the interview process?
- How do we assess SE talent in our organization?
- How do we develop SE capabilities?

Our approach was to develop a simple spreadsheet with relatively consistent, objective criteria (skills + domain knowledge)

Employees were included in the assessment development process, so that it would feel normal and applicable to their daily work

Once we collected this information, it was graphed and aggregated organizationally

Voice of the Customer	**1.00**
Design input source analysis	1
Intended use and use cases	1
Stakeholder requirements	1
System Design	**1.00**
System architecture & interfaces	1
System requirements and allocation	1
System analysis (risk, reliability, etc.)	1
Configuration & requirement management	1
Design Completion	**1.00**
Test strategies, approach, and environment	1
System characterization and integration	1
System verification	1
System validation	1



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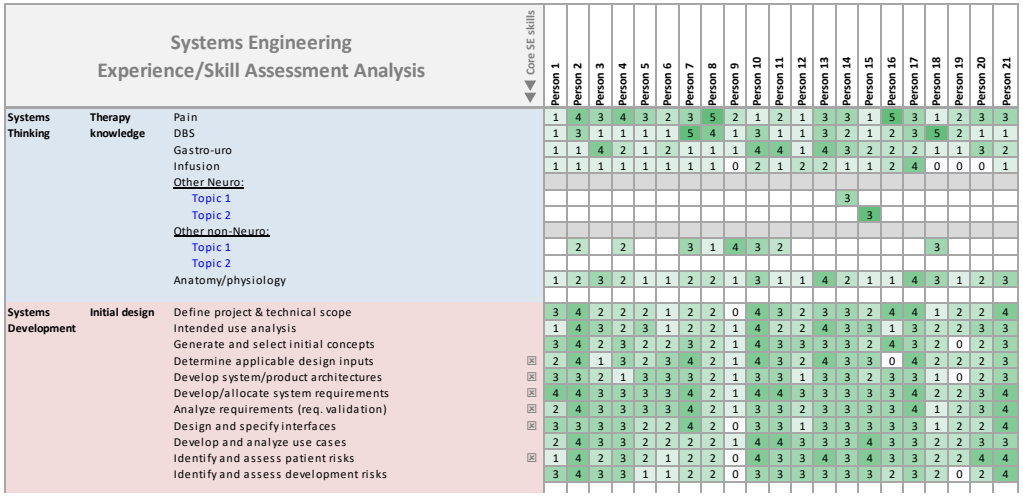
The individual assessments were used to identify learning opportunities (job assignments, training, etc.)

The organizational aggregation was used to produce “heatmaps” that showed strengths and weaknesses; this was used —in conjunction with product roadmaps—to update strategic hiring plans and identify training gaps

Overall, this process is data-driven, transparent, and relatively easy to mature

It was also used to justify promotions within the organization



Systems Engineering Experience/Skill Assessment Analysis			Core SE skills	Person 1	Person 2	Person 3	Person 4	Person 5	Person 6	Person 7	Person 8	Person 9	Person 10	Person 11	Person 12	Person 13	Person 14	Person 15	Person 16	Person 17	Person 18	Person 19	Person 20	Person 21
Systems Thinking	Therapy knowledge	Pain		1	4	3	4	3	2	3	5	2	1	2	1	3	3	1	5	3	1	2	3	3
		DBS		1	3	1	1	1	1	5	4	1	3	1	1	3	2	1	2	3	5	2	1	1
		Gastro-uro		1	1	4	2	1	2	1	1	1	4	4	1	4	3	2	2	2	1	1	3	2
		Infusion		1	1	1	1	1	1	1	1	0	2	1	2	2	1	1	2	4	0	0	0	1
		Other Neuro:																						
		Topic 1															3							
		Topic 2																3						
		Other non-Neuro:																						
		Topic 1			2		2			3	1	4	3	2							3			
		Topic 2																						
		Anatomy/physiology		1	2	3	2	1	1	2	2	1	3	1	1	4	2	1	1	4	3	1	2	3
Systems Development	Initial design	Define project & technical scope		3	4	2	2	2	1	2	2	0	4	3	2	3	3	2	4	4	1	2	2	4
		Intended use analysis		1	4	3	2	3	1	2	2	1	4	2	2	4	3	3	1	3	2	2	3	3
		Generate and select initial concepts		3	4	2	3	2	2	3	2	1	4	3	3	3	3	2	4	3	2	0	2	3
		Determine applicable design inputs	☒	2	4	1	3	2	3	4	2	1	4	3	2	4	3	3	0	4	2	2	2	3
		Develop system/product architectures	☒	3	3	2	1	3	3	3	2	1	3	3	1	3	3	2	3	3	1	0	2	3
		Develop/allocate system requirements	☒	4	4	3	3	3	3	4	2	1	4	4	3	3	3	3	3	4	2	2	3	4
		Analyze requirements (req. validation)	☒	2	4	3	3	3	3	4	2	1	3	3	2	3	3	3	3	4	1	2	3	4
		Design and specify interfaces	☒	3	3	3	3	2	2	4	2	0	3	3	1	3	3	3	3	3	1	2	2	4
		Develop and analyze use cases		2	4	3	3	2	2	2	2	1	4	4	3	3	3	4	3	3	2	2	3	3
		Identify and assess patient risks	☒	1	4	2	3	2	1	2	2	0	4	3	3	4	3	4	3	3	2	2	4	4
		Identify and assess development risks		3	4	3	3	1	1	2	2	0	3	3	3	3	3	3	2	3	2	0	2	4

Developing Systems Engineering and Systems Thinking Skills

Tom Fairlie

Lessons Learned

- The assessment process should be as simple as possible in order to reduce management overhead, misinterpretation, and misuse
- Do not use this as a performance assessment; this is intended to measure capability, not performance
- However, if you use it to support promotions (i.e., demonstrating a certain level of capability), you should spend time validating your assumptions (e.g., see if existing employees plot on a graph to their current levels)

Pros

- Employees feel engaged
- Assessments are transparent
- Relatively simple to implement

Cons

- It may be tricky to identify the correct skills
- You should identify organizational goals in order to make individual/org changes more efficient

Summary: SE development can be effectively managed with a relatively simple tool and process and improved over time as you the organization matures

Developing Systems Engineering and Systems Thinking Skills

Paul Kostek

- An outsiders perspective
- Frequently work with companies where SE is weak, undefined or non-existent
- Initial focus is getting project back on track
  - Requirements
  - Tool implementation
- Secondary focus is improving the SE organization
  - SE process definition

Developing Systems Engineering and Systems Thinking Skills
Paul Kostek

- I always ask three questions when starting/joining a project:
  1. What are we doing?
  2. Why are we doing it?
  3. How do we know when we are done?
- These questions force team members to focus not just on their assignment, but how it fits into the overall system.
- An organizational approach to developing SE processes and standards is essential for implementation of SE. Providing access to training and adopting tools with a clear expectation of results is an essential to project success.

Developing Systems Engineering and Systems Thinking Skills

Paul Kostek

- How to build an infrastructure that will:
  - Provide the SE team with resources (training and tools) to define project architecture and requirements
  - Defines a process for SE on a project

- Prepare the case for SE
  - Trade study on impact of SE on projects
  - Draft SE process for organization
  - Upfront cost and time vs rework because of poor definition or requirements
  - The SE is the technical focal for the project
  - Drives decisions and direction, keeps focus on customer and end-goals
  - Develops System Architecture
  - Creates System/Subsystem requirements

Developing Systems Engineering and Systems Thinking Skills

Paul Kostek

- Building an SE organization requires a commitment to develop the processes, tools and team member skills to integrate into business operations.
- It can sometimes require overcoming an internal belief that SE does not add value to the product development process.
- Yet, without an SE looking at the “big picture” and understanding what a customer needs/expects from a product, it is easy to produce a system that fails to meet customer expectations.
- It’s all about the requirements – failure to define a system architecture and the requirements before turning the design teams lose leads to rework and missed schedules.

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Systems Design Decisions for Medical Devices: What Makes them Difficult? Presentation Recap

Managing SE skills development is achievable…it does take work

Simple tools can be effective

Systems teams have to balance deep technical experts with broad generalists

To build a sustained SE organization you need an accepted business case/value proposition

Your Questions? *We have some for you!*

- What are the different challenges for small organizations/companies vs. large ones?
- What is the right mix of deep technical expertise vs. broad generalists?
- What is the right balance between systems engineering (process) rigor and systems thinking?

Questions?

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Thank you for attending!

Share your experiences at #HWGSEC

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