The Business Case for Systems Engineering
featuring Joe Elm interviewed by Suzanne Miller

Suzanne Miller: Welcome to the SEI podcast series, a production of the Carnegie Mellon Software Engineering Institute. The SEI is a federally funded research and development center at Carnegie Mellon University in Pittsburgh, Pennsylvania. A transcript of today's podcast is posted on the SEI website at sei.cmu.edu/podcasts. My name is Suzanne Miller, and today I am very pleased to introduce you to Joe Elm, a senior researcher at the SEI with whom I have collaborated on several projects going back to even before he was an SEI employee.

Joe Elm: That's true.

Suzanne: Joe's research--current research--focuses on understanding and maximizing the value of systems engineering when applied to projects, although he's done lots of other really interesting things. He joined CERT in 2010 and led strategic projects to enhance its abilities to address client needs. Prior to joining CERT, he led the SEI's Acquisition Support Program in its effort to improve software acquisition practices throughout the Department of Defense (DoD) and other U.S. government agencies, bringing a very extensive background in systems engineering, product development, program management, and corporate management, to the aid of government acquisition programs. Today, we're going to talk about Joe's latest research on systems engineering. Joe, thank you for joining us today.

Joe: Oh, you're quite welcome.

Suzanne: So, first off, you and I have both been involved in systems engineering work at the SEI for many, many years. I pre-date you a little bit, because I started in '93 with Roger Bate on the systems engineering CMM, even before we had CMMIs. Even then, we were answering the question, "Why is the SEI researching systems engineering? Isn't 'software' carved in stone on the building?" Well, actually it's carved in concrete. What is it about systems engineering that makes it important for the Software Engineering Institute to be involved in research?

Joe: Well, as you know, it's difficult to make a clean division between systems and software. Today's systems are so heavily reliant on software. They get the majority of their capabilities from software. So, just trying to focus your activities on software engineering without addressing the context of systems engineering just doesn't make sense and really isn't very effective. So, I think as you said, the SEI recognized that long, long ago. Though they started with things like software capability maturity models, it didn't take long to evolve that into systems engineering capability maturity models and finally the CMMI, which I don't think anybody could deny is system-focused.

Suzanne: Sure. One of the things that we used to say in the days that I was defending this is, "Software is the brains of your system, and do you really want to understand only the brain without understanding the kinetic aspect," as we talk about here, "the body and vice versa." If you only understand the body without the brain, then are you going to get what you need?

Joe: Correct.

Suzanne: Joe and I are in violent agreement on this point, so there's no issue with that. You got involved in this research a little while ago, but you came at it from a really different point. You've got a lot of involvement with INCOSE, the International Council on Systems Engineering, and some other activities. So, tell us a little bit about, sort of, how you got the SEI back into the fray with the systems engineering research you're doing?

Joe: Well, this all started back in 2004. I was representing the SEI at the National Defense Industrial Association (NDIA). At an earlier meeting, the director of systems engineering of the Office of [the] Secretary of Defense had posed a problem that he was facing. He was a strong proponent of systems engineering, but he was finding that within the DoD, many of the program managers didn't share his understanding and value of systems engineering. So, consequently, some of the projects that were being executed weren't receiving appropriate attention, weren't providing appropriate attention to systems engineering. So, he came to NDIA and said, "Give me some evidence that I can use to convince these project managers that systems engineering is a good thing for their programs."

Well, in response to that, the NDIA formed the Systems Engineering Effectiveness Committee, and they set off on a couple tasks. The first thing that they did is they looked at the research and the literature to see who had looked at the value of systems engineering. They found very little; it's a rather sparse field. There are case studies. There is discussion about what worked on a particular project, but nobody had really taken any sort of quantitative approach to addressing the value of systems engineering.

Suzanne: In this time frame, there wasn't really that much education even in systems engineering. At that point, I don't think there were any undergraduate degrees in systems

engineering, and there were few graduate degrees. That's where a lot of the research, academic research community comes from, but you didn't have that as a base to work with, right?

Joe: Right. Things were just getting started in the academic community back in those days. So, the committee looked at the literature and research, didn't find much, so then they said, "Well, we'll just go out and ask defense contractors, 'How do you determine the value of systems engineering?'" They were kind of surprised when they couldn't get an answer, because as it turns out, many of the defense contractors did not separately plan and budget their systems engineering activities. All of the systems engineering work was embedded in other tasks. It wasn't planned separately. It wasn't budgeted separately. It wasn't tracked separately. They really didn't have answers as to how much systems engineering they were providing and what its value was.

There was another problem that they had to address and that's the fact that there was not a consistent and widely accepted definition of what systems engineering was. Each company had its own definition, and they weren't all the same. In some companies, some aspects of project planning would be done by project management; in other companies, they'd be done by systems engineering. Some companies had test departments and test engineers that did test engineering; others considered verification of test as part of systems engineering. So, even if you could collect data on what a company was doing in what was called "systems engineering," it would be very difficult to compare that across companies since they were all working off of different definitions.

NDIA looked at this for a year, maybe a year and a half, and really couldn't come up with an answer to the question that the director of systems engineering had asked. It was about that time that I joined the Systems Engineering Effectiveness Committee. I proposed that we could perhaps take a different approach. Maybe what we could do was survey a number of defense projects. Through a survey [we could] assess what they were doing in systems engineering, then assess how the projects were performing, and then look for statistical correlations between those assessments. The committee accepted my proposal, and we got started on it. We made a lot of progress. As a matter of fact, we did an earlier study in 2007, which was a smaller version of the study...

Suzanne: Right, I read that study.

Joe: It essentially looked at about, I think there were 40-some projects at that point, and looked for the relationship between the performance of systems engineering and project performance. Now, as a result of that, that gained attention and interest, particularly within the Department of Defense. They asked us to see if we could expand that, and that was the impetus for this current study.

Suzanne: So, I've run studies trying to do this kind of survey work before. Getting, for those of you listening, oh 40 people, 40 projects responding, you know, "Gee, they must not have worked very hard." How difficult was it to get that many projects to give you that kind of information, because you were asking for information about effectiveness? People aren't always willing to tell you all the dirty laundry, but you need all that kind of information to make a judgment. How did you go about convincing people that this was a thing that they needed to support and help with?

Joe: Well, here we're talking about the 2007 study. At that point, we faced some significant obstacles. The most significant obstacle is that when we're asking for data to assess project performance, we're asking for data that many companies would consider confidential and proprietary.

Suzanne: Right.

Joe: And, they're just not going to respond to anybody who asks that question. So, we dealt with that in a couple ways. Number one, we conducted the survey as an online, web-based survey. We structured it so that it could be taken anonymously. So, when they logged onto the website, we captured no information regarding who the person was responding, what organization they were working with, or what project they were working with. So, that eased some of the concerns about exposing the information that they were, that we were asking for.

The second thing we did is we capitalized on the SEI's reputation as an anonymous broker. Through all of the CMMI appraisals and stuff like that, we developed a reputation for being able to collect and hold sensitive data in a confidential and secure manner. We structured this study so that only a few chosen members of the SEI had access to the data. The data came directly into the SEI. It was stored on secure servers, and then was processed really just by, there were three or four of us who had access to the data.

Finally, we made a commitment that said none of that data--the raw data--will ever be released. So, the only things that we've ever published are statistical summaries of the aggregated data, which again are untraceable to any person, organization, or project. So, those kinds of things allayed a lot of the concerns that they had.

Suzanne: So, from the 2007 report, you had about 40. In this latest report, you've got almost 150 responses. I'm guessing that that first report got everybody kind of feeling safe, because you were able to really triple the response rate. This report I see as being a very important watershed in the research on systems engineering, because this is, you know, even academic researchers would consider this a significant sample and would allow you to...

Joe: ...big enough sample to be statistically significant.

Suzanne: Exactly. So, I personally congratulate you on that achievement, because I know how hard it is to get through all that.

Joe: Well, and part of the difference arises from the fact that when we did this in 2007, there were many, many detractors; nobody thought it was going to work.

Suzanne: Right.

Joe: Okay? And, I had specific companies tell me, "We're not going to participate. It's a waste of time." Okay? Then we published our results in 2007 and those same companies said, "Wow, this is really good."

Suzanne: "I want to reference that report."

Joe: Yeah, and many of them did.

Suzanne: "It's a shame my data's not in there."

Joe: Well, more than that, in 2007, we also offered an incentive for people to participate. If they participated in the study, they got access to a more detailed report that had a lot of benchmark data. If you didn't participate in that study, you didn't get that report until a year later. So, those naysayers who didn't think we could do this had to wait a year before they got to see a lot of the benchmark data, which turned out to be rather valuable to them. So, as a result of the success of the 2007 study, we had a lot more enthusiasm going into this study. The other thing we did is we had several other channels that we could reach out to. In 2007, we simply reached out to the members of the NDIA Systems Engineering Division. Now, that covers a majority of the U.S. defense contractors, or at least the large defense contractors, but it doesn't reach a lot of the smaller ones.

This time, we reached out through that same channel, but we also partnered with the IEEE, Institute of Electrical and Electronics Engineers, through their Aerospace and Electronic Systems Society and INCOSE, the International Council on Systems Engineering. And so, we were able to reach out to their memberships as well, and ask them to participate in this study. So, between the example, or the confidence in the prior success and the fact that we could reach out to a broader audience, we were able to increase our responses a number substantially.

Suzanne: So tell us, on this latest study, I'm interested in two things: One, what were the big surprises for you, in terms of what came out of that data, the sort of highlights of the data, especially the surprises? And, did you see any significant change in how things were looking from the 2007 study to the current study?

Joe: Well, first of all, this report is not about surprises. All of this work is not about surprises. Those who are familiar with systems engineering know it works, know it has value, know it has

benefit. The purpose of this research was to develop the quantitative evidence that would convince the skeptics. I look at this report, and I don't see anything that I would not have surmised before I started. Anybody familiar with systems engineering would say much the same thing. Again, systems engineering simply did not get the degree of respect that it needed in some corners; some project managers, some executive managers simply don't perceive the value of it.

So, the purpose of this research is simply to provide almost irrefutable evidence of the value of systems engineering that they can't argue against. It has to drive them to see the value of the work.

Suzanne: What are some of the highlights of that case that you're able to make now, after this current report.

Joe: Well, the biggest single response is that projects that do more systems engineering perform better. When I say "perform better," they meet their budgets, they meet their schedules, and they meet the technical performance requirements. That's clear across the board. The projects that do more systems engineering are better in all three of those particular categories.

Suzanne: And, you had a wide range of sizes of projects? So, this goes for smaller projects as well as larger? So, this is not something that is only applicable to one class of project?

Joe: Of these 148 projects, the smallest of them was $100,000 in contract value, and the largest was $24 billion in contract value. I'm not going to point to individual projects, but across that range of projects, the results are consistent: systems engineering improves project performance.

Suzanne: Excellent. Were there any changes in what you saw in the profile of how systems engineering was being applied or differences in, not performance so much, but I'm looking at, "Has the world's perception changed since 2007 about systems engineering?" those kinds of things. Those may not even be things that you really highlighted in the report, but just sort of things that you observed as you were "slogging through the data" as we say here.

Joe: Well, I'm not sure that the research here can really address those particular issues. It is clear that over the past five or six years, systems engineering is gaining traction in, not just the defense industries, but in many other industrial sectors as well. That was one of the other differences between the 2007 study and this one. In 2007, we had only defense and aerospace contractors responding. Here, we didn't have a lot, but we did have some people from other domains such as energy, medical, a few other areas. So, we have a little broader sampling of industries represented here. We see, again, the same kinds of, same kind of value for systems engineering in all of those domains.

Suzanne: So, that's very promising. So, how are you using the results of this research in your own work? Then, what are some of the other things you're aware of in terms of how other people are using this research?

Joe: Well, you remember that the original question that we were addressing was to provide evidence for the Department of Defense on the value of systems engineering. I think we have some strong evidence now that supports systems engineering in government and other programs. So now, the prime focus is to get that word out. I'm doing that in a number of different ways. I've presented a number of seminars, I've presented a number of webinars, I've...

Suzanne: You're doing this podcast.

Joe: I'm doing this podcast, several conferences and conference papers have been delivered. That's one way of getting the information out. I've also met with a number of companies locally here in Pittsburgh, who have actually contacted me and said, "Come talk to us about this." So, I've gone out and talked with a few companies, with their executive management, to do exactly what we set out to do, to convince them of the value of systems engineering.

On the Department of Defense side, we are in the process of scheduling a meeting with the deputy assistant secretary of defense for systems engineering. He's asked us to brief him on this topic, so that he can make some use of this information. When we talk with him, we'll offer our assistance in areas like the refinement of acquisition policy towards use of systems engineering, maybe offer to develop some tools and aids to promote good systems engineering, maybe offer to develop some training for program managers and others on the value of systems engineering.

Suzanne: In addition to kind of getting the word out, if you were to be talking to, especially software-intensive, DoD programs at this point—if they're at the beginning of their journey, or even if they're in the middle—what would be the two or three big things you would recommend in terms of paying appropriate attention to systems engineering and ensuring that your systems engineering function is giving you the performance that you really want?

Joe: Well, it depends on who I was talking to. If I was talking to, for example, an acquisition program manager, okay, I would tell him that "The research shows that the money that you spend on systems engineering has a very good return on investment. Your overall project will do better if you spend this money than if you don't."

Then I would tell him, "If you want to get good systems engineering from your contractors, you have to contract for it. So, you had better put systems engineering requirements in your RFP. You had better include them in your negotiations and contract. You had better monitor them, during the execution of the contract." That is the primary message that I would give to anybody trying to buy a system.

Anybody trying to build a system, I would suggest that what they want to do is look at their own systems engineering capabilities. If you accept the results of this research that says "Systems engineering improves project performance," you can learn one other thing from this as well. This study represents essentially a benchmark of systems engineering capabilities across the industry today, okay?

Now, if your company isn't doing as much systems engineering as is indicated in this benchmark, you may be operating at a competitive disadvantage, because doing the systems engineering improves project performance. So, I would suggest that what they should do is look at their own systems engineering capabilities; see how they stack up against the rest of the industry; and then, in that comparison, look for strengths that they can leverage or weaknesses that they can improve.

Suzanne: That's good advice on any kind of improvement activity. I know that all of you out there took note of the "It depends." Yes, that is one of the things that is a required phrase at the SEI, because life is like that. We don't have answers that we can give without context, which is actually what systems engineering is about, understanding your context, right?

Joe: If the answers were easy, anybody could give them.

Suzanne: That's true too. You've given me some indication of the future direction of this work. Are you looking for collaborators or partners in this? One of the things some of our podcast audience will do, have been known to do, is to respond to requests for further action. Have you got any requests for our audience in that regard?

Joe: Absolutely. There is work going on through a number of different organizations. Within NDIA, the Systems Engineering Effectiveness Committee continues to function. Anybody associated with NDIA can participate in that committee and help us build the tools, build the guidance, and build the training that we're talking about. INCOSE has also embraced this work. There is a Systems Engineering Effectiveness working group at INCOSE, and that working group currently is working to build some training, some webinars, and some other tools that at least initially are focused on convincing executive management and project management of the value of systems engineering. If you're an INCOSE member, sign up for the Systems Engineering Effectiveness Committee, and help us there.

Suzanne: Excellent. Thank you, Joe. I really do want to thank you for joining us today and for sharing this work, which I am very excited about, personally, as well as I think the SEI as a whole. If you want to download Joe's technical report, *The Business Case for Systems Engineering*, or any of the SEI's technical reports and technical notes, please go to sei.cmu.edu/library/reportspapers.cfm. This podcast is available on the SEI website at

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