An Appraisal of Systems Engineering: Defense v. Non-Defense

featuring Joseph Elm interviewed by Suzanne Miller

Suzanne Miller: Welcome to the SEI Podcast Series, a production of the Carnegie Mellon University Software Engineering Institute. The SEI is a federally funded research and development center sponsored by the U.S. Department of Defense (DoD) and operated by 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. I am a principal researcher here at the SEI. Today, I am very pleased to introduce you to Joe Elm, a senior researcher at the SEI with whom I collaborated on several interesting projects going back to even before he was an SEI employee. He is currently the program integration manager in the Software Solutions Division (SSD). He works on seeking customer-focused solutions that integrate across SSD's various research initiatives. He has held very interesting leadership positions elsewhere in the SEI as well. He has led strategic programs for the SEI's CERT Division.

He has also been the acting director of the SEI's Acquisition Support Program, which tries to improve software acquisition practices throughout the Department of Defense and other U.S. government agencies. He brings a very extensive background in systems engineering, product development, program management, and corporate management to all of these projects. He is also one of only 212 people worldwide certified by INCOSE, the International Council on Systems Engineering, as an Expert Systems Engineering Professional. Today, we are going to talk about Joe's latest research on systems engineering, which examines systems engineering in the context of defense versus non-defense organizations. Joe, thank you very much for joining us today.

Joe Elm: Thank you very much for such a kind introduction.

Suzanne: Hey, you are one of my favorites. Oh, I should have not said that in public, should I? All right. So, Joe, let us start off by having you give us some background on systems engineering. You have extensive background in this area. You are an expert in this area. I know we discussed some of this in a previous podcast. But, I think some of our listeners probably need to understand why the Software Engineering Institute even studies systems engineering. We have software carved in cement on the front of the building.

Joe: Sure. But, in today's systems, it is very difficult to draw a line between where the system ends and the software begins, because the software becomes an integrating part of the system. Also, all of the activities that go to support software engineering are extremely similar to those that support systems engineering as well.

Suzanne: So, both these fields have an integrating function in a visibly hardware system, but they are what we call software-reliant in many cases.

Joe: Right. Try to build the system today ignoring software.

Suzanne: Try to build a light bulb ignoring software.

Joe: This is true. It gets more and more difficult every year. As such, we also find that many of the problems that we encounter in software systems have their roots in systems engineering.

Suzanne: Sure. And, the roots of these two disciplines are different, right? The systems engineering came out of a lot of the very complex systems work of the '70s and '80s that was satellites and airplanes. The need for that kind of integrating function came out of that kind of milieu, whereas software engineering sort of came from the component level of building compilers and languages and things. So, there is some different heritage but some of the functions. There are some interesting dichotomies as well as parallels in these two.

Joe: But, they are rapidly growing together and finding common ground between them.

Suzanne: Which is very necessary if software…We sometimes say that software is the brains of the system, so you have got to account for that. So, how did you get into this research that you are going to be talking about today, looking at [?]defense and non-defense aspects of systems engineering?

Joe: Well, we have to be back to the fundamental research that preceded this. It was published in reports in 2012. This started from work that we were doing to examine the value of systems engineering.

Suzanne: We have spoken about that in another podcast, which you will be able to reference on our website.

Joe: OK. Essentially, we got involved in trying to provide to the Department of Defense quantitative evidence that systems engineering contributed to the success of programs. In the 2012 report, we showed a lot of ways in which there is solid evidence that projects that do better systems engineering produce better results. They are closer to budget, closer to schedule, and meet more of their technical requirements.

Well, in conducting that research, we essentially surveyed 148 different projects worldwide. By virtue of the way that we approached the survey respondents, by far, the majority of them were projects working in the defense domain, particularly in the U.S. defense domain. But, there were some projects that were from other domains--energy, transportation, medical devices--things of that nature.

If we looked at the results that we got, I saw that we had about 116 programs that represented defense domains in general, but we also had 31 responses from projects that were in these other domains. So, after analyzing them together and seeing what the impacts of systems engineering were on project performance, I thought, *I wonder if there are any differences between what happens in defense domains and non-defense domain*s? So, I took the same data set that I previously analyzed, and I just divided it into two sets: one containing these 116 defense projects and the other containing these 31 non-defense projects. Then, I analyzed them much the same as I would analyze the ensemble of the data.

Suzanne: So, what are some of the interesting parallels and differences that you saw between those two data sets?

Joe: Well, one of the things that we found was that in assessing these projects, we were looking at the kind of performance that the projects were delivering: that was cost performance, schedule performance, technical performance. Surprisingly, what we found was that in terms of cost performance, there was very little difference between them. They both exhibited the same likelihood to produce projects on budget.

The same [was true] with the technical performance. They all met their requirements with about the same level of completeness.

Where we find the difference was on schedule performance. We found that the non-defense projects did somewhat better in meeting their schedules than the defense projects did. So, consequently, if you looked at the ensemble of the performance measures, it says that the non-defense projects performed just a little bit better than defense projects do.

Suzanne: OK. Did you have any ideas about what caused that? I know that is a small data set to be doing kind of root-cause analysis, but did you get an inklings that you want to pursue further about that?

Joe: Well, essentially what we get from this research is indication that there is a difference. We do not know the sources of that difference yet. So, that is future research that we need to look into.

Suzanne: Which is valuable because if non-defense is getting a better schedule result, defense wants to know how they are doing it so that we can have that, right? And, [we want to] figure out

what are the differences in other processes. It could be other processes that influence. It could be the way that systems engineering is performed that influences that. So, these are important research questions if we want to have improved acquisition in the defense domain.

Joe: That is where I hope to go with this research in the future.

Suzanne: OK, OK.

Joe: Now, the other thing we found is that we were also assessing the magnitude, the degree of systems engineering that was deployed on each of these projects and how effective it was, how strongly it related to these performance results. What we found, here, is that in most areas of systems engineering, the defense projects were deploying a little bit more systems engineering.

Suzanne: So, they were little a bit more rigorous in their application of systems engineering practices?

Joe: Correct. I am not specifically speaking about hours delivered.

Suzanne: Right.

Joe: I am saying in terms of the results of systems engineering, they were producing more systems engineering results than the non-defense projects were. So, here we have an interesting conundrum, which says that we have shown clear relationships between performance of systems engineering and program performance. But now what we are finding is, in the defense projects, a little more systems engineering is producing a little less performance.

Suzanne: That is a valid way of interpreting the data. You need to go further to validate that. But, that is a potential insight for this--is that the extra rigor in performing systems engineering defense is costing schedule--is one of the ways to look at that.

Joe: Possibly. Again, the data doesn't show what the sources of these differences are, it just shows that there are measurable differences.

Suzanne: So, yes. We have got research questions for the next two or three years on this at least?

Joe: Oh yes. Yes. If I can get research funding, I could start answering those questions.

Suzanne: Well, there you go. There you go. So, the SEI is interested in this from the acquisition viewpoint, but INCOSE has also been an active sponsor in this research. Are they also exhibiting interest in this result?

Joe: INCOSE is not directly involved in this research. Much of this research was done through the National Defense Industrial Association and the IEEE Aerospace and Electronic Systems Society. They were the prime supporters and sponsors of this activity. INCOSE did assist in

providing access to their membership, but the primary sponsors were NDIA and IEEE. And, yes, they have some interest in pursuing this as well as does the Department of Defense. Because, as you said before, if the commercial industries are getting better results, it would be nice to understand why that is, so that we can see if we can find the best practices that we can transplant from one domain to the other and with that transplant the results.

Suzanne: So, an interesting aspect of this, for me, is I was involved in some research on looking at how agile methods are not being used in programs that have systems engineering. So, to me, there is also an interesting connection here as to whether or not some of the changes in the way systems engineering can be done in agile settings might actually have an impact in this area. There is another one for you.

Joe: It may very well be that this is an evolutionary construct where, perhaps—and this is just supposition at this point—but, perhaps some of the commercial industries are adopting new technologies like Agile development a little faster than some of the defense industries, OK? And, maybe we are seeing early results of that.

Suzanne: Boy, we are just supposing our way all the way around the race track this morning. And, this is what we do. This is one of the things that is important about the SEI: We get these interesting results. We speculate about how they might go farther, where their sources might be. Then, we try to get to do more research to investigate that. So, I think this has great promise for helping us to understand some of the things that are very important to the acquisition community.

Joe: So, I am hopeful that in future months, I can dig more deeply into both the defense and the non-defense projects, not through the data that I have…I am going to have to get some more data. But, I am hoping that I can set up a process where I can go out and interview and discuss the way these projects in different domains deploy their systems engineering. And, perhaps from that, develop a more concrete understanding of why non-defense programs are more effective in systems engineering and produce better results.

Suzanne: At least in their schedule.

Joe: Right.

Suzanne: But, schedule is important in the acquisition domain as we know. All right. Well, I think this is really wonderful research.

Joe: Thank you.

Suzanne: I look forward to speaking with you in the future about what happens with this next phase of it. I want to thank you very much for joining us today, Joe.

Joe: Thank you very much, Suzy.

Suzanne: For more information on Joe's research and to read the technical report that he co-authored with Dennis Goldenson on this topic, please visit resources.sei.cmu.edu. Under the author index on the lower right hand corner, click on Joe Elm. This podcast is available on the SEI website at sei.cmu.edu/podcasts and on Carnegie Mellon University's iTunes U site.

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