



Quantifying Uncertainty in Early Lifecycle Cost Estimation

featuring Jim McCurley & Robert Stoddard as interviewed by Shane McGraw

Shane McGraw: 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. To learn more about the SEI, please visit our website at sei.cmu.edu. A transcript of today's podcast is posted on the SEI website, at sei.cmu.edu/podcasts. My name is Shane McGraw, and today I'm pleased to introduce you to [Robert Stoddard](#) and [Jim McCurley](#), both senior researchers in the SEI's [Software Engineering Measurement and Analysis program](#). In today's podcast, we will be discussing a new method they've developed, known as Quantifying Uncertainty in Early Lifecycle Cost Estimation, or QUELCE. Robert is a Motorola-certified Six Sigma Master Blackbelt. Prior to the SEI, he served as a Motorola quality director and distinguished member of the technical staff; a Texas Instruments software quality manager; and U.S. Army finance automation officer. Jim's area of expertise includes data analysis, statistical modeling, and empirical research methods. During his 15 years at the SEI, Jim has worked in the areas of risk management, goal-driven measurement, statistical modeling, and network security. So, between the two, we have everything covered, I think, that the SEI does here. So, welcome to you both today.

Robert Stoddard & Jim McCurley: Thank you.

Shane: The first question we have is: Tell us a little bit about the difficulties that the Department of Defense acquisition programs face in estimating the cost of developing new systems. And also, can you give us a few examples of the cost of these difficulties—for example, the size of the problem?

Jim: Well, one of the things that is commonly in the news is the cost overruns that we see the Department of Defense incurring. Recently, the F35 is a good program, in that regard. But the scale of the problem is pretty huge. The Defense Department has many kinds of programs at many levels. We work with the ones that are called major defense acquisition programs. And to be a major defense acquisition program, your research and development, testing and evaluation budget has to be over \$365 million. And your procurement budget—that is, actually getting the systems—has to be over 2 point something billion dollars.



Jim: And those are constant 2000 dollars, so it's actually more expensive than that. Among the 96 major defense acquisition programs currently in progress, as of last year, they were worth about \$1.5 trillion. And in last year alone, according to the Government Accountability Office, they went up 5 percent in cost growth. Actually, since all those programs started, they averaged an increase of 40 percent. Now, when you're talking in the trillions of dollars, obviously that's a lot of money. Not only costs, but schedules slip, too. The average schedule slip was nearly two years for each of these programs. Now, these major programs, as you might imagine, take years to implement. And yet, when they are starting the program, they have to estimate how long it's going to take to develop and what it's going to cost. And that's where a lot of uncertainty comes into play. Because when you're doing an estimate for something that you're going to be fielding 10 years down the line, there's a lot of room for error.

Shane: Absolutely.

Jim: So, QUELCE really is trying to address how to get a more rigorous handle on coping with that uncertainty.

Robert: And to build on what Jim said, the Department of Defense has now increased the requirement for cost estimation much earlier in the acquisition lifecycle. And it's so early in the acquisition lifecycle that the traditional cost estimation models and the parameters that you're required to input are really not available at that point. And so, we needed a radically new method to address the type of information that is present that early in the lifecycle.

Shane: Okay, so next question. Please tell us a little bit about this method you've developed—once again, it's Quantifying Uncertainty in Early Lifecycle Cost Estimation, we're referring to it here as QUELCE—and basically, how it works?

Jim: Well, the Defense Department, for these large programs—and we work with these large programs, because they produce the documentation that we need to get the information to be able to do QUELCE—divides up the lifecycle of a major program into a few phases. The first phase is conceptual, where they're coming up with the idea, and that has to be estimated and scheduled. And then they do a research and development-type phase, where they're basically doing prototype mockups of the system that they're doing. And then they go into a procurement phase, where they start actually producing the systems and eventually fielding them. And then operating and support costs. And so, that comprises the entire lifecycle.

Robert: And just to build on what Jim said, the actual method is a composition, a lot of proven methods that are already in place and have been for a number of years. We took a look at the fact that we have a lot of uncertain factors that are very subjective in nature, and looked around and saw that there were very recent advances in maturation on a technology related to scenario planning and scenario planning workshops. Shell Oil has done a lot of work in that area. So we



basically decided to use scenario planning workshop-type of exercises. And then we're basically adding probabilistic modeling to the outputs of those workshops, and then Monte Carlo simulation, as a connection of those modeled inputs to the traditional cost estimation tools.

Jim: Right. It's important to stress that our methods do not replace what cost analysts and cost estimators do in the Department of Defense. We're not coming up with new cost estimation models. What we're doing is trying to put some notion of what's the range of uncertainty to the inputs to those models, which is different than the way that they're currently estimating. Currently, the cost estimation models will take a point of value as an input variable to a model and then calculate an output. And maybe they might adjust the probability for risk or unknown on the output side. What we're doing is trying to address those kinds of changes that you might be able to roughly get an idea of potentially happening on the input side, so that inputs to the models are accounting for the uncertainty that we see as potentially happening. So that instead of producing point estimates for the inputs, we're producing probability distributions for the inputs.

Shane: So is this predicting outcome at all?

Jim: When you run those as inputs through the models, then you come out with different outcomes and ranges of probability.

Shane: Okay. Excellent. So now, as I understand it, and just talking to you here a little bit, the method places a lot of influence on the importance of experts, specifically in the context of current cost estimation, practice in research. So what role do experts play in the QUELCE method?

Jim: QUELCE actually recognizes the influence of experts in the entire DoD acquisition process and program management. For instance, at the earliest stages, who gets to decide what makes for a good analogy, when you're making an argument to build a new system?

Shane: Right.

Jim: Who gets to choose which historical data is appropriate for you to use in your argument? So, there's experts up and down the chain, as these systems are created as an idea and then instantiated as a technology.

Shane: Do you guys advise on who those experts should be?

Jim: No. What we want to do is to tap into their knowledge, their domain expertise, their intimate knowledge of what things cost and what the historical experience has been, to flesh out what we consider to be uncertainties that are currently going unaddressed, as they create these estimates.



Robert: And coupled with what Jim said, we recognize the dependence on these experts exerting subjective judgment on the types of change drivers that affect program execution and the probability of occurrence of those. And so, in our research and in the method, we're also accounting for structuring the uncertainty and expert judgment. And we have a notion of calibration training for experts, so that their judgment is more calibrated to be used in this method.

Shane: Excellent. So, where can our listeners go if they want to learn more about the method?

Jim: Well, we did produce a [technical report](#) that's available on the SEI website. If you go to the SEI website and in their search box, type the word QUELCE (Q-U-E-L-C-E), it actually does come up as the first entry. So you can access our [technical report](#) there. Also, there were [some blog postings](#) on the SEI blog that referred to the QUELCE method last year. We'll be producing more reports, as the research goes on. And we show up at various conferences and make presentations at various places.

Shane: Excellent. Bob, Jim, thank you very much for joining us today. This podcast is also available on the SEI website at sei.cmu.edu/podcasts, and on Carnegie Mellon University's iTunesU site. As always, if you have any questions, please don't hesitate to e-mail us at info@sei.cmu.edu. Thank you.