

# QUELCE Cost Estimation Method

## Quantifying Uncertainty in Early Lifecycle Cost Estimation

**COST GROWTH IN LARGE-SCALE PROGRAMS IS COMMON**, with a \$91 billion cost growth to date (engineering and estimating) in the DoD portfolio as of December 31, 2017.<sup>1</sup> Poor cost estimation, including early lifecycle estimates, represents almost \$8 billion of the \$91 billion. QUELCE is a new approach to cost estimation that provides better estimates by producing more accurate inputs to existing estimating processes and tools. The method helps programs anticipate and document risks and sources of uncertainty that may impact future cost.

### Overview

#### How Is This Method Different from Other Cost Estimation Methods?

QUELCE produces more accurate inputs to existing cost estimating relationships by systematically quantifying uncertainty associated with underlying, and often unspoken, assumptions about program execution. Subject-matter experts make judgments that capture a range of domain-specific uncertainties and risks. These judgments form the basis of an executable model that can be used to evaluate a broad variety of future acquisition and development scenarios to assess cost and schedule impacts. It also provides the tooling needed to consolidate this information into the estimate more quickly using visual methods.

#### Who Should Use This Method?

- Program management offices and cost estimation organizations that are building cost estimates for systems that are pre-milestone A, pre-milestone B, or rebaselining
- Any organization that wants a systematic method for incorporating uncertainty and risks into its cost estimates

#### The Estimation Problem

To produce cost estimates of large-scale programs, domain experts, cost analysts, and others must make judgments about often unprecedented and very complex software-reliant systems. The challenge is even greater earlier in a program lifecycle when experts must make judgments based on analogy with existing systems that do not share all of the same characteristics.

Accurate estimates for the cost of a program are crucial because they set expectations about funding needs. However, when estimates are developed early in a project that spans decades and involves complex new technologies, the magnitude of uncertainty is great. It is important that programs be able to effectively quantify uncertainty.

*"The QUELCE methodology, training, supporting tools, and expert guidance could not have been more relevant, timely, and insightful given our current highly cost competitive environment."*

— Neil Mackertich, Raytheon Company

<sup>1</sup> Department of Defense Comprehensive Selected Acquisition Reports (SARs) for the December 31, 2017, Reporting Requirement as Updated by the President's FY 2019 Budget. <https://media.defense.gov/2018/Apr/03/2001898705/-1/-1/1/DECEMBER-2017-SAR-PRESS-RELEASE.PDF>

## Our Solution

The QUELCE method takes a workshop approach with domain experts and other program participants to produce early lifecycle cost estimates expressed as cost distributions rather than single points. Because many inputs are based on expert judgment, the workshop begins with a series of training exercises to calibrate the experts' judgments.

The workshop participants continue by identifying potential future changes, or change drivers, to the program that could directly or indirectly influence cost, such as changes in sponsorship or suppliers. They next evaluate the probability that each change driver will occur and the degree to which each change could affect other potential changes in a cascading fashion.

The QUELCE method then uses a Bayesian Belief Network (BBN) model to quantify uncertainties among change drivers. From the BBN, the domain experts may define a number of likely scenarios, each of which will have different inputs to cost models. The base scenario comprises the total uncertain situation without any intervention. The domain experts identify additional scenarios via the types of interventions made on one or more change drivers.

Finally, QUELCE applies Monte Carlo simulation for each scenario to calculate thousands of what-if cost possibilities based on the uncertain distributions of the inputs to the cost estimation relationship. The result is a cost estimate in the form of a distribution for each scenario, as opposed to a single "guesstimate."

## Features of the QUELCE Method

Using data-mining techniques, the SEI uses a proof-of-concept, searchable repository of DoD experiences in program execution to inform the expert probability assessments. The repository is a source of program change drivers—events that occurred during the life of a program that directly or indirectly affected its cost—along with their probability of occurrence. After the stakeholder workshop, the SEI team leverages data from programs in this repository to help program stakeholders identify which potential changes to include in the cost estimates of their program.

QUELCE provides a detailed model of all potential change drivers identified by domain experts, as well as their cascading relationships. This model enables more accurate cost estimates compared to traditional methods that cover only a fraction of the possible changes and alternatives.

QUELCE results in cost estimates with defined upsides and downsides of uncertainties. The method produces a set of scenario cost estimates, each represented as a distribution, that a decision maker can use to understand the relative level of risk associated with a particular program scenario. The model and analyses also provide good documentation of the basis of the program's estimate.

QUELCE produces an executable model that a program can use to run alternative scenarios and to update as changes occur in the future to re-estimate the program. Automation is a key factor in the model: a program can perform re-estimation quickly as it discovers which potential changes become realities and which potential changes it can ignore.

QUELCE is designed to help acquisition programs request funds at levels consistent with the magnitude of risk to achieving program success. There will be less rework to reconcile program and independent cost estimates, and fewer and less severe cost overruns will occur due to poor estimates.

## Engage with Us

If your organization would like to learn more about QUELCE or schedule a workshop to help quantify uncertainty in cost estimation, please contact SEI Customer Relations.

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## About the SEI

The Software Engineering Institute is a research and development center that works with defense and government organizations, industry, and academia to advance the state-of-the-art in software engineering and cybersecurity to benefit public interest. Part of Carnegie Mellon University, the SEI is a national resource in pioneering emerging technologies, cybersecurity, software acquisition, and software lifecycle assurance.

## Contact Us

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