# Attachment 1: Monte Carlo Simulation

Contingency is typically estimated using statistical analysis informed by judgment based on past experience and considers only residual (post-mitigated) risk exposures.

Monte Carlo simulation is a computerized mathematical technique that simulates the execution of a project thousands of times, accounting for potential realization of discrete risk events and project uncertainties based on the probability distribution function and the consequence of each risk. The technique builds models of possible results by substituting a range of values for any factor that has inherent uncertainty. The model is then used to calculate the results in an iterative manner, involving thousands of iterations, each using a different set of random values from the probability distribution functions.[1] The output provides decision makers with a range of possible outcomes for the project and the associated probabilities that those outcomes will occur. The discrete probability distribution of outcomes often takes a shape similar to an inverted bell; therefore, are often referred to as “Bell” curves. The cumulative version of these probability distribution of curves, often takes a shape similar to an “S”; therefore, are often referred to as “S” curves. Using these “S” curves, the amount of contingency required to be added to the base cost estimate to obtain a certain level of confidence can be determined. This quantitative result is used as an input to determine the amount of contingency required at different confidence levels for both the project schedule and project cost.

OPG uses @Risk, a leading risk analysis software tool from Palisade Corporation, an internationally recognized leader in this field. @Risk is a tool which facilitates the running of a Monte Carlo simulation, based on the risk inputs. At the time of RQE, OPG had also retained a risk modelling subject matter expert from Palisade to assist in the architecture and robustness of the model and to oversee the simulation.

[1] Palisade Corporation, *Monte Carlo Simulation* <http://www.palisade.com/risk/monte_carlo_simulation.asp>.

The results of the Monte Carlo simulation are an important, but not the sole input into the determination of the appropriate level of contingency to be included in the project estimate in developing, say, a 90% confidence estimate. The judgement of the project staff, project management, project executive management and OPG's executive management are also important inputs. Ultimately, the confidence level in achieving a certain schedule and cost outcome, and validation of the overall adequacy of the contingency estimate required to achieve that outcome is informed both by the quantitative results of the Monte Carlo simulation and by management judgement.