

Easily Estimate Projects Using Statistical PERT

Use Microsoft Excel to Quickly Create Probabilistic Estimates for Any Bell-Shaped Uncertainty.

Abstract |

Want to make confident estimates? How confident do you want to be? Highly confident estimates mean higher project costs and longer schedules. Shrinking expected costs and shortening schedules involves more risk and less certainty. In this paper, you will use Microsoft Excel's built-in statistical functions and a new, simple, and probabilistic estimation technique called Statistical PERT. Statistical PERT lets estimators easily make probabilistic estimates for virtually any bell-shaped uncertainty. And unlike other estimation techniques, Statistical PERT incorporates emotional confidence (subjective opinion) about how likely the most likely outcome really is to influence the resulting probabilistic estimates.

Key words |

Estimation, Estimates, SPERT, PERT, Probabilistic, Statistical PERT

Introduction

Have you ever made an estimate in which you lacked confidence? Perhaps you had very limited information about what you were estimating, or you made your estimate in a context of great uncertainty. Highly confident estimates mean higher project costs and longer schedules. Choosing lower-cost estimates and shortening project schedules involves more risk and greater uncertainty. How can you create estimates that perfectly fit your (and your project sponsor's) risk tolerance? And how can you rationally engage your emotional "gut instinct" while making project estimates?

In this paper, you will use Microsoft Excel's built-in statistical functions and a new estimation technique called Statistical PERT (SPERT). SPERT lets estimators easily make probabilistic estimates for virtually any bell-shaped uncertainty. And unlike other estimation techniques, SPERT incorporates an estimator's emotions and instincts (subjective opinion) about *how likely* the most likely outcome really is.

SPERT is easy to use. It requires only a rudimentary knowledge of statistical probabilities. Specifically, estimators need basic familiarity with the best-known probability distribution—the normal distribution (also called the Gaussian distribution). SPERT formulas inside an Excel-based template manipulate the standard deviation which reshape the normal curve's implied appearance. This reshaping influences the resulting SPERT probabilistic estimates.

Estimators use SPERT with bell-shaped uncertainties (so-called because when the range of possible values and frequencies are plotted on a graph, they have a bell-shaped appearance). Bell-shaped uncertainties have an improbable minimum value, an equally improbable maximum value, and a most likely outcome which is probable and lies roughly in the middle between the minimum and maximum values. SPERT estimators make rational, three-point estimates, but also rely on

their emotions or “gut instinct” to better conform the normal distribution to a specific uncertainty. The result is a better-fitting distribution curve that can yield more reliable, probabilistic project estimates.

The Problem with PERT

Estimating projects is an activity filled with uncertainty. Sources of this uncertainty can be the incompleteness and/or unavailability of useful data or information about some matter, such as how long a task might take, or how much a material cost might be (Liang, Huang, & Yang, 2012, p. 1452).

Modern project management has sought to address the uncertainty of projects by recognizing that any deterministic estimate is simply one of many possible outcomes; there are, in fact, a range of other possible outcomes for how long an activity might take, or how much a material might cost. Using PERT, deterministic estimates are developed, but they are developed using a formula that accounts for a range of possible outcomes, both probable and improbable. The PERT formula creates an expected value for a beta-distributed uncertainty which can be used in a project schedule instead of the most likely outcome (Monhor, 2011, p. 616). PERT, then, quantifies time uncertainty with numerical approximations for how long an activity will take (Poh & Lam, 2014, p. 120). Even though more sophisticated and ostensibly more accurate methods of estimating exist, PERT remains popular more than 50 years after its development because it is easy to use and provides useful estimates, whereas other, newer estimation methods are simply too complex and difficult to use (Ibid).

The accuracy of PERT estimation is dependent upon the estimator’s choice of the probability distribution (Liu, Jiang, & Chen, 2011, p. 809).

But PERT cannot take into account an estimator’s subjective judgment about *how likely* the most likely outcome really is. Tasks A and B may share the same three-point estimate and the same PERT mean, but according to an estimator’s subjective opinion, Task A may be more likely to finish on or around the mode than Task B. Using PERT, a project estimator cannot account for this “gut instinct” or emotional confidence, and the estimator cannot employ expert knowledge, private information, and other sources of information about Task A, which gives rise to subjectively higher

confidence that Task A will finish on or around the most likely point-estimate, while Task B has subjectively more uncertainty surrounding its mode. Statistical PERT seeks to address this limitation.

Introducing Statistical PERT

Using Statistical PERT involves a five-step process:

- 1) Create a three-point estimate for any bell-shaped uncertainty
- 2) Estimate the mean using the PERT formula
- 3) Render a subjective opinion about the most likely outcome (the mode)
- 4) Create a SPERT standard deviation
- 5) Choose a planning estimate

However, if an estimator is using a free Statistical PERT template for Microsoft Excel, there are only *three* steps required because the formulas in a SPERT Excel template remove the burden of manually calculating the mean (Step 2) and SPERT standard deviation (Step 4). Moreover, using a SPERT template makes choosing a planning estimate (Step 5) much easier to do too.

Statistical PERT relies upon the statistical functions that come standard with Microsoft Excel 2010 or later. There are no special Excel add-ins to buy, and the technique does not require programming or use Excel macros. Freely licensed SPERT templates make Statistical PERT easier to use, but this estimation technique does not require their use. You can use SPERT with a blank Excel worksheet.

Step 1 – Create a Three-Point Estimate

Three-point estimates are very familiar to virtually every project manager. To make a three-point estimate, choose minimum and maximum values that represent plausible, extreme values for a bell-shaped uncertainty, and choose a most likely outcome that lies roughly between these two unlikely point-estimates.

It’s noteworthy to point out that while Statistical PERT uses Excel’s built-in, normal distribution functions, a three-point estimate does not need to imply perfect symmetry. As long as the implied, asymmetrical shape of an uncertainty is still reasonably bell-shaped, Statistical PERT can yield beneficial results within an estimator’s tolerance for error. For convenience and ease-of-use, Statistical PERT uses the normal

distribution instead of PERT's beta distribution. As long as the estimator is aware of the potential for, and the size of, error arising from using the normal distribution to model asymmetrical uncertainties, and that the size of error is within the estimator's tolerance level, Statistical PERT can provide a useful way to quickly and easily create probabilistic estimates for bell-shaped uncertainties. This is further explained in Step 5.

Step 2 – Estimate the Mean

The PERT formula $[\text{Min} + 4\text{ML} + \text{Max}] / 6$ is well-known; it estimates the mean of a beta distributed uncertainty using a three-point estimate (Monhor, 2011, p. 616). The variables are: Min = Minimum, ML = Most Likely, Max = Maximum. Example: For a three-point estimate of {100, 150, 250}, the estimated PERT mean is:

$$(100 + [4 * 150] + 250) / 6 = 158.333$$

But the same PERT formula can be used to estimate the mean for the normal distribution too. What some project estimators may not realize is that a PERT risk-adjusted estimate is only 50% reliable for symmetrical, bell-shaped properties of an uncertainty (Khamooshi & Cioffi, 2013, p. 489). Most project managers want to be more than 50% confident in their estimates, but there is no easy way to create estimates with different confidence levels such as 75%, 80%, 85%, or 90% using just the PERT formula alone. This is something that Statistical PERT overcomes.

Step 3 – Render an Opinion About the Mode

Estimators who want to create probabilistic estimates face an important problem: finding a probability curve that best conforms to the shape of the project uncertainty. The implied bell-curve for a three-point estimate of {100, 150, 250} is shown in Exhibit 1 (using a special beta distribution found in Palisade's Excel add-in, @Risk7®).

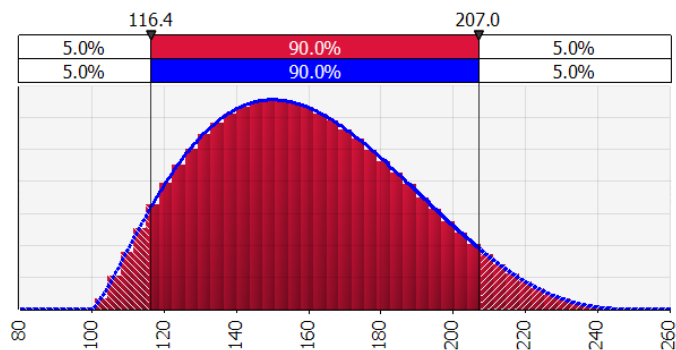


Exhibit 1: PERT beta distribution using @Risk7.

The expected mean for this distribution is 158.333 and the standard deviation is 27.64. But what happens if the estimator feels emotionally confident in the most likely outcome (the mode)? If the estimator were subjectively confident in the most likely outcome, the standard deviation would decline, the kurtosis—which is a measure of the thickness of the left- and right-side tails of the curve—would shrink, and the appearance of the curve would have a tall, skinnier appearance. PERT estimation, however, cannot adjust the implied probability curve based upon an estimator's subjective opinion about the mode.

Statistical PERT implicitly manipulates the bell-shaped curve by modifying the standard deviation of the curve based upon the estimator's subjective opinion about the most likely outcome. To do that, the estimator first renders a subjective opinion about *how likely* the most likely outcome really is. Although Statistical PERT can use either a few or many terms that describe the estimator's confidence, it is easy to start by choosing from among six subjective opinions:

- Nearly certain
- High confidence
- Medium-high confidence
- Medium-low confidence
- Low confidence
- Guesstimate

In the next step, the estimator's subjective opinion about the most likely outcome is equated to a Ratio Scale Multiplier (RSM). The RSM is used to generate a SPERT standard deviation for the bell-shaped curve. The standard deviation reflects the estimator's confidence in the most likely outcome, and it is used in

Excel's statistical functions to generate probabilistic estimates.

Step 4 – Create a SPERT Standard Deviation

This step matches Step 3's subjective opinion to an RSM using the SPERT-7 Rule (see Exhibit 2). The SPERT standard deviation formula uses an RSM to generate a standard deviation that matches the estimator's subjective opinion about the mode. The SPERT-7 Rule is an easy-to-remember rule for equating each of the six subjective opinions in Step 3 with a corresponding RSM value, where each RSM value is a multiple of 7%:

Subjective Opinion	SPERT-7 Ratio Scale Multipliers (RSMs)
Nearly certain	7%
High confidence	14%
Medium-high confidence	21%
Medium-low confidence	28%
Low confidence	35%
Guesstimate	42%

Exhibit 2: SPERT-7 rule subjective opinions.

The SPERT standard deviation (SD) formula is:

$$\text{SPERT SD} = (\text{Max} - \text{Min}) * \text{RSM}$$

where:

Max = maximum point-estimate

Min = minimum point-estimate

RSM = Ratio Scale Multiplier

Suppose an estimator had “high confidence” in the most likely outcome of 150 in a three-point estimate of {100, 150, 250}. According to the SPERT-7 Rule, “high confidence” corresponds to the Ratio Scale Multiplier of 14%. Using the SPERT standard deviation formula, the standard deviation for the probability curve implied by the three-point estimate would be:

$$\text{SPERT SD} = (250 - 100) * 14\% = 21$$

Having calculated a standard deviation which accounts for the estimator's subjective opinion, the last step utilizes the built-in statistical functions in Excel to create probabilistic planning estimates.

Step 5 – Choose a Planning Estimate

The purpose for Steps 1 through 4 is to obtain both a mean and standard deviation so we can use Excel's built-in statistical functions for the normal curve, NORM.DIST (normal distribution) and NORM.INV (normal inverse). These two Excel functions are easier to use than the Excel functions for the beta distribution or other probability distributions that are built-in to Excel.

NORM.DIST finds the cumulative probability of any value between the minimum point-estimate and the maximum point-estimate used in Step 1. NORM.INV finds any value of X between those two extreme point-estimates for any cumulative probability we specify.

For example, suppose we want to find the cumulative probability of 180, which is between the two extreme point-estimates in our three-point estimate of {100, 150, 250}, as shown in Exhibit 3. The cumulative probability is the probability that the uncertainty will have a value equal to or less than 180. Put another way, the cumulative probability measures the area under the probability curve from the left-side tail of the curve to where 180 is on the x-axis.

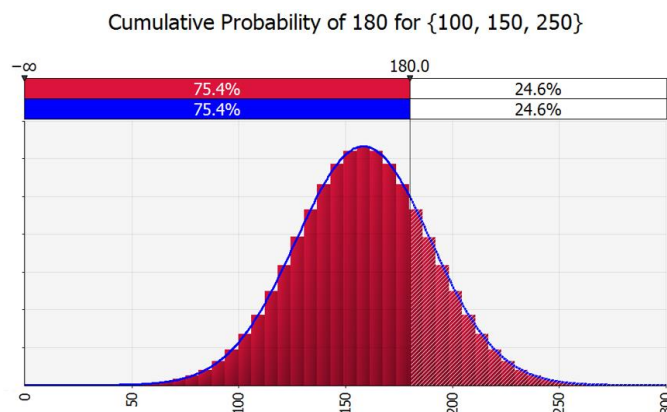


Exhibit 3: Cumulative Probability of 180

NORM.DIST requires four arguments:

X (a point on the x-axis),

mean (the arithmetic average, also known as the expected value),

standard deviation (for the implied normal curve),

TRUE/FALSE Boolean to indicate whether the result should be a cumulative probability or not. (We will always specify *TRUE*).

With NORM.DIST, we can freely choose any X value and find its corresponding cumulative probability. In Step 2, we estimated the mean for a three-point estimate using the PERT formula (158.333). In Step 4, we obtained a standard deviation for the uncertainty using the SPERT-7 Rule and the SPERT standard deviation formula (21). Now we enter these arguments into the NORM.DIST function in Excel. If we choose, for example, 180 as the X value for which we want to find the cumulative probability, and we maintain that we have “high confidence” in the most likely outcome of 150 (so the SPERT standard deviation is 21, as we saw earlier), then the entry in Excel looks like this:

$\text{NORM.DIST}(180,158.333,21,\text{TRUE}) = 0.8489$

Exhibit 4 shows how the cumulative probability of 180 now covers a moderately greater portion of the area under the bell curve than it formerly did in Exhibit 3. Notice, too, how the shape of the bell curve appears narrower, or taller, than it did before:

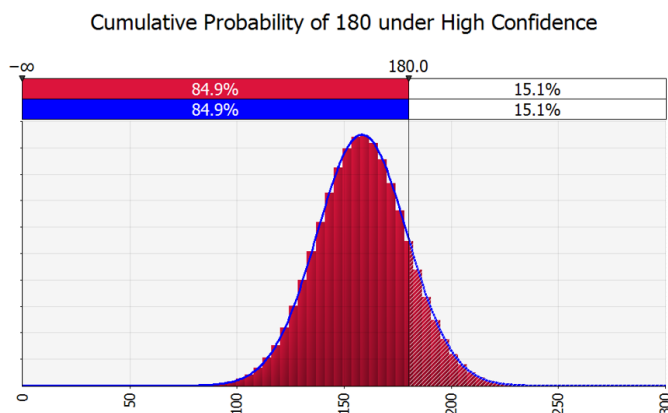


Exhibit 4: Probability of 180 under High Confidence

For a three-point estimate of {100, 150, 250}, where we have subjectively “high confidence” in the most likely outcome of 150, there is an 85% probability that this bell-shaped uncertainty will be equal to, or less than, 180; there is a 15% probability that the uncertainty will equal some value greater than 180. (Note that if we ran a PERT Monte Carlo simulation using @Risk7 and the PERT beta distribution, 180 would have just 77% cumulative probability since PERT alone does not account for “high confidence” about the mode).

The NORM.INV function is similarly easy to use. It calculates the value along the x-axis corresponding to any cumulative probability we specify (between 0% and 100%).

In exchange for ease-of-use, we must be willing to accept that fitting a symmetrical curve to an asymmetrical probability creates some amount of error, but if that error is within our tolerance for error, Statistical PERT can provide decision makers with quick, easy, insightful, risk-based choices.

When the range between the mode and the maximum point-estimate is twice as great as the range between the minimum point-estimate and the mode, the error is less than 2% for all cumulative probabilities between 50% and 95%. This assumes: 1) the SPERT subjective confidence is “medium-high” which closely mimics standard deviations calculated in @Risk7’s RiskPERT beta distribution, and 2) the beta distribution is the standard of truth for representing an uncertainty’s risk properties and is, therefore, suitable for making comparisons with the normal probability distribution to determine the error using SPERT.

For example, using a three-point estimate of {100, 150, 250} to estimate task duration (in days), we would enter 185 days into the project schedule using Statistical PERT (at the 80% confidence level with “medium-high” confidence in the mode), but we would enter only 183 days if we had access to expensive software to model the uncertainty using Monte Carlo simulation and the beta distribution. This small error is the trade-off for using a simple, easy-to-use estimation technique like Statistical PERT.

Conclusion

Statistical PERT, unlike PERT, provides a way for estimators to leverage subjective opinion about the most likely outcome based on expert knowledge, public or private knowledge, intuition, historical records, or simply from “gut instinct.” From these sources of information, estimators formulate a subjective opinion about the most likely outcome for a bell-shaped uncertainty, and then use that subjective opinion to rationally adjust probabilistic estimates for that uncertainty.

In exchange for fitting a symmetrical probability curve to an asymmetrical uncertainty—which creates a small, tolerable measure of error—Statistical PERT allows estimators to easily use their subjective opinion to create probabilistic project estimates at nearly any confidence level.

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