**UMD Project Management Symposium**
# Stop Predicting, Start Forecasting

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## ABSTRACT

This whitepaper evaluates two types of estimates: deterministic (single-value) estimates, and stochastic (probabilistic) estimates. Deterministic estimates do not reveal how likely they are to occur, do not align stakeholder expectations, and do not lead to well-informed business decisions by organizational leaders. In contrast, stochastic estimation depicts future project uncertainties, like task duration or project cost, using the language of statistics. Stochastic estimates indicate how likely they are to occur, align stakeholder expectations, allow an organization to match project estimates to the risk policy of the organization (or project), permit dynamic and right-sized project buffering, and create better, more informed decision-making by organizational leaders. Project practitioners can learn how to create stochastic estimates using a freely licensed, stochastic estimation technique called Statistical PERT, which uses the built-in statistical functions of Microsoft Excel.

## INTRODUCTION

One of the most important skills a project manager learns is to **estimate** future project outcomes. Project managers and other project professionals—such as cost engineers, project schedulers and others—are collectively responsible for estimating a project's duration and cost. For agile projects where project duration and/or project budget are fixed, project managers are usually expected to predict a release date for new or enhanced product functionality.

Project predictions involve deterministic estimates—single value estimates that represent future uncertainties. However, deterministic estimates do a poor job of communicating risk and uncertainty, and they fail to effectively align stakeholder expectations about future events.

Weather forecasters have made an entire profession of estimating uncertain, future events. Like project managers, weather forecasters use historical data, statistical models, computer simulation, and their own, expert opinions that draw upon their instincts, intuitions, and personal experience. Weather forecasters collectively use these resources to create both weather ***forecasts*** and ***predictions***. Of these two, *forecasting* is superior to *predicting* because forecasting explicitly reveals a sense of risk and uncertainty about future events. Forecasting better aligns stakeholders and fosters better stakeholder decision-making about the future. Project managers can learn to effectively use statistics, the language of weather forecasters.

## WEATHER FORECASTING

The American Meteorological Society (AMS) describes a meteorologist—what this whitepaper casually refers to as a "weather forecaster"—as someone "who uses scientific principles to explain, understand, observe, or forecast the earth's atmospheric phenomena and/or how the atmosphere affects the earth and life on the planet" (All About Careers in Meteorology, n.d.). Weather forecasters provide the public with vital, sometimes life-saving information with respect to severe weather patterns and storms. The mission of the United States' National Weather Service (NWS) is to provide weather forecasts and warnings to protect life and property, and to enhance the national economy (NWS Products and Information Guide, 2011) To do that, weather forecasters collect data about atmospheric conditions from 10,000 weather stations around the world, use thousands of ships around the globe to gather even more weather facts, and supplement all that with 500 weather balloons, plus aircraft and satellites, to learn all about the world's ever-changing weather conditions (Meteorology Fields, n.d.)

Forecasting remains the core of meteorology. Gathering thousands of data points each hour of the day would be unfruitful without the ability to convert all that data into an actionable weather forecast. Like project managers, weather forecasters need to effectively communicate both certain and uncertain future outcomes so their stakeholders can make informed decisions about the future.

Before proceeding, it is important to distinguish between *predictions* and *forecasts*, because these terms are often used interchangeably. The AMS uses both terms to describe the work of meteorologists. Meteorologists *predict* the daytime high and low temperatures, but they make *forecasts* about the likelihood of precipitation, and the impact and direction of major storms, like hurricanes and tropical storms.

Dr. Jeffrey C. Bauer, an economist who also formally trained in meteorology, offers a good distinction between *predicting* and *forecasting*. Dr. Bauer explains that *predicting* is, "a specific estimate of the expected value of a key variable at a future point in time," while *forecasting* is, "an estimate of the probabilities of the possibilities for a key variable at a future point in time" (Bauer, 2014, p. 4). This whitepaper will use Dr. Bauer's definitions to differentiate *predictions* from *forecasts*.

Weather forecasting involves statistical probabilities. Everyone is familiar with the nature of a weather forecast described using probabilities. Weather forecasters commonly make statements such as these:

- "Today we will have partly cloudy skies with a 20% chance of rain"
- "Tonight will be mostly clear skies with only a slight chance of rain"
- "Tomorrow, however, there is an 80% chance of rain"

In each statement above, a weather forecaster has given probabilistic answers to the question of, "How likely will it rain in the future?". For people living in the weather forecaster's service area (usually a county), these weather forecasts provide important, actionable information that lets people make appropriate plans for their immediate future (Forecast Terms, 2017). If someone were planning a picnic, the weather statements above might result in a picnic held later today—but not tomorrow.

Imagine if a weather forecaster calculated that there was a 40 percent chance of severe thunderstorms in the forecast area over the next 12 hours, but instead of offering a probabilistic forecast, the weather forecaster instead made the following *prediction*: "It will not rain tomorrow,"—because, the forecaster reasons, there is a greater likelihood (60 percent) that the storm will *not* affect the forecast area than the chance it *will* affect the forecast area. Such a prediction would violate the NWS's mission by unnecessarily endangering life and property. It would give people living in the forecast area a false sense of security regarding potentially threatening weather. They would fail to take proper precautions to protect themselves and their property from severe thunderstorms that *might* move through the forecast area.

Project managers often give their sponsors and key stakeholders an improper sense of security by creating project *predictions* rather than project *forecasts*.

**DETERMINISTIC ESTIMATES**

Project managers face many uncertainties. They must estimate when a project will finish, how much the project will cost, and, for agile projects, they may estimate how much of the product backlog will be accomplished by the end of the project's fixed schedule. Uncertainty arises from incomplete and/or unavailable data that is useful and reliable, making it challenging to estimate how long project tasks might take to complete, or how much project materials might cost (Liang, Huang, & Yang, 2012).

Often, project managers create deterministic estimates for their project uncertainties. Project managers estimate the duration of scheduled tasks with precise, single-value estimates (usually in hours, days or weeks). They construct a project budget to find the total cost of the project (sometimes down to the penny!). When these deterministic estimates—predictions—are initially shared with the project sponsor and other stakeholders, they immediately set sponsor expectations even though these estimates are created when there is the least amount of project knowledge available.

Most experienced project managers have had to navigate the difficult waters of sharing an initial project prediction with a project sponsor, who then expects the project to be completed according those early project predictions for both schedule and budget. Later, when better project information is available to the project manager, it can be politically unviable for the project manager to get approval for a revised (usually longer) project schedule and (usually increased) project budget. To avoid this hazard, some project managers create, then share, initial project schedules and budgets that they know are bloated because their sponsor will hold them accountable to whatever schedule and budget the sponsor first sees.

Project predictions—deterministic estimates—are inferior to stochastic estimates because project predictions do not indicate how likely they are to occur, they fail to align stakeholder expectations, and they do not lead to informed decision-making by organizational leaders.

Project predictions do not indicate how likely they are to occur. They do not indicate whether they represent the mode, median, mean, or some other value along an implied, bell-shaped, probability curve. When a weather forecaster predicts a daytime high temperature that is normal for the area and time of year, people generally assume a bell-shaped probability distribution and add or subtract five degrees (Fahrenheit) to the predicted high temperature value to reach an expectation of how hot it will be (Jocelyn & Savelli, 2010). People inherently assume that the predicted high temperature is the mode. When project managers offer project predictions, there often is no similar, common understanding of what that prediction represents: is it the mode? an optimistic P10 estimate? a pessimistic P90 estimate? Recipients of project predictions do not know the predicted reliability of the project predictions they receive.

Project predictions fail to align stakeholder expectations. Whether the prediction is the delivery date for a new project, or a project budget, or the number of story points for an agile product backlog—project predictions do not convey any sense of uncertainty or risk. A deterministic estimate is just one possible outcome for a project uncertainty. Usually, many other outcomes are possible, some of which are both possible and probable, while other outcomes are merely possible but improbable. Deterministic estimates do not convey the range of other, alternative outcomes that are possible. The majority of people who learn of a weather forecaster's prediction for the daytime high temperature or the nighttime low temperature regard those predictions as one of many other, possible outcomes (Jocelyn & Savelli, 2010). But project sponsors and other stakeholders sometimes do not similarly regard project predictions as one of many possible outcomes. Failure to recognize this leads to misalignment between project sponsors, key stakeholders, the project manager, and the project team.

Project predictions do not lead to well-informed decision-making by organizational leaders. An organizational leader evaluating three project proposals, each with an expected revenue benefit of $1M, cannot evaluate the relative riskiness of each proposal using deterministic benefit estimates. Organizational leaders making business decisions based upon project predictions may regrettably choose to fund a high-risk project proposal that has the same expected benefit as another project proposal that has much less risk surrounding its predicted benefit.

## STOCHASTIC ESTIMATES

Weather forecasters at the National Hurricane Center (NHC) use stochastic (probabilistic) estimates to create a forecast cone for a hurricane or tropical storm. The so-called "cone of uncertainty" is well-known to residents living along the Atlantic seaboard of the United States. The forecast cone represents a stochastic estimate of where NHC believes a hurricane or tropical storm is likely to go that is within approximately one standard deviation of the forecasted track (Definition of the NHC Forecast Cone, 2016). Residents living near the cone of uncertainty understand that they are still at-risk of a direct hit, albeit with much less chance of occurrence than residents living inside the cone of uncertainty. NHC's cone of uncertainty aligns stakeholder expectations, and fosters better, more informed decision-making by residents who are threatened by impending, severe weather conditions.

Stochastic estimates indicate how likely they are to occur, align stakeholder expectations, allow an organization to match project estimates to the risk policy of the organization (or project), permit dynamic and right-sized project buffering, and create better, more informed decision-making by organizational leaders.

Stochastic estimates indicate how likely they are to occur. They can be conveyed via single-value estimates associated with a cumulative probability, or via confidence intervals. For instance, single-value schedule estimates rarely have a reliability of less than 50 percent, and most critical-path method projects, common in the construction industry, are scheduled with probabilities of 80 percent or greater (Cioffi & Khamooshi, 2013). Using confidence intervals, project managers can make statements like this one: *"This project's budget is estimated to be between $1.1M and $1.4M with 90% confidence."* Here, sponsors will expect to pay up to $1.4M (with a small chance the project will cost more), and they will similarly expect to pay no less than $1.1M.

Stochastic estimates align stakeholder expectations. In the example given in the previous paragraph, project stakeholders—which includes the project sponsor, project manager, project team, business managers, and others participating in or affected by the project—all know a range of possibilities for how much the project will cost. Sponsors must be willing to pay up to $1.4M, and even then, there is a small likelihood that the project cost might exceed that amount. If project sponsor is only willing to spend $1.2M on the proposed project, a 90 percent confidence interval of $1.1M to $1.4M should suggest to the sponsor that the current project proposal may be too risky to proceed without exploration and possible modification of the project's charter.

Stochastic estimates allow an organization to match project estimates to the risk policy of the organization and of the specific project proposal. If the risk policy of an organization stipulates that all task duration estimates should be 80 percent reliable, a scheduler using a statistical model can fit a risk distribution to each uncertainty, then calculate schedule estimates (which the scheduler must add to a project schedule) that are all 80 percent probable. If the risk policy *for a specific project or task* is either relaxed or made more stringent than the organizational risk policy, the scheduler can easily choose other, alternative, task duration estimates that match the reliability policy for the specific project or task.

Stochastic estimates permit dynamic and right-sized project buffering. Often, project buffers are calculated using a simple heuristic of adding 5 or 10 percent to the project budget (Meredith & Mantel, 2006, p. 339). Dr. Moselhi, who has 30 years of construction industry experience, argued that such a simple method of calculating a project budget "is not sufficient unless this level of contingency is linked with some probability (or confidence) at which cost overruns will not exceed the allocated contingency" (Moselhi, 1997). With stochastic estimates, project managers can use dynamic, right-sized project buffers derived from statistical models that satisfy Dr. Moselhi's call for confidence. One such method is the Unified Scheduling Method (USM) created by George Washington University's professors, Dr. Homayoun Khamooshi and Dr. Denis Cioffi (Cioffi & Khamooshi, 2013). USM allows project managers to create a dynamic, right-sized schedule reserve that is tied to the reliability of the task duration estimates in a project schedule, and that corresponds to the need for schedule safety by the project manager and sponsor.

Finally, stochastic estimates foster better, more informed decision-making by organizational leaders. When organizational leaders are presented with probabilistic estimates, leaders have a range of probabilistic estimates to consider. They gain a sense of relative risk for each estimate, and they make informed, risk-based decisions about future project uncertainties.

## GETTING STARTED WITH STOCHASTIC ESTIMATION

Project managers unfamiliar with stochastic estimation may wonder how they can start creating stochastic estimates and probabilistic project forecasts? These same project managers may already be familiar the Program Evaluation and Review Technique (PERT), a stochastic estimation technique created by the United States Navy in the 1950s when the Navy developed the world's first, submarine-launched, ballistic missiles (Seymour & Hussein, 2014, p. 235). What project managers may not realize is that PERT is a stochastic estimation technique capable of approximating the mean for a bell-shaped uncertainty—like task duration or cost—using the familiar PERT formula: *Minimum + 4(Most Likely) + Maximum / 6*. However, the PERT mean is only about 50 percent reliable (the actual reliability depends on the skew and kurtosis of the implied bell-shaped curve).

Another, easy way to get started with stochastic estimation is to use Statistical PERT®[1]. Statistical PERT is a freely-licensed, probabilistic estimation technique that relies upon the built-in statistical functions of Microsoft Excel®. The Normal Edition of Statistical PERT uses Excel's two normal distribution functions, NORM.DIST and NORM.INV, and the Beta Edition of Statistical PERT uses Excel's two beta distribution functions, BETA.DIST and BETA.INV. Neither edition requires special software beyond Excel, but the Normal Edition is easier to modify. The Normal Edition is suitable for any project uncertainty that has bell-shaped properties and is either symmetrically shaped or mildly-to-moderately skewed.

Statistical PERT Normal Edition was presented to project managers at the 2016 Project Management Institute's Global Congress (Davis, 2016). This technique uses five steps to create stochastic estimates[2]. The five steps are:

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)

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[1] https://www.statisticalpert.com

[2] Using a freely available Statistical PERT spreadsheet template eliminates the need to manually perform steps 2 and 4.

4) Create a Statistical PERT standard deviation
5) Choose a planning estimate per a specified confidence level

Statistical PERT is a simple way to create probabilistic estimates and range forecasts of project uncertainties, like project finish date or the project budget. The technique takes advantage of the built-in statistical functions of Excel, so every project manager can begin experimenting with probabilistic forecasts for their projects.

When the need for greater accuracy arises, or when a project's complexity is too great for simple estimation techniques like PERT and Statistical PERT, project managers can use computer-based simulation models (often called Monte Carlo simulation). However, Monte Carlo simulation requires time to construct and calibrate, a deep knowledge of statistical functions and probability distributions, and the software is expensive to purchase. Nevertheless, Monte Carlo simulation affords project teams a sophisticated way to forecast uncertain project outcomes similarly to the way weather forecasters forecast the future path of hurricane.

## CONCLUSION

Deterministic project estimates are commonly created by project managers, but such estimates do little to align the expectations of their project sponsors and other key stakeholders. Project predictions do not indicate how likely they are to occur, and they do not lead to informed decision-making by organizational leaders.

In contrast, stochastic project estimates have a calculated reliability value (confidence level) to indicate how likely they are succeed. Stochastic estimates align stakeholder expectations because the expected reliability of each estimate is calculated and disclosed to project stakeholders. Stochastic estimates support organizational and project risk policies, so project estimates are neither too risky nor too conservative. Additionally, stochastic estimates permit dynamic, right-sized project buffering (rather than just adding 5 or 10 percent to the project timeline or budget), so project schedules and budgets are safeguarded without wasting organizational resources. Finally, stochastic estimation supports better, more informed decision-making by organizational leaders.

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