

Quantitative Risk Analysis with Microsoft® Project

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Abstract

Quantitative Risk Analysis has become an important component of project management. According to *Guide to the Project Management Body of Knowledge* (PMBOK® Guide, Fifth edition 2013, Project Management Institute) “Quantitative Risk Analysis is performed on risks that have been prioritized by the Qualitative Risk Analysis process as potentially and substantially impacting project ‘s completing demands. The Quantitative Risk Analysis process analyzes the effect of those risk events and assigns a numerical rating to those risks.”

Microsoft Project has a qualitative risk analysis methodology capability But what about quantitative cost and schedule risk analysis? Quantitative risk analysis gives the project manager the ability to see how a project schedule will be affected if project risks become issues. As a result of this insight, project managers are implement risk responses plans which mitigate risk and therefore improve the management of their projects.

PERT Analysis in Microsoft Project

Up to version 2007, Microsoft Project had an built in schedule risk analysis capability using PERT (Program Evaluation and Review Technique). Though later versions of Microsoft Project (2010, 2013) do not have this capability, we have included this discussion as many organizations still use the earlier versions. The PERT model was developed in 1950s to address uncertainty in the estimation of project parameters. According to classic PERT, the expected task duration is calculated as the weighted average of the most optimistic, the most pessimistic, and the most likely time estimates. The expected duration of any path on the precedence network can be found by summing up the expected durations.

Using PERT in Microsoft Project 2007 (and earlier) is very easy using the PERT toolbar. To enable the PERT toolbar: on the View menu, click the Toolbars menu, and choose PERT Analysis (see Figure 1).

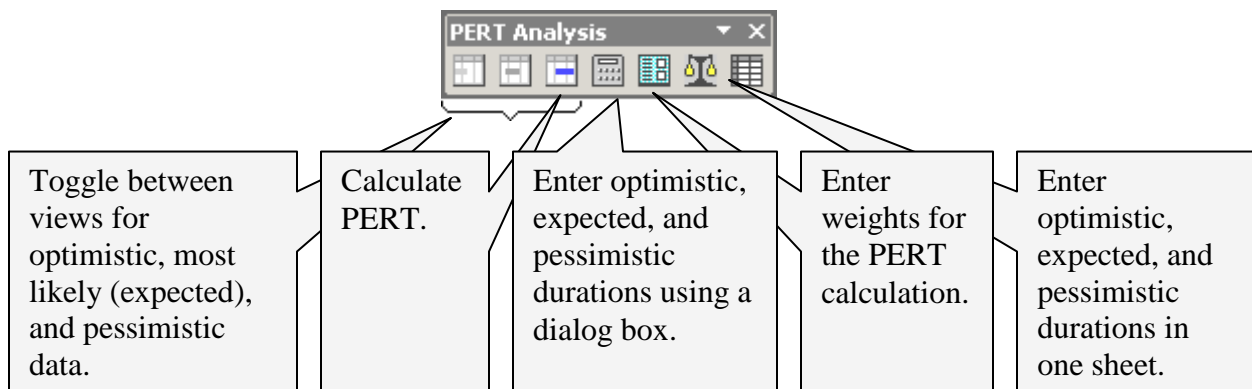


Figure 1: PERT Analysis toolbar in Microsoft Project

Microsoft Project has four views that help you to enter data for PERT analysis: separate views for optimistic, expected, and pessimistic duration, as well as a PERT entry sheet. The most powerful view is the last one as it allows the user to enter and see all durations together. After you enter the task estimates, press the **Calculate PERT** button on the toolbar. Calculations are performed based on optimistic, expected, and pessimistic durations. You will see results of the calculation in the **Gantt Chart** view.

The classic PERT methodology has a number of limitations. The main problem is associated with accurately estimating the optimistic, most likely, and pessimistic durations of the task. Another problem with classic PERT is that it gives accurate results only if there is a single dominant path through the precedence network. If there are a number of parallel paths through the network, it generally provides an overly optimistic estimate. We recommend using the classical PERT model for schedule risk analysis if you have accurate estimations for optimistic, most like and pessimistic durations based on reliable historical data and if your project has a single dominant path through the network.

Monte Carlo Simulation Tools

To overcome the challenges associated with the PERT method, Monte Carlo simulations can be used as an alternative to perform schedule risk analysis. Monte Carlo is a mathematical method used on risk analysis in many areas and is used to approximate the distribution of potential results based on probabilistic inputs. Each simulation is generated by randomly pulling a sample value for each input variable from its defined probability distribution, e.g. uniform, normal, lognormal, triangular, beta, etc. These input sample values are then used to calculate the results, i.e. total project duration, total project cost, project finish time. The inputs can be task duration, cost, start and finish time, etc. This procedure is then repeated until the probability distributions are sufficiently well represented to achieve the desired level of accuracy. They are used to calculate the critical path, slack values, etc. Monte Carlo simulations are an effective methodology for the analysis of project schedules with uncertainties.

To use Monte Carlo simulations with Microsoft Project you need to have add-on tool. RiskyProject from Intaver Institute (www.intaver.com) is one such tool. This and similar software tools will help you find answer on the questions such as:

- What is the chance of your project will be completed on schedule and within budget?
- What is the chance that the particular task will be on the critical path?
- What tasks may have the most effect on project duration?
- What is the project success rate?

Every Monte Carlo simulation tool has its own specific functionalities; however, some features are common for all of them. These tools use different statistical distributions including custom distributions are assigned to project inputs (task duration, cost, etc.), they perform a Monte Carlo simulation, and output the results of the simulation is several common formats. For example, you can use a frequency or cumulative probability charts or histograms to see the chance that the project will be completed within a given period of time (see Figure 2). You can calculate the criticality index or probability that a task lies on the critical path.

project outputs (project duration, cost, risks, finish times, etc.) are to the uncertainties of th You can perform a sensitivity analysis to understand how sensitive the project duration is to the inputs (task duration, finish time, etc.). The results of a sensitivity analysis can be shown on a Tornado chart (Figure 3). The tasks which are listed highest on the chart have the most potential to affect project duration.

Monte Carlo simulation tools may offer features such as probabilistic or conditional branching. An example of probabilistic branching is when a user defines that there is 40% chance that task B will be successor of task A and 60% chance that task C will be successor of task A. An example of conditional branching is when the user defines that task A task will be followed by task B, if task A duration is greater or less then a certain value.

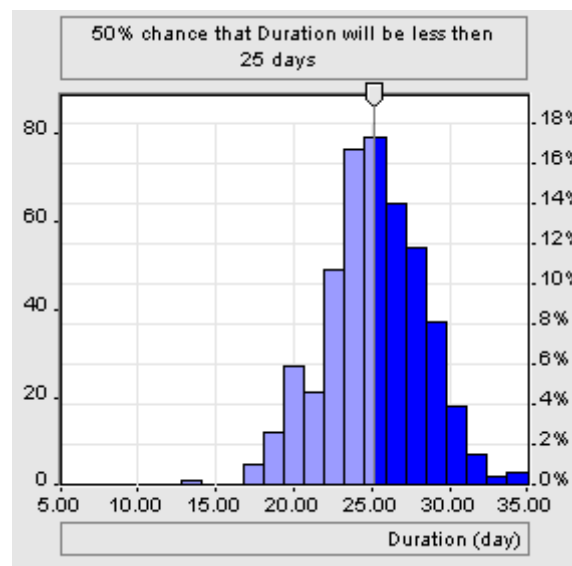


Figure 2: Frequency charts can be used to assess the chance that project will be completed within a given period of time








| | Name | Sensitivity Chart | Coeffici... | |
|---|--|--|-------------|--|
| 1 | Task Web site development |  | 0.671 | |
| 2 | Task Web site content development |  | 0.671 | |
| 3 | Task Writing information topics |  | 0.652 | |
| 4 | Task Beta testing (by three selected clients) |  | 0.558 | |
| 5 | Task Web Site Design |  | 0.285 | |
| 6 | Task Web site layout and structure design |  | 0.185 | |
| 7 | Task Evaluation and purchase of web site templates |  | 0.171 | |

Figure 3: Results of sensitivity analysis

The classic Monte Carlo simulation method has a number of limitations. Statistical distributions of project inputs such as task duration should be obtained based on reliable historical data and in many cases this data is not available. For example, a project manager usually knows that particular construction job will take between 1 and 3 days and can be defined by a Normal distribution. However, in some cases, especially in research and development projects, this information is not available and using Monte Carlo simulation may not improve your forecasts. It is also very important to constantly track your project performance and update input data and associated distributions using performance measurement data. Another problem associated with Monte Carlo simulations is that, if a project slips, project managers usually perform certain actions. It is difficult to define and forecast the management response within a Monte Carlo simulation method.

To overcome these and other challenges Event Chain Methodology has been developed as an extension of the classic Monte Carlo simulations for schedule risk analysis. Project uncertainties can be defined as a set of risks or probabilistic events (risk lists), which can be assigned to tasks, resources, or the entire schedule. These events can occur during the execution of a task and can lead to a delay, restart, cancellation, etc. Events can cause other events and generate event chains. Project managers can monitor these events, determine the critical risks – those that have the most potential to affect project schedules - and mitigate them. Event Chain Methodology allows you to perform quantitative schedule risk analysis analysis by combining a project schedule with its associated risk register.

You do not need to be a statistician to perform a Monte Carlo simulation with Microsoft Project. These tools like RiskyProject and similar quantitative risk analysis software are designed for project managers who want to bring the power of quantitative schedule risk analysis to bear on their project and have been successfully used by project managers in different industries for years.