Quantitative Risk Analysis with Microsoft Project

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Quantitative Risk Analysis has become an important component of project management. According to *Guide to the Project Management Body of Knowledge* (PMBOK ® Guide, Third edition 2004, 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 implements Qualitative Risk Analysis methodology. But what about quantitative analysis? Quantitative Risk Analysis gives the project manager ability to see how project schedule will be affected if certain risks are occur. As a result, project managers are able to mitigate risk factors and manage their projects better.

PERT Analysis in Microsoft Project

Microsoft Project implements one the Quantitative Risk Analysis technique PERT (Program Evaluation and Review Technique). The PERT model was developed in 1950s to address uncertainty in the estimation of project parameters. According to classic PERT, 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 is very easy using the PERT toolbar. To enable the PERT toolbar on the View menu, from the Toolbars menu, choose PERT Analysis (see Figure 1).

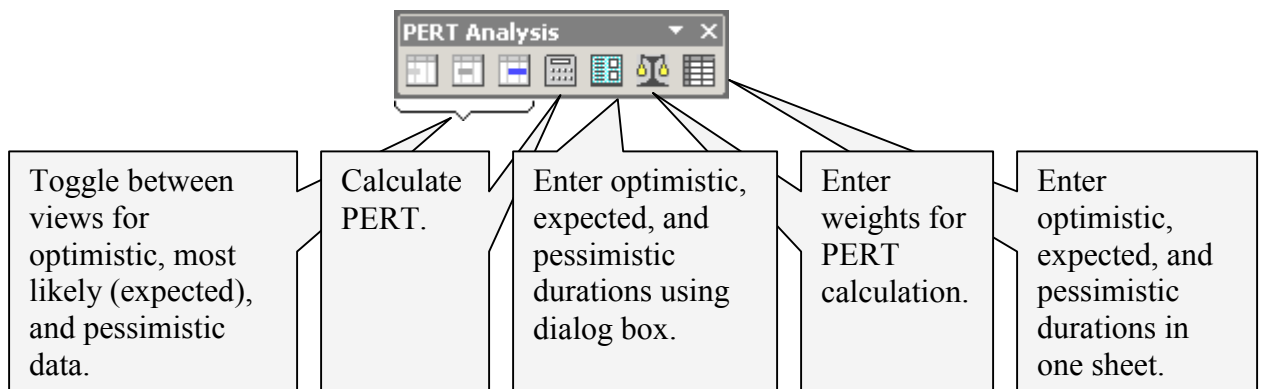| Toggle between views for optimistic, most likely (expected), and pessimistic data. | Calculate PERT. | Enter optimistic, expected, and pessimistic durations using dialog box. | Enter weights for PERT calculation. | Enter optimistic, expected, and pessimistic durations in one sheet. |

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 project data, 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 a precedence network. If there are a number of parallel paths through the network it gives an overly optimistic estimation. We recommend using the classical PERT model for quantitative 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. 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 have been proven an effective methodology for the analysis of project schedule with uncertainties.

To use Monte Carlo simulations with Microsoft Project you need to have add-on tool. There are a number of such tools available on market including @RISK for Project from Palisade Corporation (www.palisade.com), RiskyProject from Intaver Institute (www.intaver.com), Pertmaster software from Pertmaster Limited (www.pertmaster.com), Risk+ from S/C Solutions Inc. (www.cs-solutions.com). These software tools will help you find answer on the questions such as:

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

Each Monte Simulation tool has its own specific functionalities; however, some features are common for all of them. First, all of these software allow the user to: assign different statistical distributions including custom distributions to project inputs (task duration, cost, etc.), perform Monte Carlo simulation, and output results in different 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 tasks.

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

Monte Carlo simulation tools may offer features such as probabilistic or conditional branching. An example of probabilistic branching is when the user defines that there is 40% chance that task A will be successor of task B and 60% chance that task C will be successor of task B. 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.
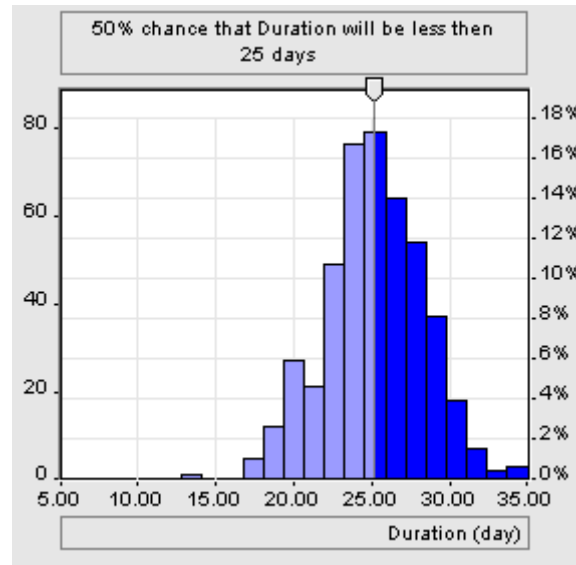
Figure 2: Frequency chart can be used to assess the chance that project will be completed within a given period of time

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 durations should be obtained based on reliable historical data and in many cases this data is available. For example, a project manager usually knows that particular construction job will task between 1 and 3 days and can be defined by normal distribution. However, in some cases, especially for research and development projects, this information is not available and using Monte Carlo simulation may not improve your estimations. 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 simulation method. Project uncertainties can be defined as a set of risks or probabilistic events (risk lists), which can be assigned to tasks, resources, or project schedule. Such events can occur at the middle of the task and can lead to task delay, restart, cancellation, etc. Events can cause other events and generate event chains. Project managers cam monitor these events, determine the critical risks - which affect project schedules the most - and mitigate them. Event Chain Methodology allows you to perform Quantitative Risk Analysis by combining project schedule and risk lists.

You do not need to be a statistician to use Monte Carlo simulation tools with Microsoft Project. They are designed for project managers who want to bring the power of Quantitative Risk Analysis to the project. Project managers are successfully using such tools in different industries for years.