

DYNAMIC PROJECT MANAGEMENT WITH COST AND SCHEDULE RISK

In the world of project management, there are essentially two major sources of risks: schedule risk and cost risk. In other words, will the project be on time and under budget, or will there be a schedule crash and budget overrun, and, if so, how bad can they be? To illustrate how quantitative risk management can be applied to project management, we use ROV PEAT to model these two sources of risks.

To follow along, start the PEAT software, select the *Project Management--Dynamic Cost and Schedule Risk* module, and *Load Example*. We begin by illustrating a simple linear path project in the *Simple Linear Path 1* tab (Figure 1). Note that users can click on the Projects menu to add additional projects, or delete and rename existing projects. The example loaded has 5 sample predefined projects. In this simple linear path project, there are 11 sample tasks in this project and each task is linked to its subsequent tasks linearly (i.e., Task 2 can only start after Task 1 is done, and so forth). For each project, a user has a set of controls and inputs:

- *Sequential Path versus Complex Network Path*. The first example illustrated uses the sequential path, which means there is a simple linear progression of tasks. In the next example, we will explore the complex network path where tasks can be executed linearly, simultaneously, and recombined at any point in time.
- *Fixed Costs*. The fixed costs and their ranges suitable for risk simulation (minimum, most likely, maximum) are required inputs. These fixed costs are costs that will be incurred regardless if there is an overrun in schedule (the project can be completed early or late but the fixed costs will be the same regardless).
- *Time Schedule*. Period-specific time schedule (minimum, most likely, maximum) in days, weeks, or months. Users will first select the periodicity (e.g., days, weeks, months, or unitless) from the droplist and enter the projected time schedule per task. This schedule will be used in conjunction with the variable cost elements (see next bullet item), and will only be available if the *Include Schedule-Based Cost Analysis* is checked.
- *Variable Cost*. This is the variable cost that is incurred based on the time schedule for each task. This variable cost is per period and will be multiplied by the number of periods to obtain the total variable cost for each task. The sum of all fixed costs and variable costs for all tasks will of course be the total cost for the project (denoted as *Project Total Cost*).
- *Overrun Assumption*. This is a percent budget buffer or cushion to include in each task. This column is only available and used if the *Include Budget Overruns and Buffers* checkbox is selected.
- *Probability of Success*. This allows users to enter the probability of each task being successful. If a task fails, then all subsequent tasks will be canceled and the costs will not be incurred, as the project stops and is abandoned. This column is available and will be used in the risk simulation only if the *Include Probabilities of Success* checkbox is selected.
- *Run*. The run button will perform the relevant computations based on the settings and inputs, and also run risk simulations if the *Perform Risk Simulation* checkbox is selected (as well as the requisite simulation settings such as distribution type, number of trials, and seed value settings are entered appropriately). This will run the current project's model. If multiple projects need to

be run, you can first proceed to the *Portfolio Analysis* tab and click on the *Run All Projects* button instead.

To see which of these input assumptions drive total cost and schedule the most, a tornado analysis can be executed (Figure 2). The model can then be risk simulated and the results show probability distributions of cost and schedule (Figure 3). For instance, the sample results show that for Project 1, there is a 95% probability that the project can be completed at a cost of \$397,929. The expected median or most likely value was originally \$377,408 (Figure 1). With simulation, it shows that to be 95% sure that there are sufficient funds to complete the project, an additional buffer of \$20,521 is warranted.

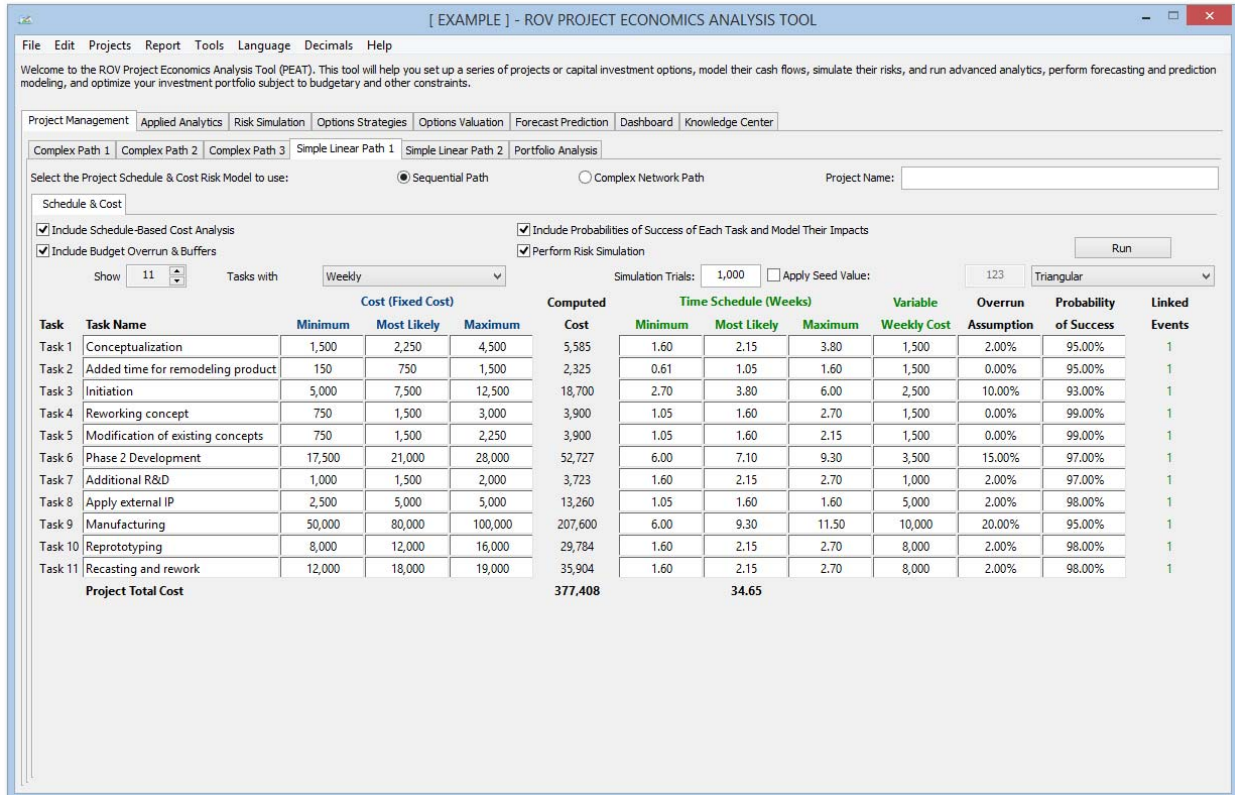


FIGURE 1 Simple linear path project management with cost and schedule risk.

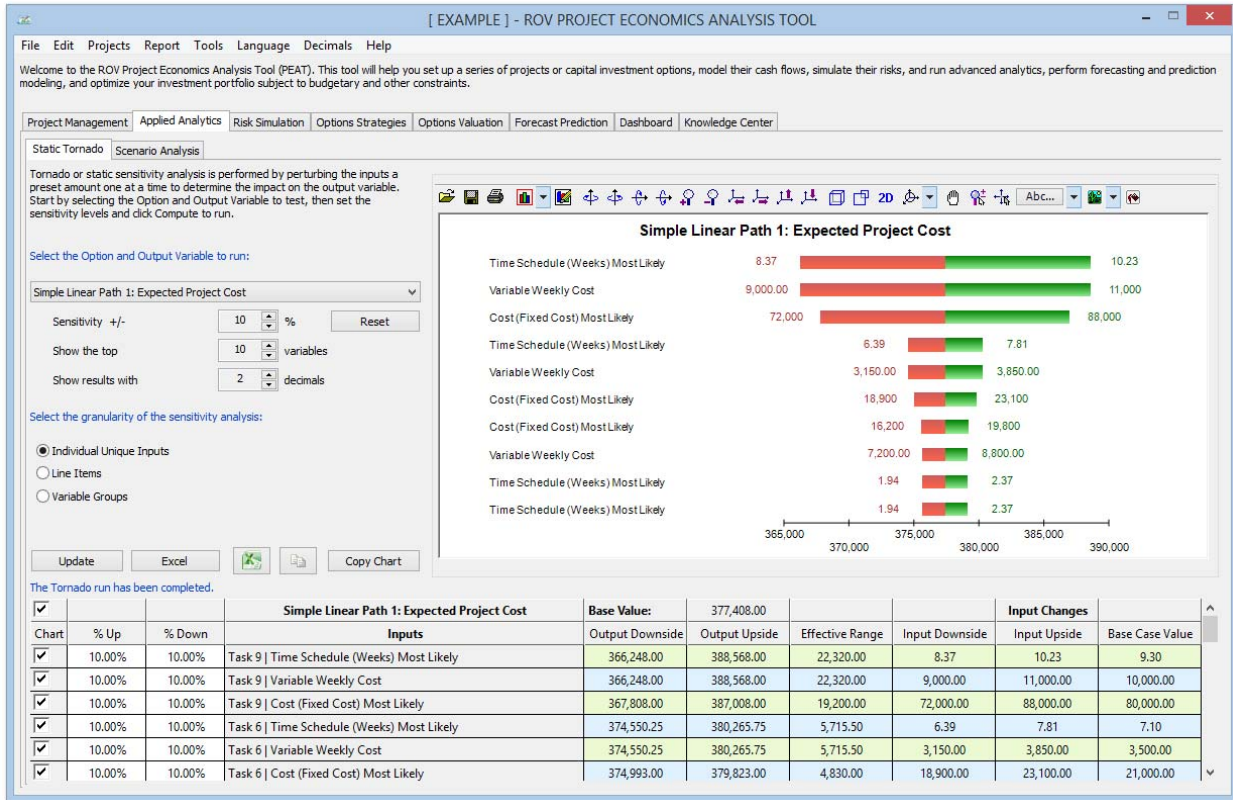


FIGURE 2 Simple linear path tornado analysis.

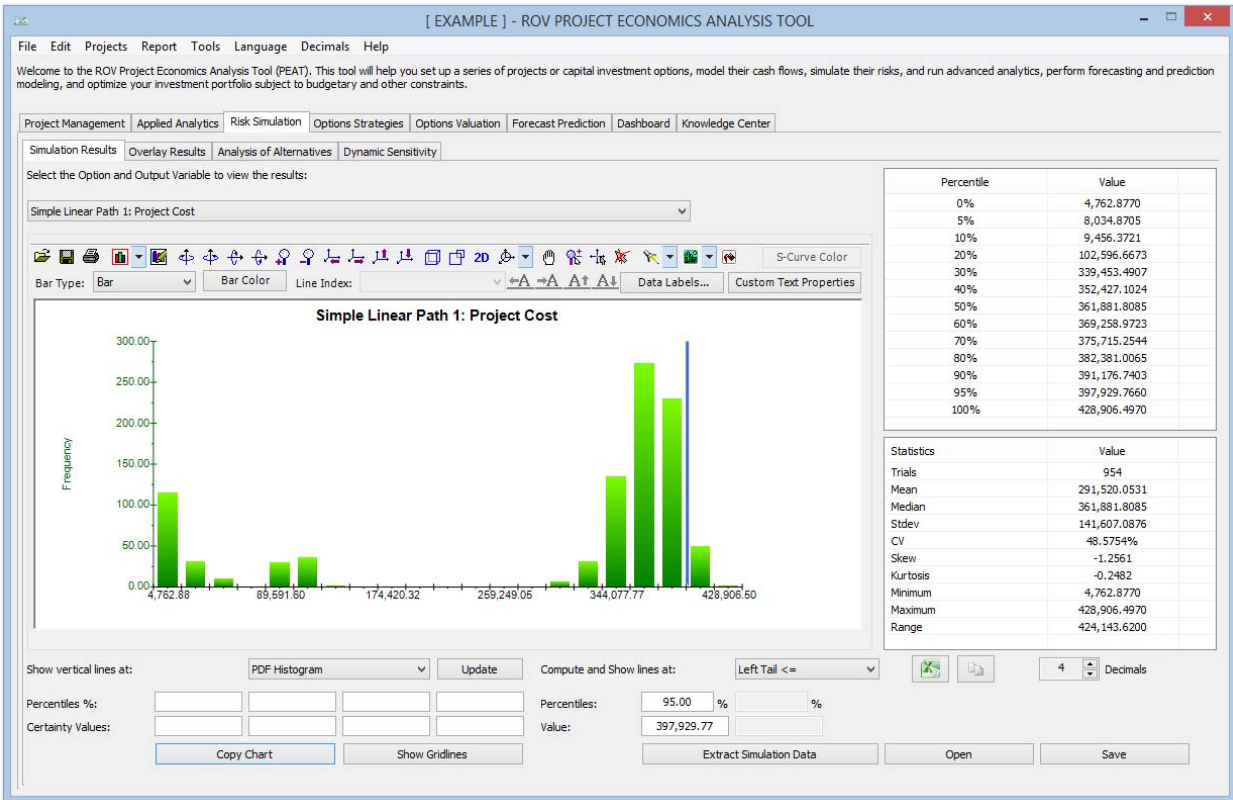


FIGURE 3 Monte Carlo risk simulated results for risky cost and schedule values.

In complex projects where there are nonlinear bifurcating and recombining paths (Figure 4), the cost and schedule risk modeling is more difficult to model and compute. For instance, in the *Complex Path 1* tab, we can see that after Task 1, future tasks can be run in parallel (Tasks 2, 3, and 4). Then, Tasks 3 and 4 recombine into Task 8. Such complex path models can be created by the user simply by adding tasks and combining them in the visual map as shown. The software will automatically create the analytical financial model when *Create Model* is clicked. That is, you will be taken to the *Schedule & Cost* tab and the same setup as shown previously is now available for data entry for this complex model (Figure 5). The complex mathematical connections will automatically be created behind the scenes to run the calculations so that the user will only need to perform very simple tasks of drawing the complex network path connections. Below are some tips on getting started:

- Start by adding a new project from the *Projects* menu. Then, click on the *Complex Network Path* radio selection to access the *Network Diagram* tab.
- Use the icons to assist in drawing your network path. Hover your mouse over the icons to see their descriptions. You can start by clicking on the third icon to *Create a Task*, and then click anywhere in the drawing canvas to insert said task.
- With an existing task clicked on and selected, click on the fourth icon to *Add a Subtask*. This will automatically create the adjoining next task and next task number. You then need to move this newly inserted task to its new position. Continue with this process as required to create your network diagram. You can create multiple subtasks off a single existing task if simultaneous implementations occur.
- You can also recombine different tasks by clicking on one task, then holding down the *Ctrl* key, click on the second task you wish to join. Then click on the fifth icon to *Link Tasks* to join them. Similarly, you can click on the sixth icon to *Delete Link* between any two tasks.
- When the network diagram is complete, click on *Create Model* to generate the computational algorithms where you can then enter the requisite data in the *Schedule & Cost* tab as described previously.

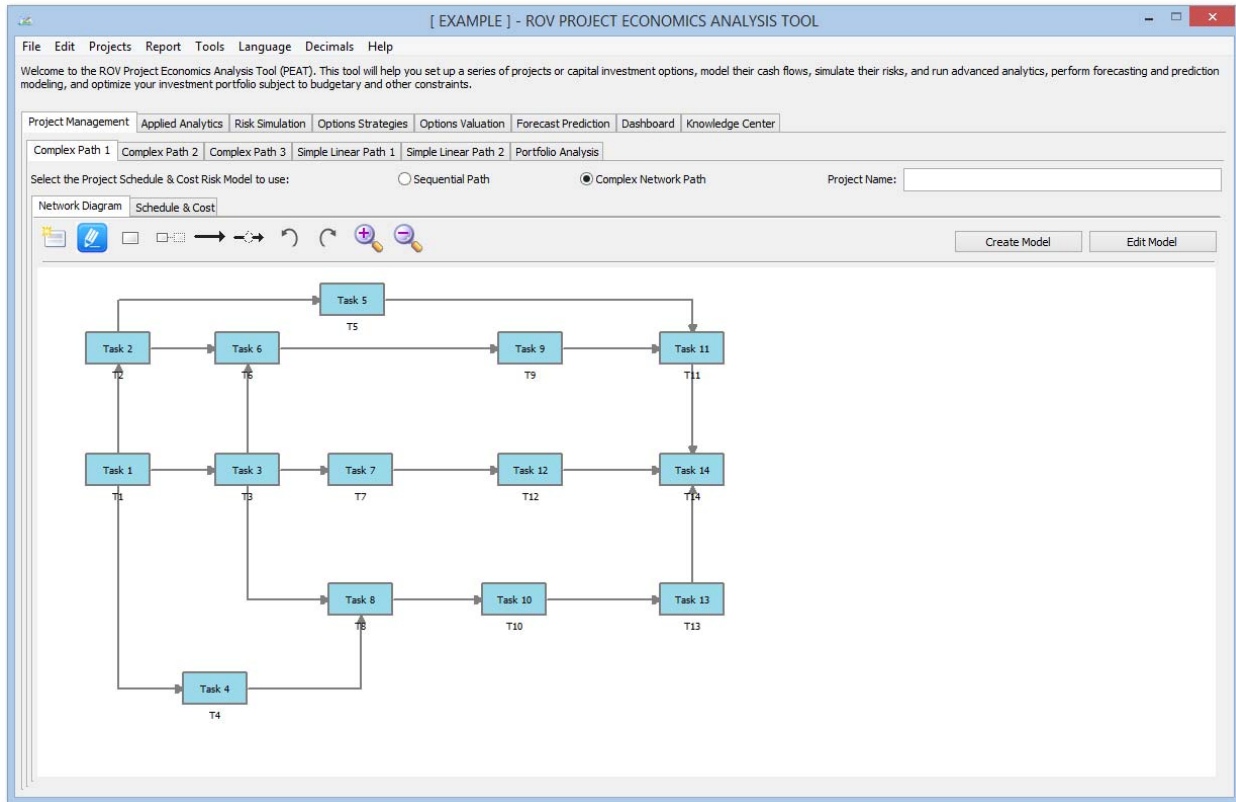


FIGURE 4 Complex path project management.

The screenshot displays the 'Schedule & Cost' model in the ROV Project Economics Analysis Tool. The table below shows the results of the simulation, including cost and duration data for each task and the overall project. The critical path is T1, T3, T7, T10, T14.

Task	Task Name	Cost (Fixed Cost)			Computed Cost	Time Schedule (Weeks)			Variable Weekly Cost
		Minimum	Most Likely	Maximum		Minimum	Most Likely	Maximum	
Task 1	T1	34	39	47	800	34	39	47	19.5
Task 2	T2	17	32	37	544	17	32	37	16
Task 3	T3	21	41	48	882	21	41	48	20.5
Task 4	T4	24	27	36	392	24	27	36	13.5
Task 5	T5	25	32	34	544	25	32	34	16
Task 6	T6	29	35	46	648	29	35	46	17.5
Task 7	T7	31	37	37	722	31	37	37	18.5
Task 8	T8	14	20	24	220	14	20	24	10
Task 9	T9	24	38	39	950	30	48	55	19
Task 10	T10	24	38	40	760	24	38	40	19
Task 11	T11	9	12	16	84	9	12	16	6
Task 12	T12	30	31	45	512	30	31	45	15.5
Task 13	T13	40	42	61	924	40	42	48	21
Task 14	T14	16	17	22	162	16	17	22	8.5
Project Total Cost					8,141				
Expected Total Duration						197.00			
Critical Path 1, 3, 8, 10, 13-14					56.30%				
Critical Path 1, 3, 6, 9, 11, 14					29.70%				
Critical Path 1, 4, 8, 10, 13-14					9.30%				

FIGURE 5 Complex project simulated cost and duration model with critical path.

After running the model, the complex path map shows the highlighted critical path (Figure 6) of the project, that is, the path that has the highest potential for bottlenecks and delays in completing the project on time. The exact path specifications and probabilities of being on the critical path is seen in Figure 5 (e.g., there is a 56.30% probability that the critical path will be along Tasks 1, 3, 8, 10, 13, 14).

If there are multiple projects or potential project path implementations, the portfolio view (Figure 7) compares all projects and implementation paths for the user to make a better and more informed risk-based decision. The simulated distributions can also be overlaid (Figure 8) for comparison.

Figure 7 allows users to see all projects that were modeled at a glance. Each project modeled can actually be different projects or the same project modeled under different assumptions and implementation options (i.e., different ways of executing the project), to see which project or implementation option path makes more sense in terms of cost and schedule risks. The *Analysis of Alternatives* radio selected allows users to see each project as standalone (as compared to *Incremental Analysis* where one of the projects is selected as the base case and all other projects' results show their differences from the base case), in terms of cost and schedule: single-point estimate values, simulated averages, the probabilities each of the project will have a cost or schedule overrun, and the 90th percentile value of cost and schedule. This *Portfolio Analysis* tab also charts the simulated cost and schedule values using bubble and bar charts for a visual representation of the key results.

Of course more detailed analysis can be obtained from the *Risk Simulation | Simulation Results* tab (Figure 8), where users can view all the simulation statistics and select any confidence and percentile values to show. Refer to Dr. Johnathan Mun's *Modeling Risk (3rd Edition)* Chapter 5 for more detailed discussions and explanations of risk-based decision using probability distributions, confidence levels, and percentiles.

The *Overlay* chart in Figure 9 shows multiple projects' simulated costs or schedules overlaid on top of one another to see their relative spreads, location, and skew of the results. We clearly see that the project whose distribution lies to the right has a much higher cost to complete than the left, with the project on the right also having a slightly higher level of uncertainty in terms of cost spreads. Refer to Dr. Johnathan Mun's *Modeling Risk (3rd Edition)* Chapter 5 and Technical Note 1 for more details on interpreting these PDF and CDF charts, as well as how to make better and more informed decisions using their results.

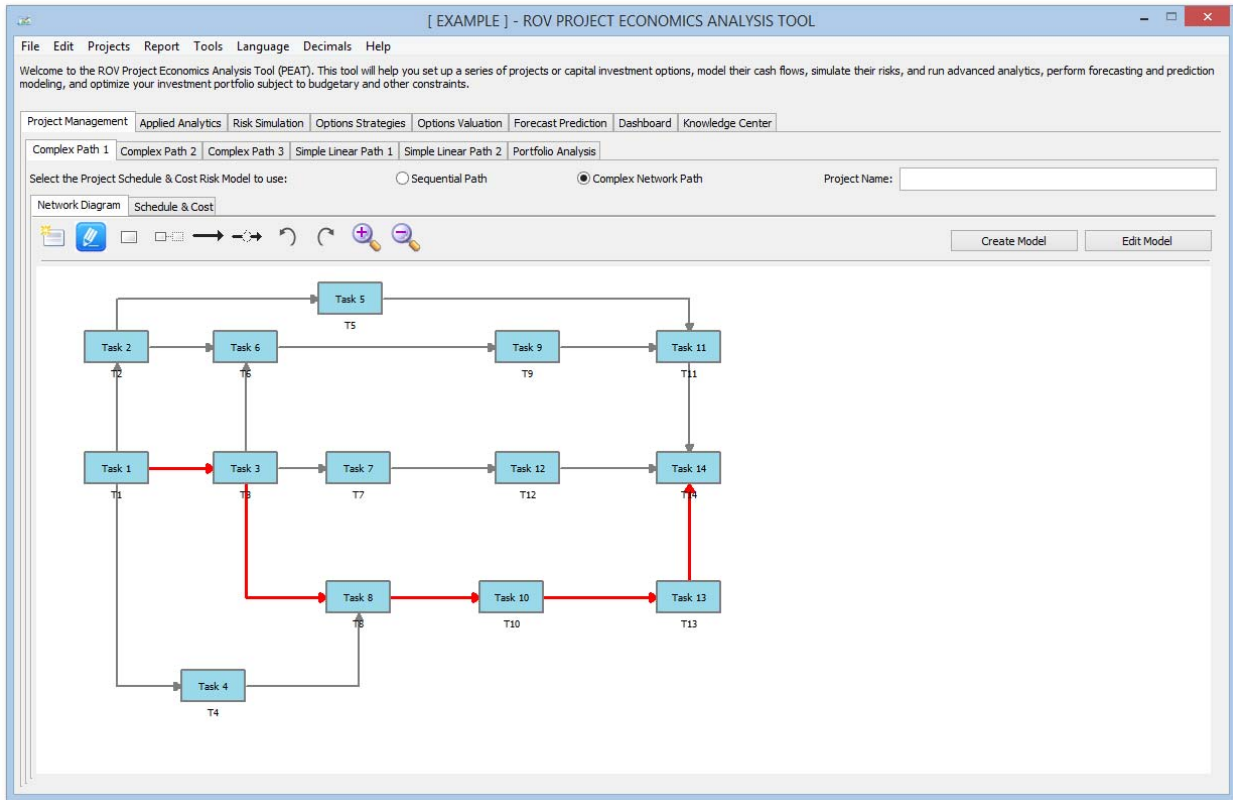


FIGURE 6 Complex project critical path.

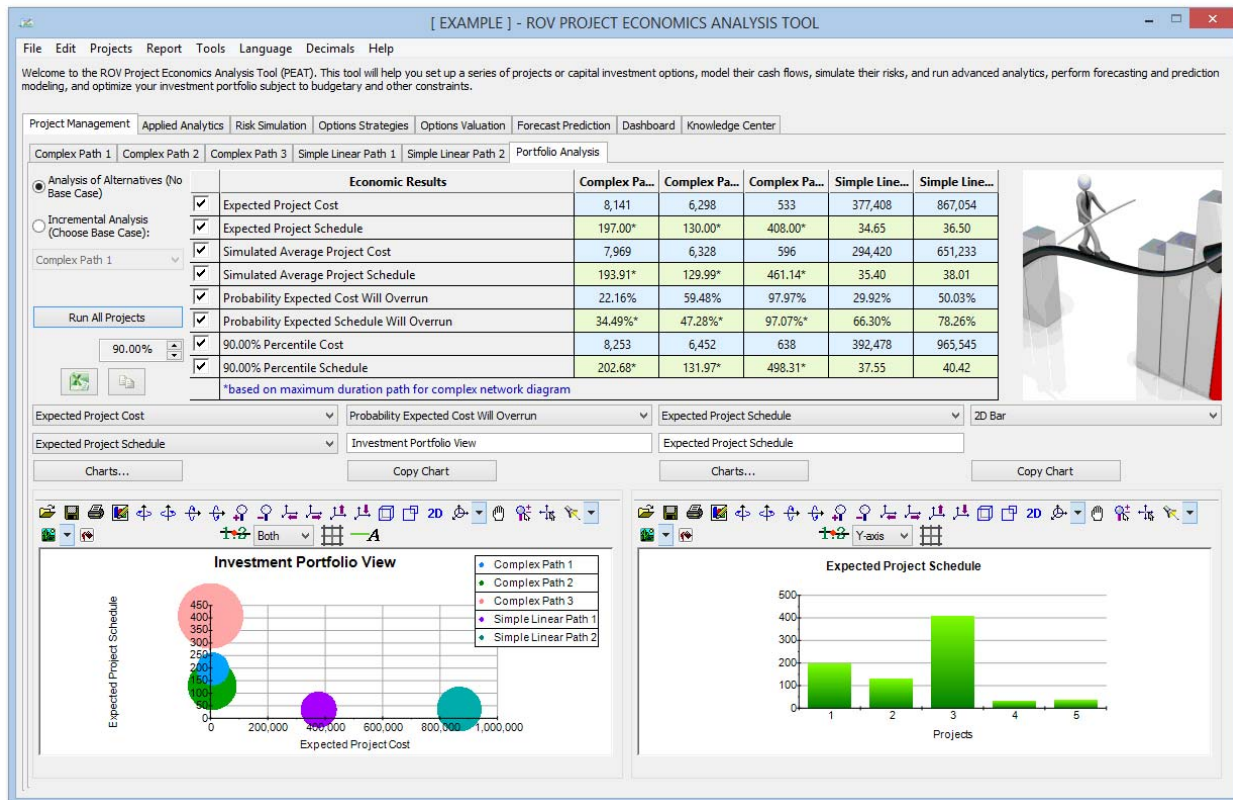


FIGURE 7 Portfolio view of multiple projects at once.

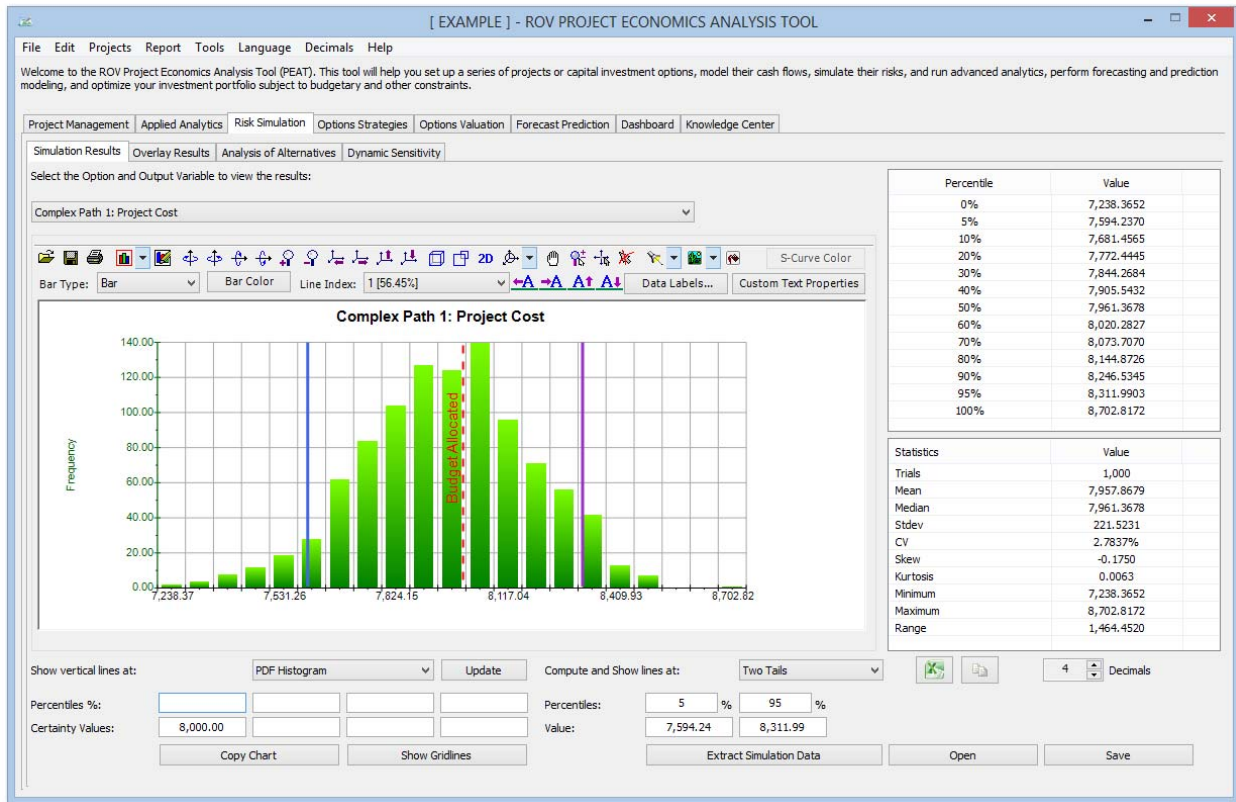


FIGURE 8 Risk Simulated results on project cost and schedule.

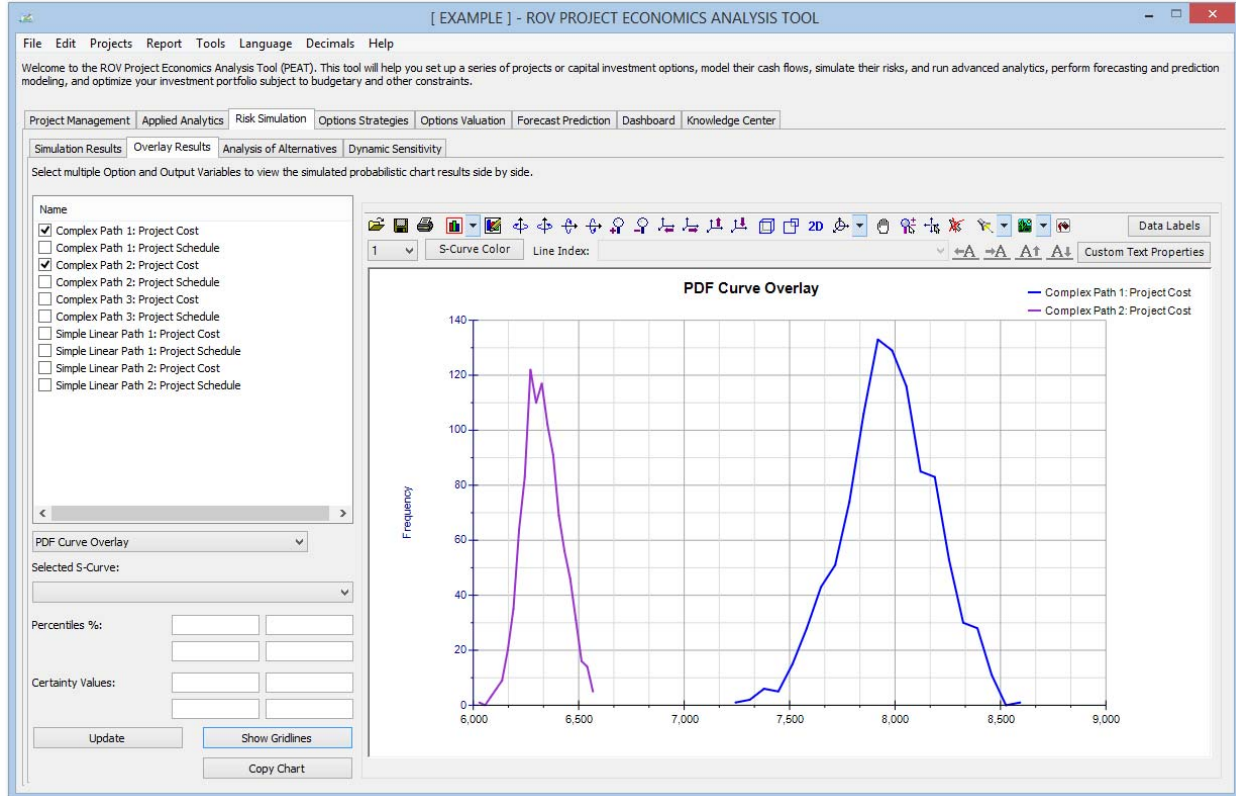


FIGURE 9 Overlay charts of multiple projects' cost or schedule.

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