

Project Management

Short Examples Series

using

Risk Simulator



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Project Management – Cost Estimation Model

File Name: *Project Management – Cost Estimation Model*

Location: *Modeling Toolkit | Project Management | Cost Estimation Model*

Brief Description: *This model illustrates how to use Risk Simulator for running a Monte Carlo simulation on a multiphased project to forecast costs and cost overruns, simulating discrete events (success/failure and go/no-go outcomes), linking these events, and linking the input parameters in a simulation assumption to calculated cells*

Requirements: *Modeling Toolkit, Risk Simulator*

This is a cost estimation model used to forecast the potential cost and cost overruns of a multi-phased project, using simulation, where the later phases of the project will depend on the earlier phases. That is, you cannot proceed to the second phase unless the first phase is successful and so forth.

In this example, the model estimates the total cost of a project with 5 phases, where at each phase, there might be several sub-phases. For each phase or sub-phase, the minimum, maximum, and most likely estimates of costs are obtained and simulated (Figure 1). These cost estimates depend on the forecasts of weeks required in each phase and the cost per week. These costs are simulated through parameter linking to Triangular distributions. For instance, the cells in column G are distributional assumptions linked to columns H, I and J. In addition, the estimates of minimum, likely, and maximum costs in these columns depend on the estimates of time to completion and cost per week in columns L to O. Cost overruns in each phase and their chances are also simulated in column P. A probability of success is estimated based on past experience and subject matter expert estimates, listed in column Q. Using these projections of project success/failure, Bernoulli distributions are set up in column R to simulate the discrete event of a success (1) or failure (0). We then link these events in column S where only if the previous period is successful will the current phase continue assuming that it too is successful. Otherwise, if the previous phase was a failure, all future phases are canceled and the project stops at that point. Finally, the values in column K are the expected values after accounting for the simulated results of time to completion, cost per week, overrun estimates, and success or failure of each phase.

Work Breakout Structure	Cost				Time in Weeks				Overrun Assumption	Probability of Success	Success/Failure	Linked Events	
	Assumption	Minimum	Likely	Maximum	Cost	Minimum	Likely	Maximum					Unit Cost
	Phase 1 Conceptualization	\$2,250	\$1,500	\$2,250	\$4,500	\$2,295	1	1.5					3
Added time for remodeling product	\$750	\$150	\$750	\$1,500	\$750	0.1	0.5	1	\$1,500	0%	95%	1	1
Phase 2 Initiation	\$7,500	\$5,000	\$7,500	\$12,500	\$8,250	2	3	5	\$2,500	10%	93%	1	1
Reworking concept	\$1,500	\$750	\$1,500	\$3,000	\$1,500	0.5	1	2	\$1,500	0%	99%	1	1
Modification of existing concepts	\$1,500	\$750	\$1,500	\$2,250	\$1,500	0.5	1	1.5	\$1,500	0%	99%	1	1
Phase 3 Development	\$21,000	\$17,500	\$21,000	\$28,000	\$24,150	5	6	8	\$3,500	15%	97%	1	1
Additional R&D	\$1,500	\$1,000	\$1,500	\$2,000	\$1,530	1	1.5	2	\$1,000	2%	97%	1	1
Apply external IP	\$5,000	\$2,500	\$5,000	\$5,000	\$5,700	0.5	1	1	\$5,000	2%	98%	1	1
Phase 4 Manufacturing	\$80,000	\$50,000	\$80,000	\$100,000	\$96,000	5	8	10	\$10,000	20%	95%	1	1
Reprototyping	\$12,000	\$8,000	\$12,000	\$16,000	\$12,240	1	1.5	2	\$8,000	2%	98%	1	1
Recasting and rework	\$12,000	\$8,000	\$12,000	\$16,000	\$12,240	1	1.5	2	\$8,000	2%	98%	1	1
Phase 5 Market	\$150,000	\$120,000	\$150,000	\$240,000	\$165,000	4	5	8	\$30,000	10%	90%	1	1
Additional market research	\$20,000	\$10,000	\$20,000	\$30,000	\$22,000	1	2	3	\$10,000	10%	95%	1	1
Repositioning	\$30,000	\$20,000	\$30,000	\$50,000	\$33,000	2	3	5	\$10,000	10%	95%	1	1
Grand Total Cost					\$385,555								

Figure 1: Cost estimation a multi-phased project

Procedure

To run the model, simply:

1. Go to the *Model* worksheet and click on **Risk Simulator | Change Profile** and select the *Cost Estimation Model* profile.
2. Run the simulation by clicking on **Risk Simulator | Run Simulation**.

The forecast chart (Figure 2) results show a trimodal distribution (a distribution with three peaks) because of the discrete event simulation we ran (i.e., the success and failure probabilities). The right-tail probability past the single point estimate is found to be 44.50%. This means that there is a 44.50% probability that the expected total cost of this project of \$385,555 is not going to be enough (click on **Right-Tail** and enter **385555** then hit **Tab** on the keyboard). Therefore, to be 95% certain there are adequate funds to cover the cost of the project, you need \$457,006 (click on **Left-Tail** and enter **457006** then hit **Tab** on the keyboard).





Figure 2: Simulated cost outputs

Project Management – Critical Path Analysis (CPM PERT GANTT)

File Name: *Project Management – Critical Path Analysis (CPM PERT GANTT)*

Location: *Modeling Toolkit | Project Management | Critical Path Analysis (CPM PERT GANTT)*

Brief Description: *This model illustrates how to use Risk Simulator for running simulations on time to completion of a project and critical path determination, creating GANTT charts and CPM/PERT models, simulating dates and binary variables, and linking input assumptions*

Requirements: *Modeling Toolkit, Risk Simulator*

This model illustrates how a Project Management *Critical Path Analysis* and completion times can be modeled using Risk Simulator. The typical inputs of minimum, most likely, and maximum duration of each process or subproject can be modeled using the *triangular* distribution. This distribution typically is used in the *Critical Path Method* (CPM) and *Program Evaluation Review Technique* (PERT) in project management, together with the *beta* distribution. In other words, the assumptions in the model can also take the *beta* and *gamma* distributions rather than the *triangular* distribution. However, the *beta* and *gamma* distributions are more complex for project managers to use, hence the popularity of the *triangular* distribution.

In this two-part model, the first is a CPM critical path analysis to determine the critical path as well as the expected completion time of a project (Figure 3). The second part of the model is on the same project, but we are interested in the actual potential completion date with a GANTT chart analysis (Figure 4).

Critical Path Method and Time to Market Analysis

Task Number	Predecessor	Lead/ Lag	Duration Optimistic	Duration Expected	Duration Pessimistic	Simulated Duration	Earliest Start Time	Earliest Finish Time	Last Start Time	Last Finish Time	Slack	On Critical Path 1=yes 0 = no
Start (S)						0.0	0.0	0.0	0.0	0.0		
Task 1	Start FS		10	15	20	15.0	0.0	15.0	3.0	18.0	3.0	0
Task 2	1 FS	-5	15	20	22	20.0	10.0	30.0	13.0	33.0	3.0	0
Task 3	2 FS		21	26	30	26.0	30.0	56.0	33.0	59.0	3.0	0
Task 4	2 SS	10	15	18	23	18.0	20.0	38.0	26.0	44.0	6.0	0
Task 5	4 FS		13	15	17	15.0	38.0	53.0	44.0	59.0	6.0	0
Task 6	3,5 FS		30	38	45	38.0	56.0	94.0	59.0	97.0	3.0	0
Task 7	6 FS	-5	20	25	30	25.0	89.0	114.0	92.0	117.0	3.0	0
Task 8	6 FS	5	10	15	20	15.0	99.0	114.0	102.0	117.0	3.0	0
Task 9	6 SS	20	11	18	22	18.0	76.0	94.0	99.0	117.0	23.0	0
Task 10	7,8,9 FS		23	30	45	30.0	114.0	144.0	117.0	147.0	3.0	0
Task 11	10 FS	5	22	28	39	28.0	149.0	177.0	152.0	180.0	3.0	0
Task 12	Start FS		120	140	180	140.0	0.0	140.0	0.0	140.0	0.0	1
Task 13	12 FS	-5	13	18	22	18.0	135.0	153.0	135.0	153.0	0.0	1
Task 14	13 SS	10	15	20	25	20.0	145.0	165.0	145.0	165.0	0.0	1
Task 15	14 FS		10	15	20	15.0	165.0	180.0	165.0	180.0	0.0	1
Task 16	11, 15 FS		30	33	44	33.0	180.0	213.0	180.0	213.0	0.0	1
Task 17	16 FS	5	8	11	11	8.0	213.0	221.0	213.0	221.0	0.0	1
Task 18	17 FS	10	15	25	15.0	221.0	236.0	223.0	238.0	2.0	0	
Task 19	17 FS	13	17	19	17.0	221.0	238.0	221.0	238.0	0.0	1	
Task 20	18, 19 FS		20	25	40	25.0	238.0	263.0	238.0	263.0	0.0	1
End (E)						0.0	263.0	263.0	263.0	263.0		

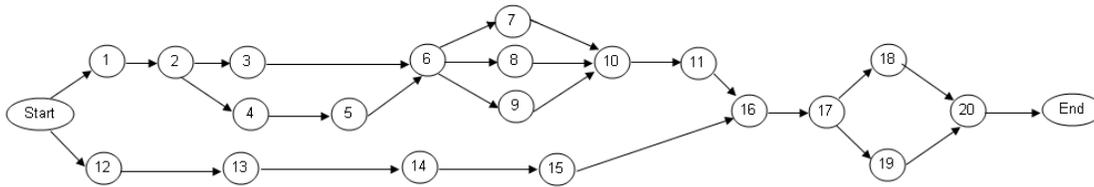


Figure 3: Critical path model and time to market analysis

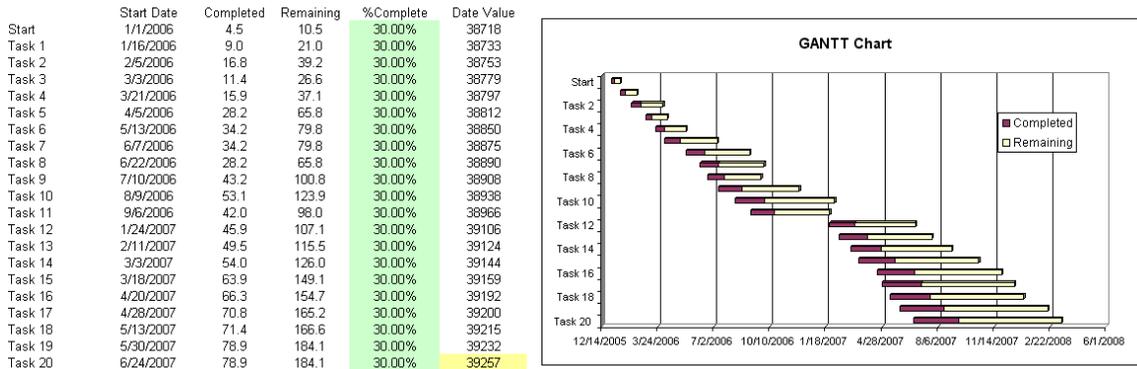


Figure 4: GANTT chart

Procedure

1. The cells in column G in the model already have simulation assumptions set. To view the assumptions, select cell G5 and click on **Risk Simulator | Set Input Assumption**. You will see that a *triangular* distribution is set where the input parameters (minimum, most likely, and maximum) are linked to the corresponding cells in columns D to F (Figure 5). Note that when you click on the input

parameters, you will see the links to D5, E5, and F5. Notice also that the input parameter boxes are now colored light green, indicating that the parameters are linked to a cell in the spreadsheet. If you entered or hard-coded a parameter, it would be white. You can link a parameter input to a cell in a worksheet by clicking on the link icon (beside the parameter input box) and clicking on the relevant cell in the worksheet.

- For simplicity, other assumptions have already been preset for you, including the completion percentage in Column E of the second part of the model, where we use the *beta* distribution instead. Further, several forecasts have been set, including the Finish Time (L25), Ending Date (F63), and critical path binary values (N5:N24) for various tasks. All that needs to be done now is to run the simulation: **Risk Simulator | Run Simulation**.

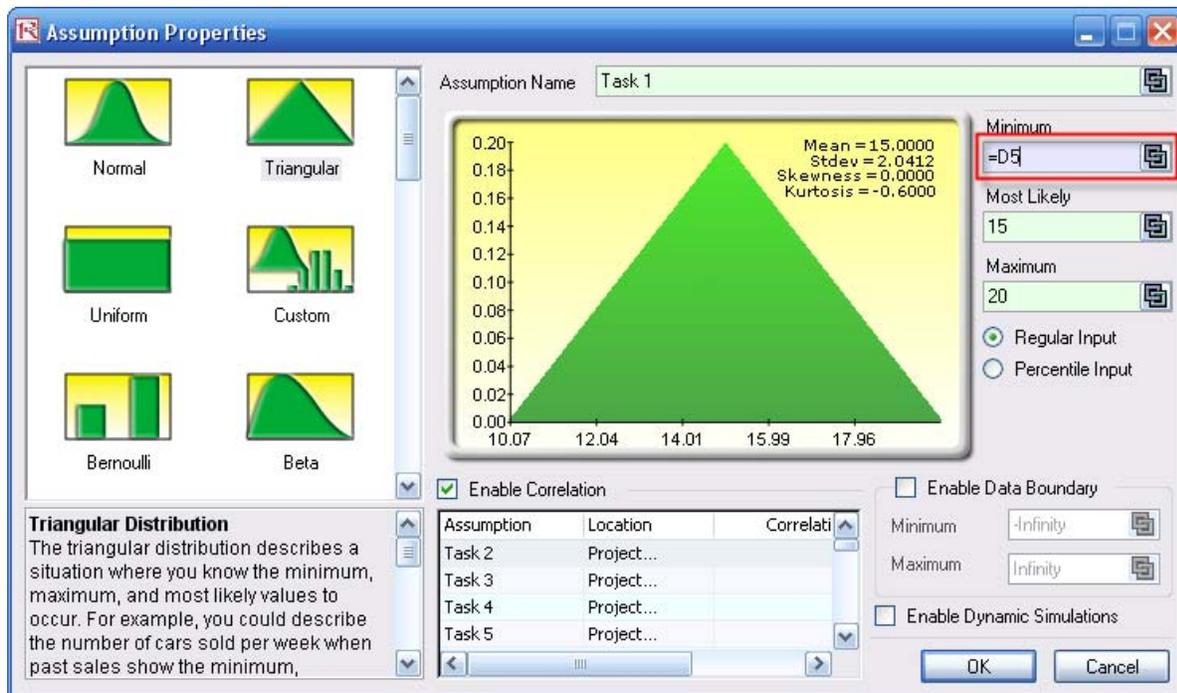


Figure 5: Setting the input assumptions

Results Interpretation

Several results are noteworthy:

- Looking at the Finish Time forecast chart after the simulation is completed, select **Left-Tail** and enter **95** in the *Certainty* box and hit **TAB** on the keyboard (Figure 6). This shows a value of 301.71, which means that there is a 95% chance that the project will complete in slightly under 302 days or that only a 5% chance exists where there will be an overrun of 301 days. Similarly, you can enter in **285** in the *Value* box and hit **TAB**.

The forecast chart returns a value of 69.60%, indicating that there is only a 69.60% chance that the project can finish within 285 days, or a 30.40% chance the project will take longer than 285 days. Other values can be entered similarly.



Figure 6: Forecast results

- B. Select one of the Tasks (e.g., **Task 10**). The forecast chart is bimodal, with two peaks, one at 0 and another at 1, indicating “NO” and “YES” on whether this particular task ends up being on the critical path (Figure 7). In this example, select the **Left-Tail** and

type in **0.99** and hit **TAB** on the keyboard. Notice that the certainty value is 58.20%, indicating that this project has a 58.20% chance of not being on the critical path (the value 0) or 41.80% chance of being on the critical path (the value 1). This means that Task 10 is potentially very critical. In contrast, look at **Task 9's** forecast chart. The **Left-Tail** certainty is 100% at the value **0.99**, indicating that 100% of the time, this project is not going to be on the critical path, and therefore has less worry for the project manager.



Figure 7: Task forecast

- C. Finally, the Ending Date forecast can be used to determine the potential ending date of the project. Looking at the forecast chart output, select the **Left-Tail**, enter **95**, and hit **TAB** (Figure 8). The corresponding 95th percentile returns a value of 39301. This is a text format for a specific date in Excel. To convert it into a date we understand, simply type this number in any empty cell and click on **Format | Cells** (or hit **Ctrl-1**) and select **Number | Date**, and the cell value changes to August 7, 2007. This means that there is a 95% chance that the project will be completed by August 7, 2007.

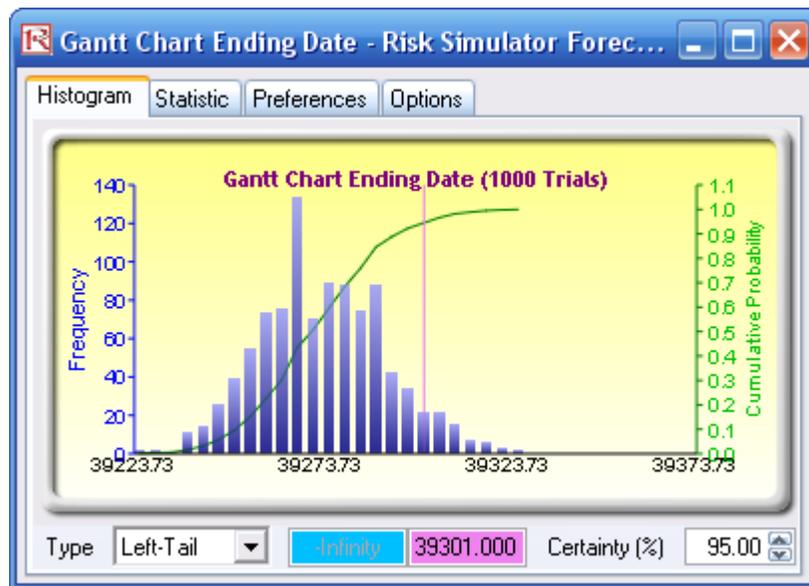


Figure 8: GANTT chart forecast end date

You can now experiment with other values and certainty levels as well as modify the model to suit your needs and project specifications. In addition, you can use the same methodology to simulate binary values (variables with 0/1 values) and dates.

Project Management – Project Timing

File Name: Project Management – Project Timing

Location: Modeling Toolkit | Project Management | Project Timing

Brief Description: This model illustrates how to use Risk Simulator for simulating a project's completion date and how to revert the simulated results back to dates

Requirements: Modeling Toolkit, Risk Simulator

This Project Management model (Figure 9) is used to illustrate how the completion dates of a project can be simulated and the resulting values converted back into a regular date format. The model assumes that the tasks are all sequential. For nonsequential and path-dependent projects, see the *Project Management – Critical Path Analysis (CPM PERT GANTT)* model instead.

Project Management and Timing

Contractual Start Date		30-Jan-06														
	Start Date St	Duration in weeks				Finish Date	Probability	Start lag in weeks			Finish lag in weeks					
		Assumption	Min	ML	Max			Assumption	Min	ML	Max	Assumption	Min	ML	Max	
CONCEPT PHASE (Task 01)																
	Phase Completion	30-Jan-06	18.0	15	18	24	5-Jun-06	90%								
	Rework risk	5-Jun-06	3.0	2	3	5	26-Jun-06	10%								
Total (c)							7-Jun-06									
INITIATION (Task 02)																
	Phase Completion	30-Jan-06	5.0	3	5	9	6-Mar-06	85%								
	Delay risk	6-Mar-06	5.0	3	5	7	10-Apr-06	15%								
Total (c)							11-Mar-06									
DEVELOPMENT (Task 03)																
	Phase Completion	7-Jun-06	7.0	6	7	8	26-Jul-06	15%					2.5	1.1	2.5	3.1
MANUFACTURING (Task 04)																
	Product A	13-Sep-06	5.0	3	5	7	18-Oct-06	85%	7.0	6	7	8				
	Product B	18-Oct-06	4.0	3	4	5	15-Nov-06	10%								
	Product C	15-Nov-06	5.0	3	5	9	20-Dec-06	5%								
	Customized	20-Dec-06	9.0	4	9	11	13-Jan-18									
GO TO MARKET (Task 05)																
USA																
	Product A	8-Nov-06	7.0	6	7	8	27-Dec-06	90%	3.0	1	3	4				
	Product B	27-Dec-06	8.0	6	8	9	21-Feb-07									
	Product C	21-Feb-07	7.0	6	7	9	11-Apr-07									
Europe																
	Product A	8-Nov-06	8.0	7	8	9	3-Jan-07	10%	3.0	2	3	6				
	Product B	3-Jan-07	6.0	5	6	10	14-Feb-07									
	Product C	14-Feb-07	6.0	4	6	9	28-Mar-07									
Final Completion Date							9-Apr-07									

Figure 9: Project Timing Model

The input assumptions used for simulation are listed under the *Assumption* column, which are all set as *triangular* distributions (a typical distribution used in project management and related to the PERT distribution). These assumptions are then linked to the minimum (Min), most likely (ML), and maximum (Max) values of completion in weeks for each task and subtask. The final completion date is set as the output forecast. Because dates, when simulated, are presented in numerical values, using the forecast chart, you can determine the 90% certainty that the project will be completed by a certain time period, and

so forth. In the example, the 90% Left-Tail confidence interval shows a value of 39210.046 as seen in Figure 10. Entering this value in any cell in Excel and then changing the properties of the cell to show dates rather than a numerical value (right-click on the cell, and select **Format Cells** | **Date**, and select the date format of your choice) will reveal that the 90th percentile date of completion is May 8, 2007.



Date Conversion:	8-May-07	39,210.00
	39,210.05	8-May-07

Figure 10: Probabilistic project completion dates