Probabilistic cost estimation with @Risk

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ABOUT PALISADE CORPORATION

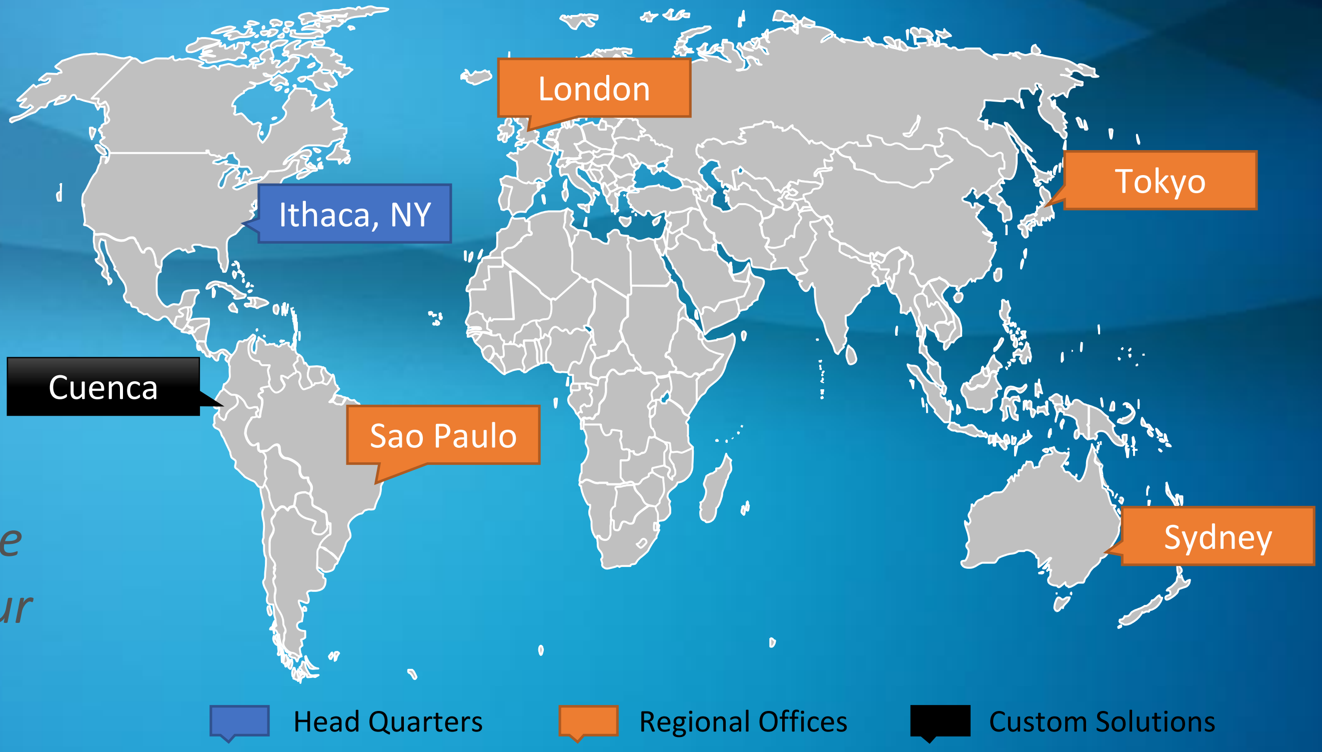
30 Years of leadership in Risk Analysis Software Market

World wide support with 6 regional offices and 150,000 customers in 94 countries

Used by professionals from 25 different industries

93 Fortune 100 companies use our software

60,000 college students use our software every year



PRODUCTS

The Decision Tools Suite 7.6:

• @RISK	Montecarlo Simulation
• Top Rank	Deterministic Sensitivity Analysis
• Evolver	Deterministic Optimization
• Risk Optimizer*	Probabilistic Optimization *Only available in @Risk Industrial
• Precision Tree	Decision Tree Analysis
• Stat Tools	Statistical Analysis
• Neural Tools	Neural Network Predictive Analysis
• Big Picture	Mind mapping

• @Risk for Project**	Project Risk Assessment **Requires Microsoft Project

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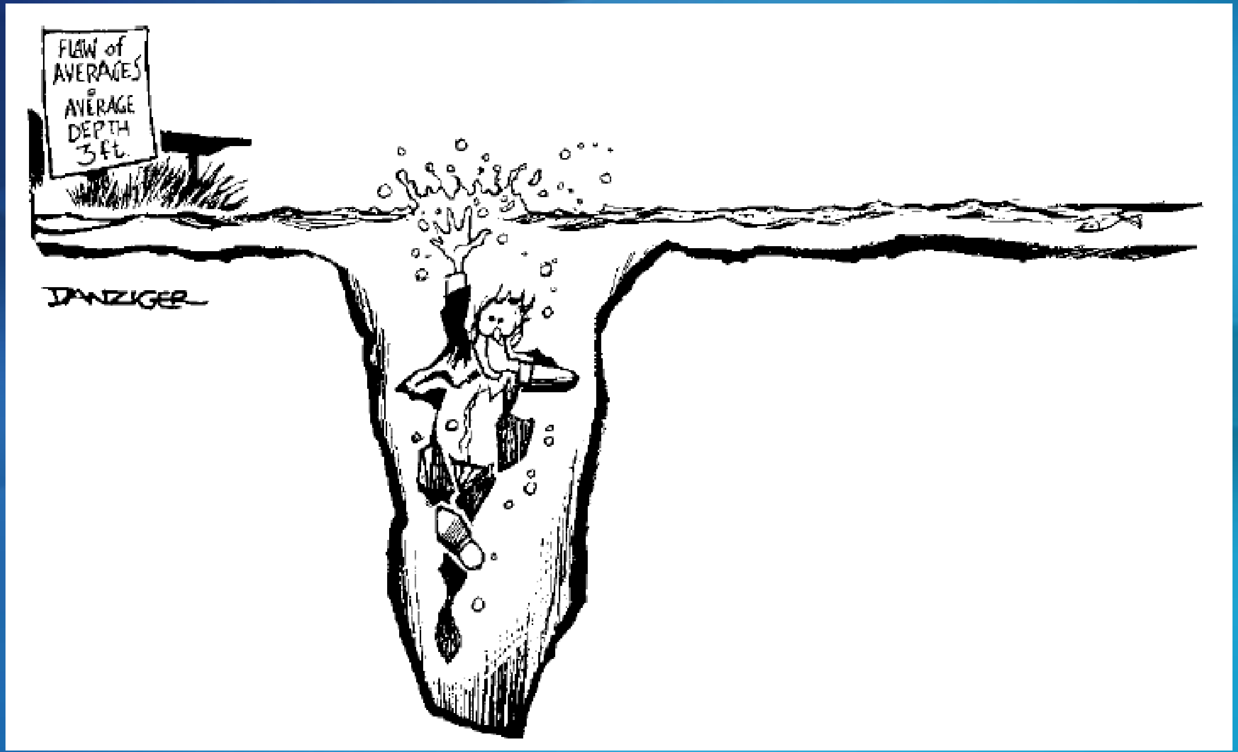
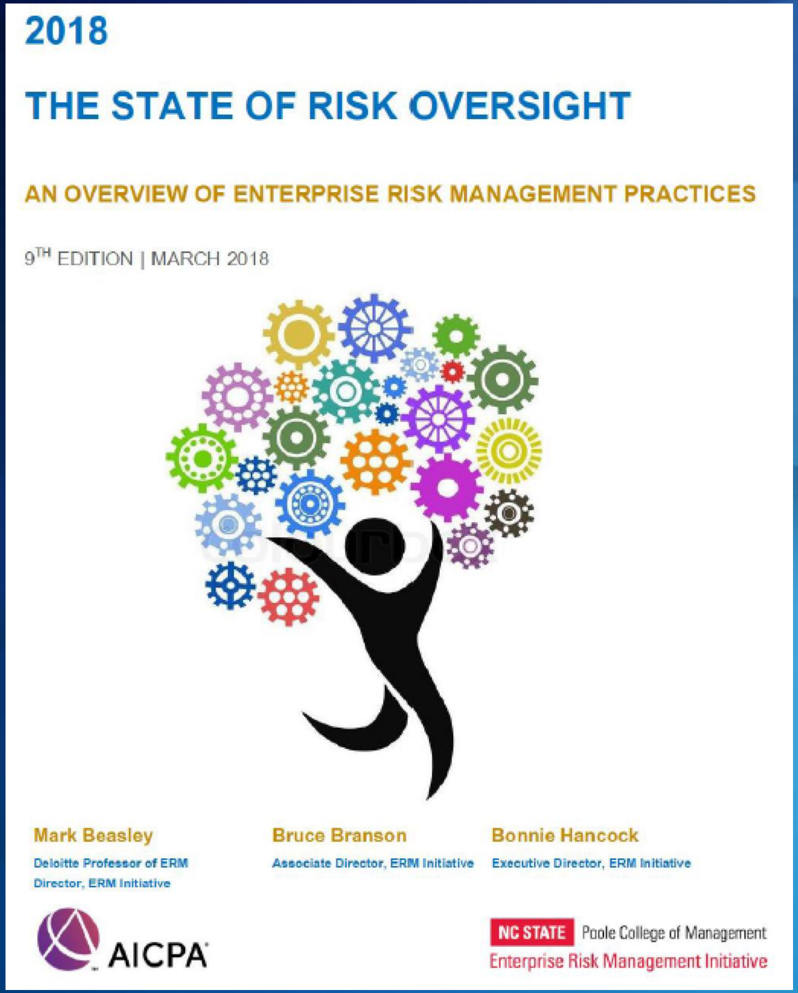
The flaw of averages



Plans based on **average** assumptions are <u>incorrect</u> in **average**

THE STATE OF RISK OVERSIGHT


2018

THE STATE OF RISK OVERSIGHT

AN OVERVIEW OF ENTERPRISE RISK MANAGEMENT PRACTICES

9TH EDITION | MARCH 2018

Mark Beasley
Deloitte Professor of ERM
Director, ERM Initiative

Bruce Branson
Associate Director, ERM Initiative

Bonnie Hancock
Executive Director, ERM Initiative

AICPA

NC STATE Poole College of Management
Enterprise Risk Management Initiative

- 47% of projects exceed their original Budget due to an incorrect estimation of costs and resources.
- Almost 50% of all projects were changed throughout their life cycle due to changes in required tasks.
- 48% of projects have shown losses of different types which create a sense of failure. This situation makes organizations' plans less productive and more expensive.
- In average, organizations waste 10% for each dollar being invested in projects due to a non-sufficient performance of projects.
- Probabilities of achieiving succesful projects are highly discouraging, with a rate as low as 50%. Therefore, there is an urgent need of a culture shift towards **Project Management**.

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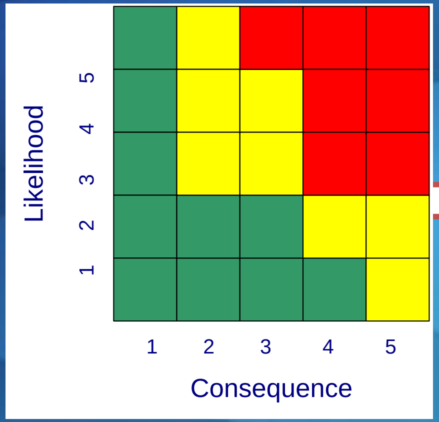
TRADITIONAL QUALITATIVE RISK ANALYSIS

Ocurrence	Score
Not likely	1
Low probability	2
Likely	3
Very likely	4
Certain	5



Risk Register

Priority	Description	Impact	Mitigation / Responsibility
1			
…			
n			

Impact in Time	Impact in cost	Technical impact	Score
Minimum or No Impact	Minimum or no impact	Minimum or No Impact	1
Additional activities are required / Deadlines will be fulfilled	Increase Budget < 1%	Reduction in project's performance with small impact.	2
Minor deviation in current plan schedule	Increase Budget < 5%	Reduction in project's performance with médium impact. However, there are alternatives to meet expectations.	3
It affects the critical path of the project	Increase Budget < 10%	Not acceptable but there are available alternatives	4
A project's milestone won't be accomplished	Increase Budget > 10%	Not acceptable. There are no available alternatives.	5

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TRADITIONAL QUALITATIVE RISK ANALYSIS

Risk Index = Probability x Impact

PROBABILITY						
5	5	10	15	20	25	30
4	4	8	12	16	20	24
3	3	6	9	12	15	18
2	2	4	6	8	10	12
1	1	2	3	4	5	6
	1	2	3	4	5	6
	IMPACT					

Critical Index	
Maximum	CRITICAL
High	CRITICAL
Medium	NOT CRITICAL
Low	NOT CRITICAL
Minimum	NOT CRITICAL

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QUANTITATIVE RISK ANALYSIS

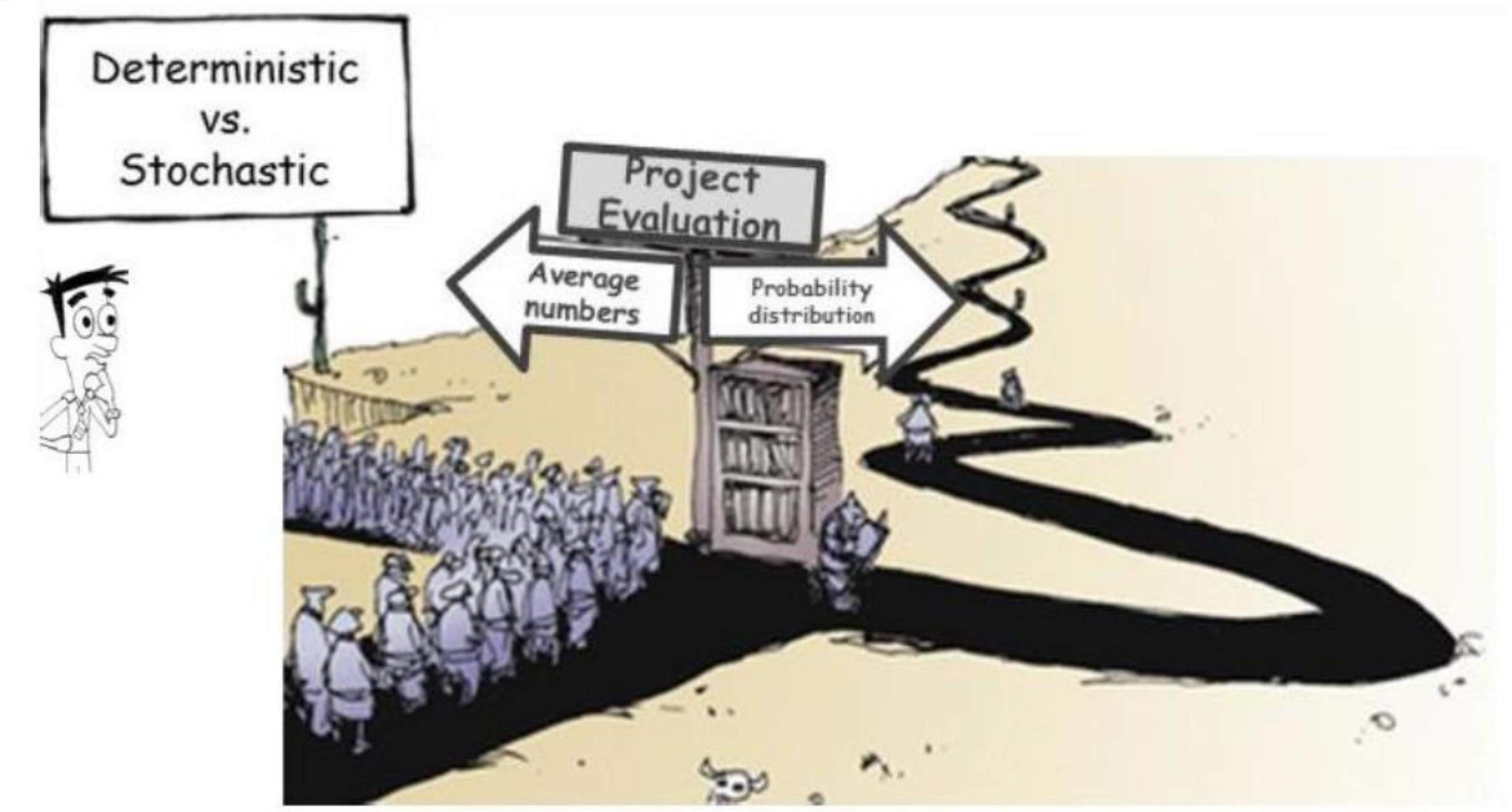
Risk Analysis

- **Qualitative Risk Analysis –** Risk analysis used to screen risks wherein risk probabilities of occurrence and impacts are expressed narratively or in ranked categories of severity

- **Quantitative Risk Analysis -** Risk analysis used to estimate a numerical value (usually probabilistic) on risk outcomes wherein risk probabilities of occurrence and impact values are used directly rather than expressing severity narratively or by ranking as in qualitative methods

- Assessing the range of possible outcomes, their probabilities or likelihoods, causal factors, and their interrelationships.

DETERMINISTIC VS PROBABILISTIC RISK ANALYSIS



WHAT DOES @RISK DO?

- **@Risk helps to make a transition from Deterministic models into Probabilistic models**
  - It can include one or several variables
  - It provides additional information to the "single number approach"

- **@Risk generates results that are important for Risk Analysis**
  - It provides a statistical distribution of results by using Montecarlo Simulation

WHAT IS MONTECARLO SIMULATION?

» **It is not a single method**

» **It is a set of procedures that …**

- Combine a set of inputs
- Generates random samples according to one or several probability distributions
- Calculates a set of scenarios for a final output

» **History**

- Enrico Fermi (1930)
- Stanislaw Ulam (1946) – Solitaire
- John Von Neumann

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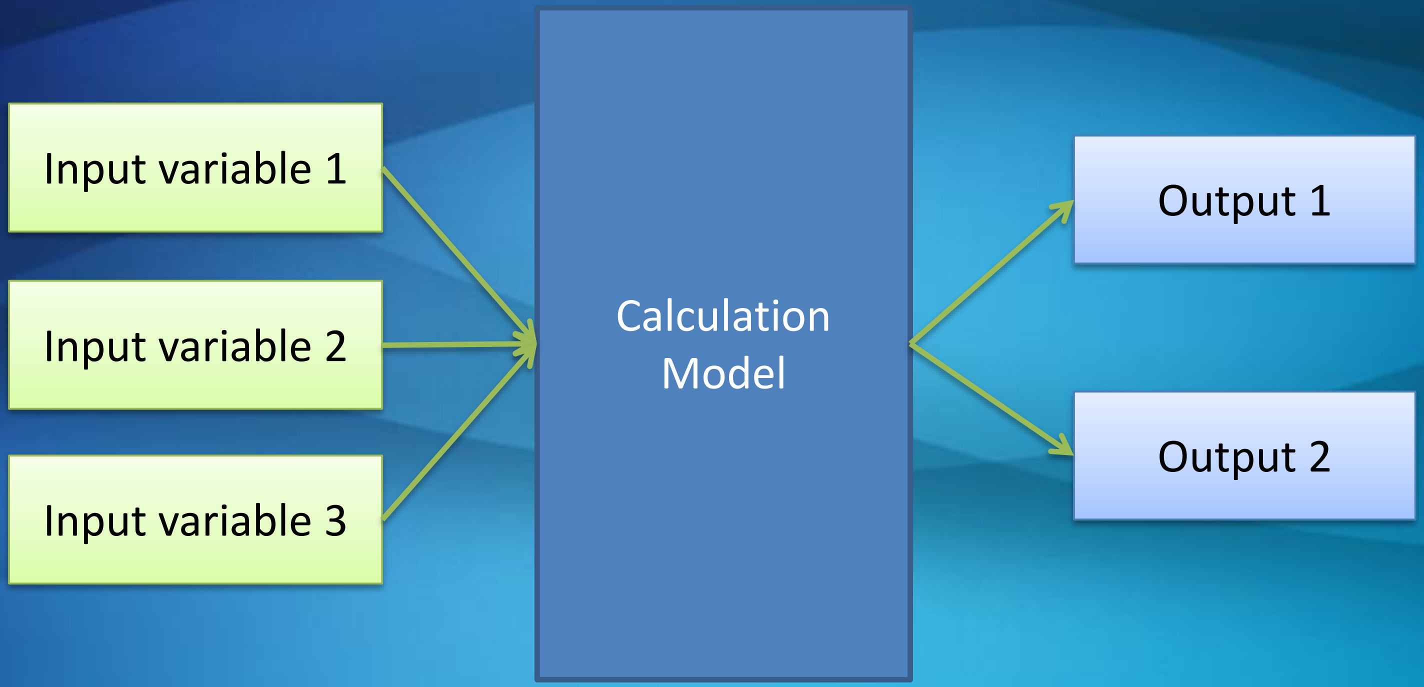
A typical Deterministic Model



Every input variable is located inside of an Excel cell without any type of uncertainty. Generally speaking, input variables are obtained from AVERAGE historical data.

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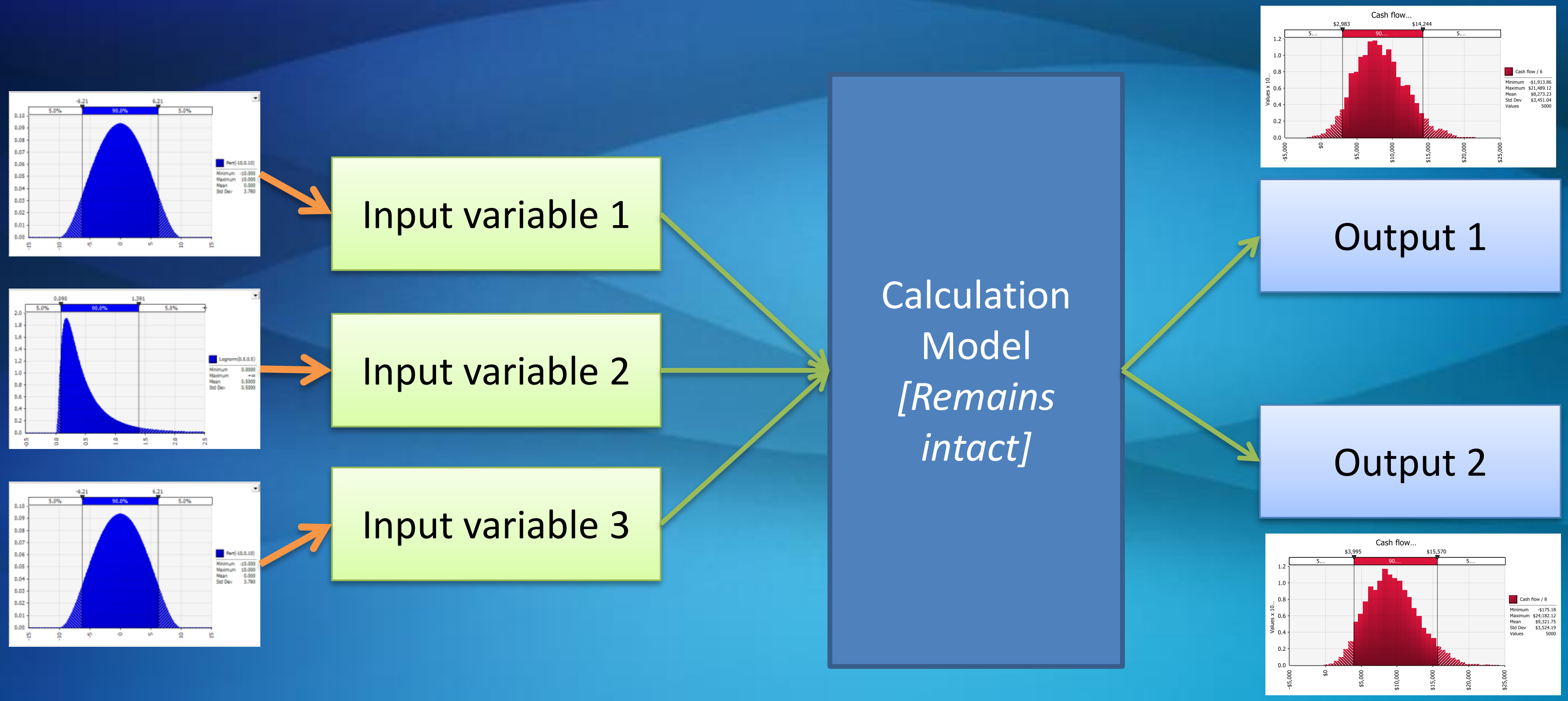
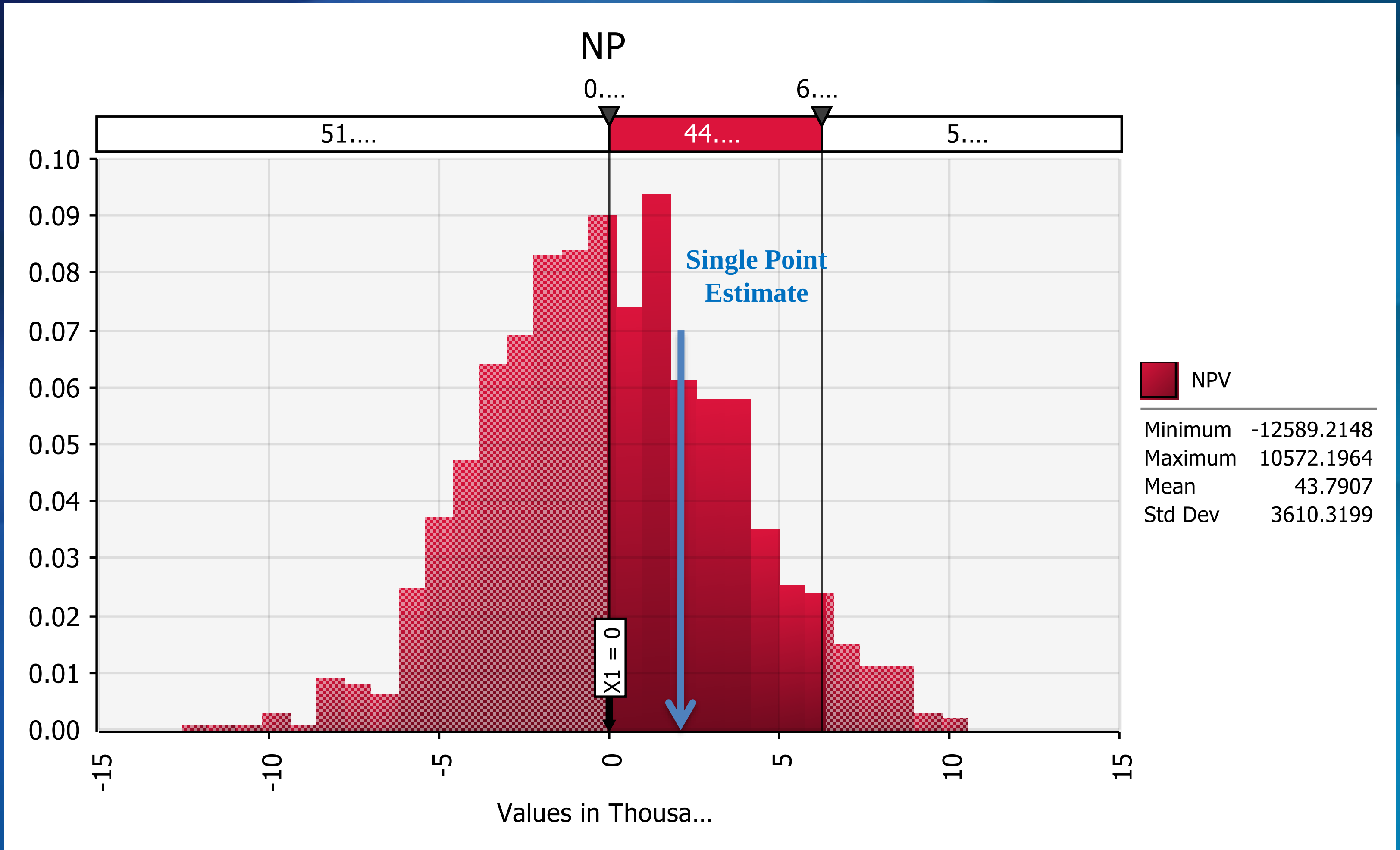
A typical Motecarlo Model (Probabilistic approach)



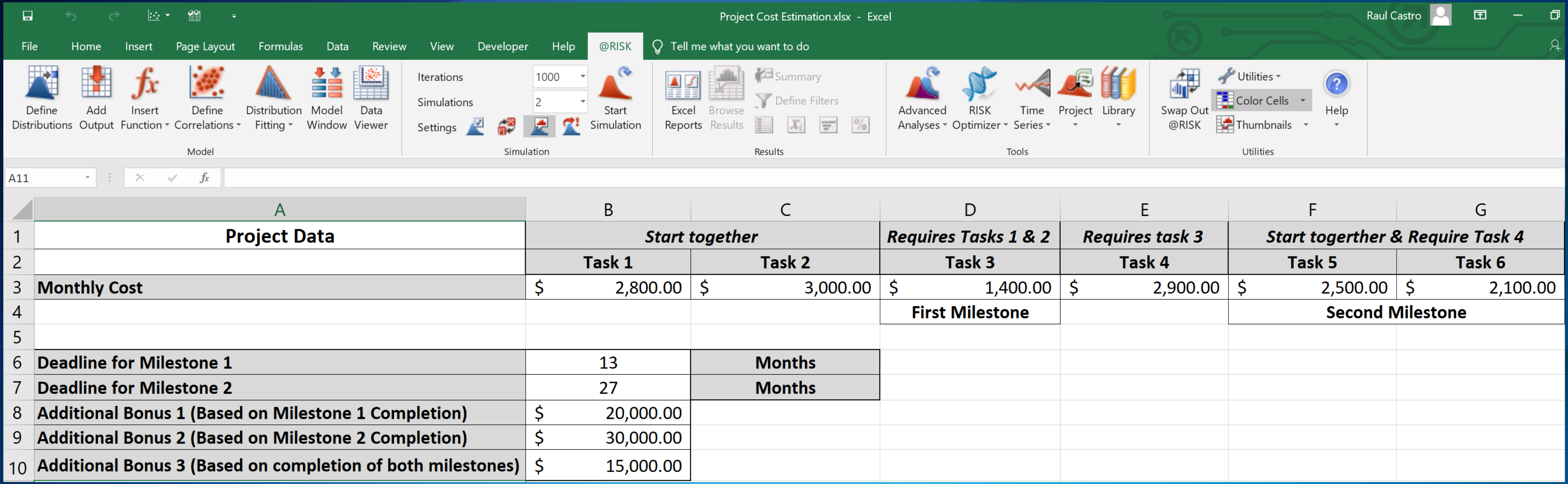
Each input variable is associated to a probability distribution. It is possible to include correlations among these variables.

The model gets to be recalculated thousands of times by using sample data from input variables. Therefore, new distributions are generated for each of the output variables that were previously defined by the user.

Deterministic vs Probabilistic Approach



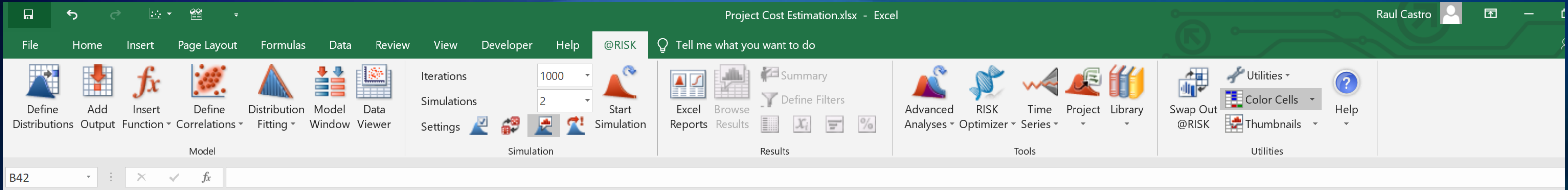
Case : Project cost estimation model



	A	B	C	D	E	F	G
1	**Project Data**	***Start together***		***Requires Tasks 1 & 2***	***Requires task 3***	***Start togerther & Require Task 4***	
2		**Task 1**	**Task 2**	**Task 3**	**Task 4**	**Task 5**	**Task 6**
3	**Monthly Cost**	$ 2,800.00	$ 3,000.00	$ 1,400.00	$ 2,900.00	$ 2,500.00	$ 2,100.00
4				**First Milestone**		**Second Milestone**	
5							
6	**Deadline for Milestone 1**	13	**Months**				
7	**Deadline for Milestone 2**	27	**Months**				
8	**Additional Bonus 1 (Based on Milestone 1 Completion)**	$ 20,000.00					
9	**Additional Bonus 2 (Based on Milestone 2 Completion)**	$ 30,000.00					
10	**Additional Bonus 3 (Based on completion of both milestones)**	$ 15,000.00					

Net project Cost = Gross project cost + Bonuses (if applicable)

Case : Project cost estimation model



	A	B	C	D	E	F	G
12	Variability parameters for unkown duration times	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6
13	Historical data	NO	NO	NO	NO	NO	YES
14	Minimum number of months	6.0	6.00	5.00			
15	Lower percentile				8%		
16	Limit for lower percentile				4.50		
17	Intermediate percentile				50%		
18	Limit for intermediate percentile				5.40		
19	Most Likely value		6.90	5.90		6.9	6.0
20	Upper percentile				92%		
21	Limt for upper percentile				6.30		
22	Maximum number of months	9.0	8.50	7.50			
23	Standard deviation						0.5
24	Absolute deviation with respect to Most Likely Value					0.9	
25	Simmetry						
26	Low Probability of extreme values	NO	NO	YES	NO	YES	
27							
28	Uncertain inputs						
29	Months to complete	7.50	6.90	5.90	5.40	6.90	6.00

Case : Project cost estimation model

	B	C	D	E	F	G
Uncertain inputs						
Months to complete	**7.50**	**6.90**	**5.90**	**5.40**	**6.90**	**6.00**
Outputs						
	Task 1	**Task 2**	**Task 3**	**Task 4**	**Task 5**	**Task 6**
Part of critical path (1=Yes, 0=No)	1	0	1	1	1	0
Time to complete milestone 1 (Months)	13.40					
Time to complete milestone 2 (Months)	25.70	**Project FINISHED**				
Bonus for achieving Milestone 1 on time	$ -					
Bonus for achieving Milestone 2 on time	$ 30,000.00					
Bonus for archieving both milestones	$ -					
Gross project cost	$ 95,470.00					
Net project cost	**$ 65,470.00**					

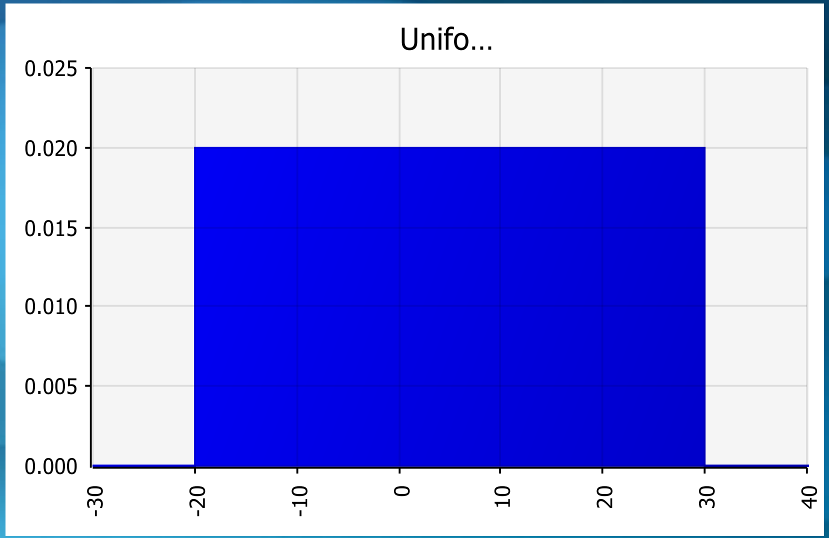
Uniform Distribution (RISKUNIFORM)

Description

- All values occur within a range with the same probability
- It is also known as “Rectangular Distribution”

Examples

- Random number generation (needed to generate other type of variables)
- Time samples taken at random intervals



Input parameters
• Minimum expected value • Maximum expected value

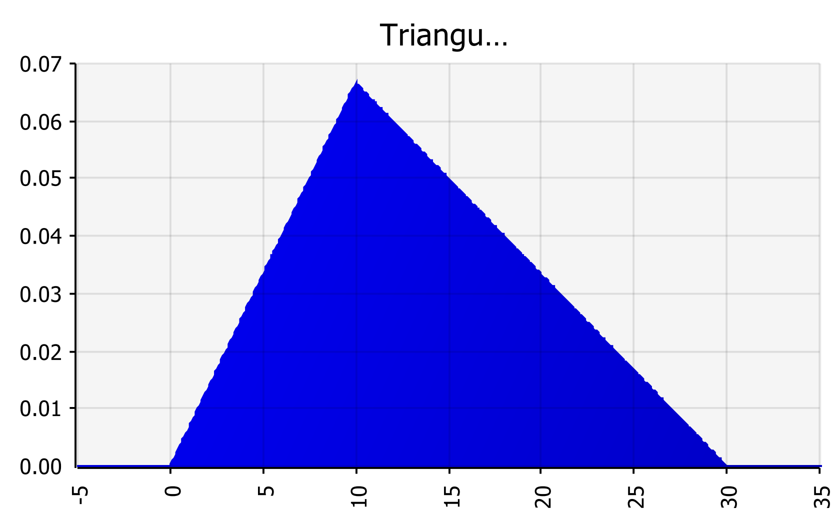
Triangular Distribution (RISKTRIANG)

Description

- It is used whenever there is information about minimum, maximum and most likely values
- It is recommended when we have little information about the reality we need to model
- Easy to calculate and generate

Examples

- Product pricing
- Manufacturing costs



Input parameters
• Most likely value (mode) • Minimum and Maximum values

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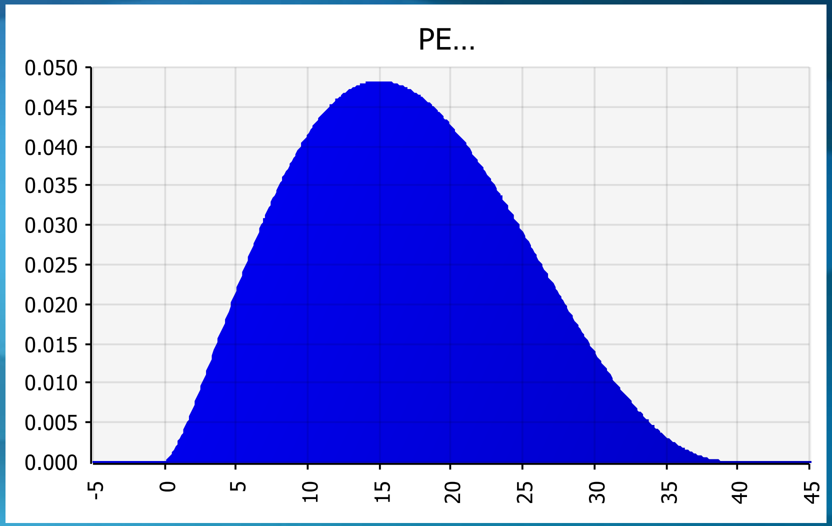
Pert Distribution (RISKPERT)

Description

- The best alternative to the Triangular Distribution
- Smoothing approach
- Extreme values are less likely to occur

Examples

- Product pricing
- Manufacturing costs
- Sales volume
- Raw materials prices



Input parameters
• Most likely value (mode) • Minimum and máximum values

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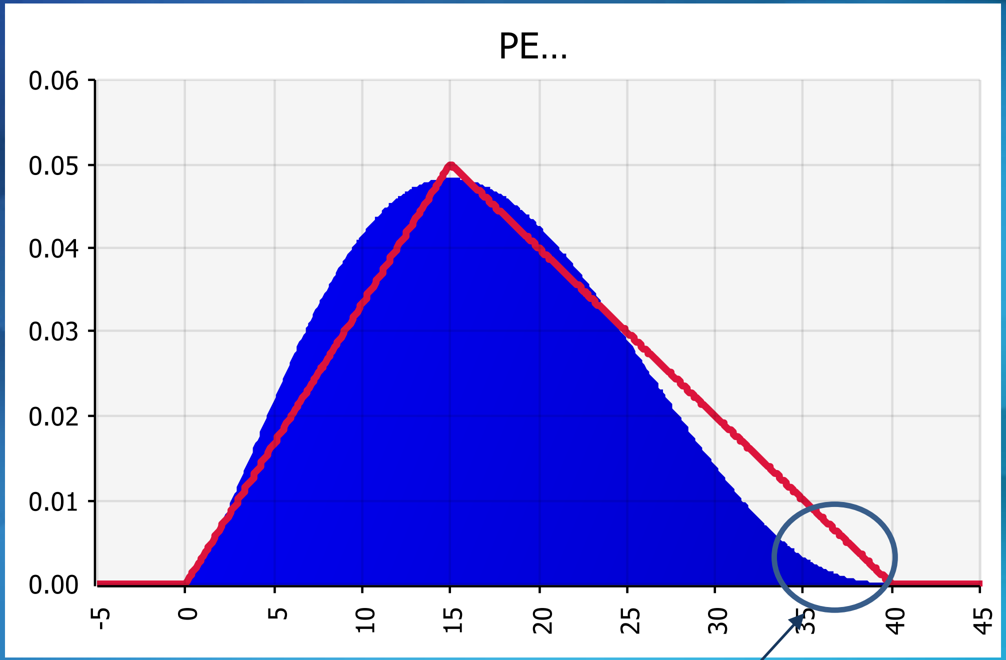
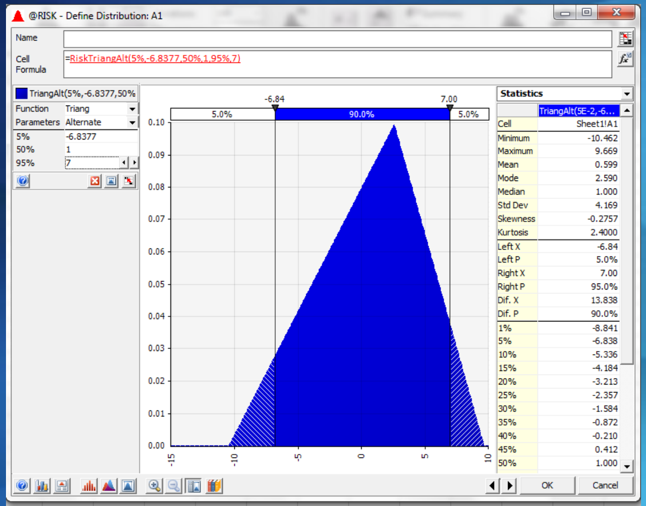
Triangular vs Pert



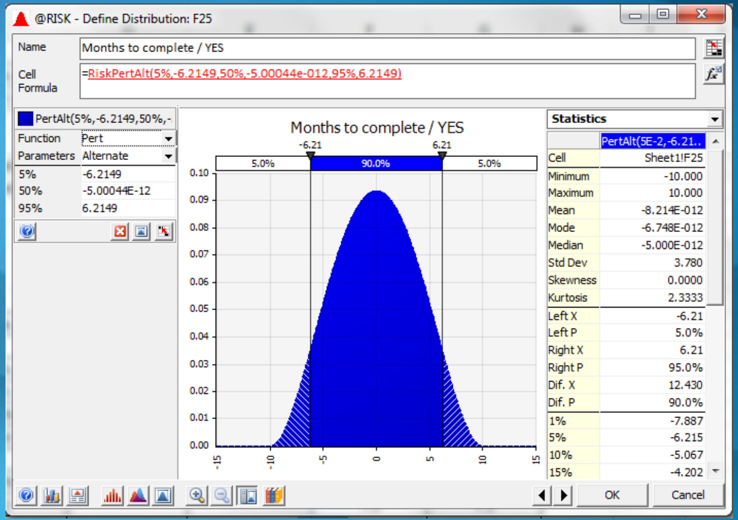
% of cases for Upper Tail in Triang Function (greater than Pert Distribution)

ALT functions in @Risk

RiskTriangAlt



RiskPertAlt



Input parameters

- % associated to lower percentiles
- Lower percentile value
- % associated to second percentile
- Second percentile
- % associated to upper percentile
- Upper percentile

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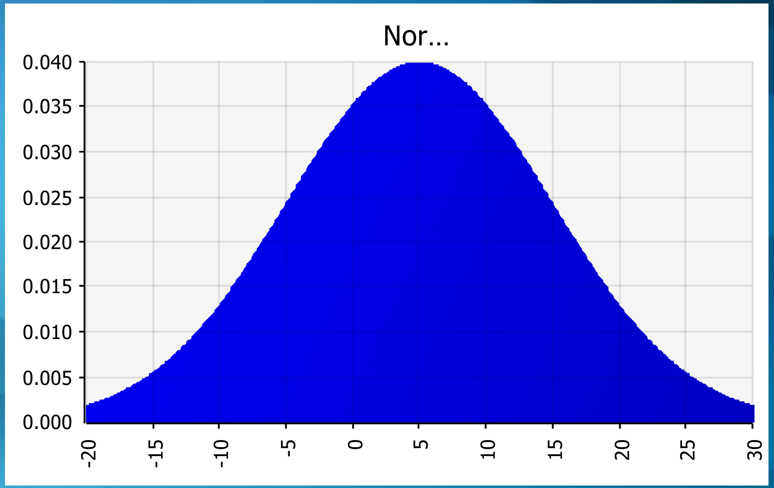
Normal Distribution (RISKNORMAL)

Description

- It is the most popular distribution of all as it describes many natural phenomena suchas people's IQ and heights.
- It is being used in several scientific applications where variability is explained by a single cause.
- It has Infinite Limits – Watch out !



Examples

- Process variation
- Inflation rates
- Price of goods
- Measurement errors
- Population sampling
- Volume forecasts

Input variables
• Mean • Standard Deviation

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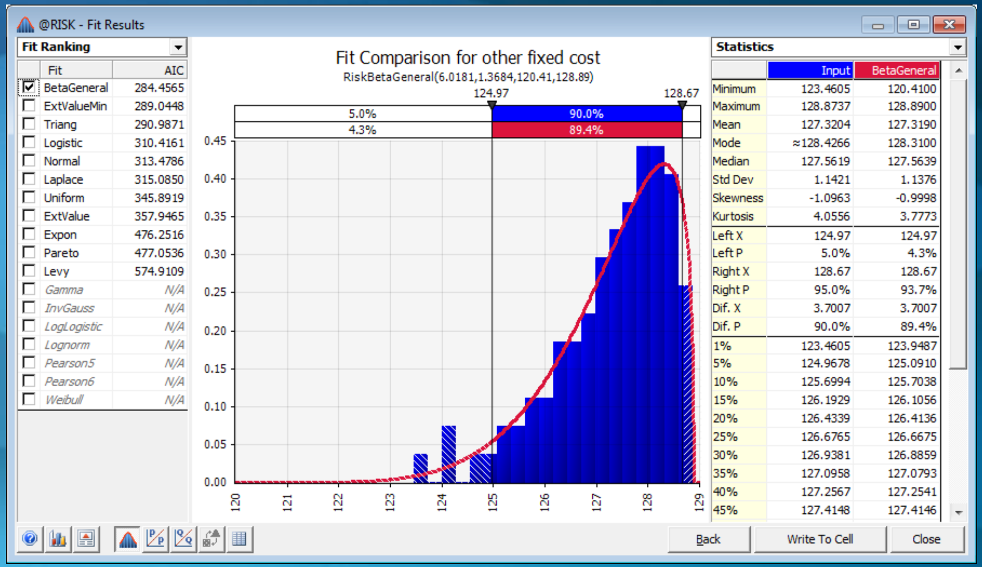
Distribution Fitting

Description

- Highly Effective to compare a hypothetical distribution against historical sample data
- It combines the effect of multiple assumptions
- It is important to remove any trends or stationary behaviour of data



Example

- Historical price data

Input parameters

- Data source

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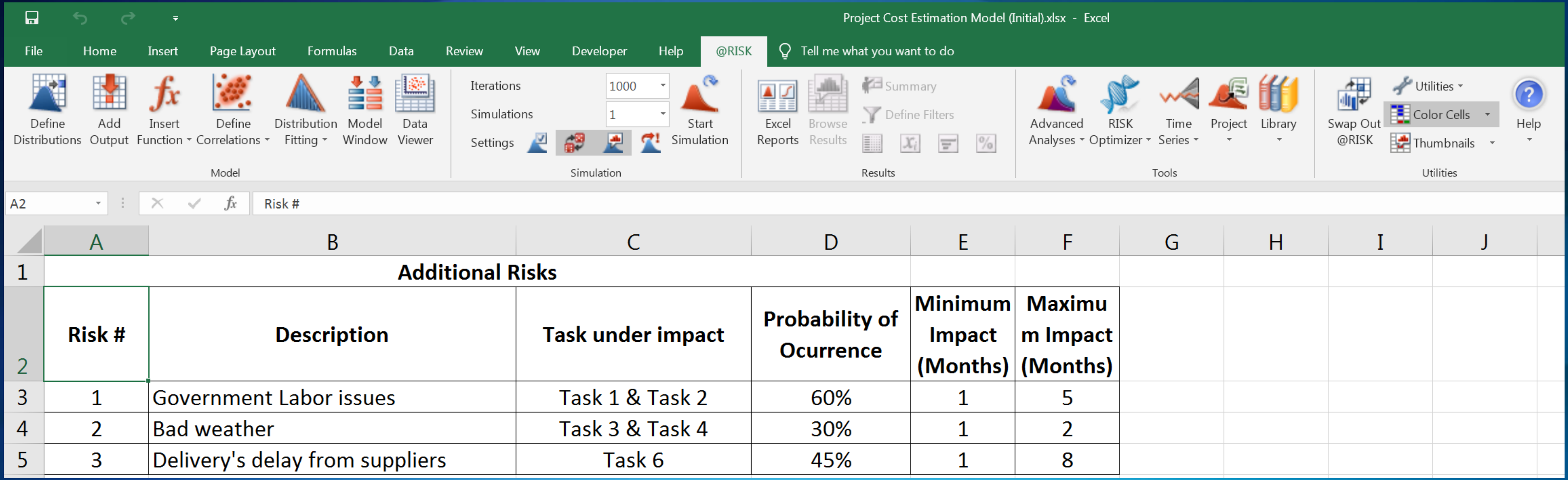
The Risk Register



Additional Risks

Risk #	Description	Task under impact	Probability of Ocurrence	Minimum Impact (Months)	Maximum Impact (Months)
1	Government Labor issues	Task 1 & Task 2	60%	1	5
2	Bad weather	Task 3 & Task 4	30%	1	2
3	Delivery's delay from suppliers	Task 6	45%	1	8

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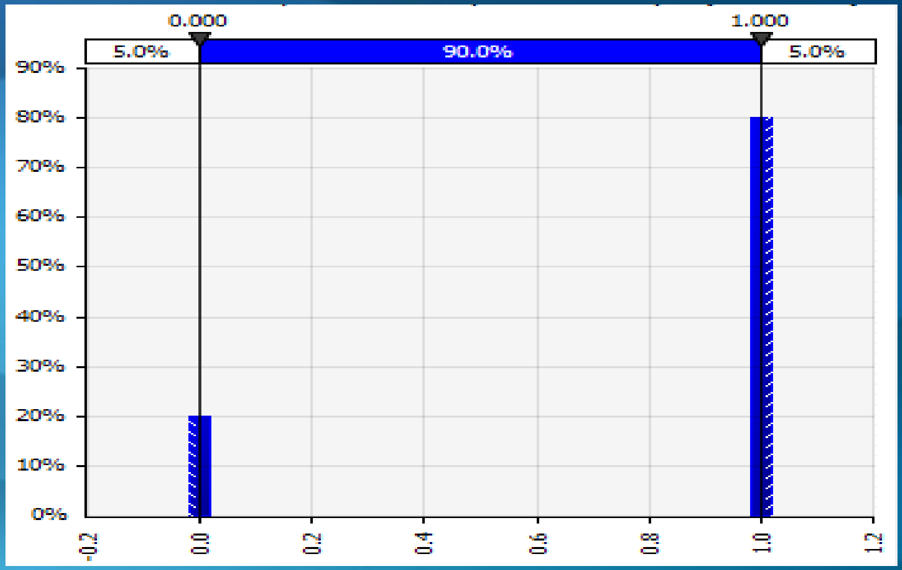
Bernoulli Distribution (RISKBERNOULLI)

Description

It only allows integer values

- 0 = Failure, 1 = Success
- p : Probability of success in a single trial
- **RiskBernoulli(p)** = Result for a trial



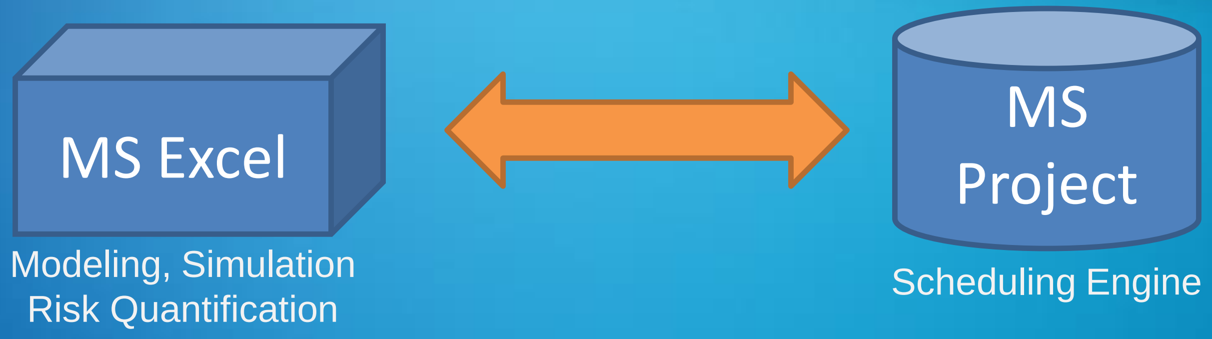
Example

- Flipping a coin
- Ocurrence of a single event

Input parameters
p = Probability of ocurrence of a Success

@RISK for MS Project

- Allows **simulation of project schedules** using @RISK for Excel
- **Modeling is done in Excel** vs. earlier versions of @RISK for Project where all modeling was done in Microsoft Project
- All **scheduling calculations** are still done in Project
- *How does this happen?*



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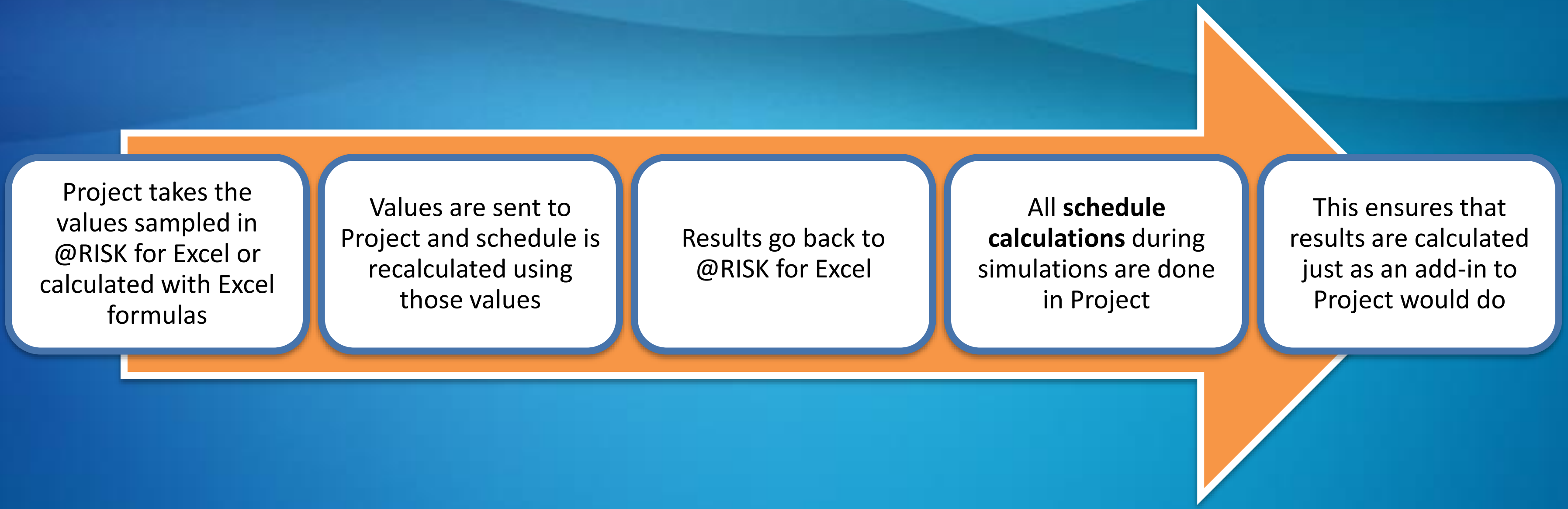
Excel is a New “View” of a Project

» A new **communication layer** between Excel and Project was built

- This allows live updating of schedules in Project when changes are made in Excel
- Combines the best of two worlds – Excel formulas, functions, graphs and the Microsoft Project scheduling engine



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Risk Approach

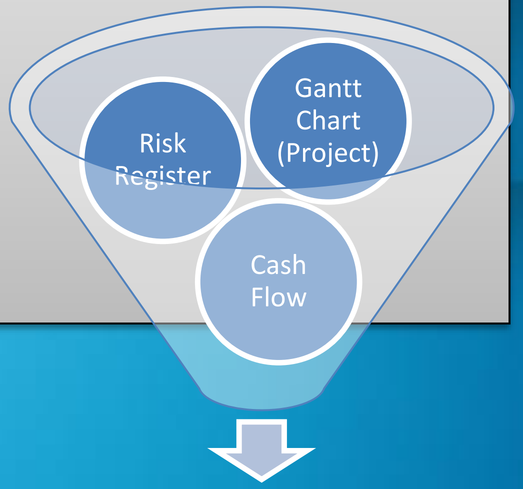
Traditional vs Integration Approach

Traditional

- » Use Excel for Cost Risk Management
- » Use MS Project for Duration Cost Management
    - CPM, Slack time, etc.

Integration

- » Excel + MS Project
- » Run analysis simultaneously
    - Cost + Duration
- » Components linked
    - Gantt Chart
    - Risk Register



Schedule Risk Analysis

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What does a User Need?

» An installed copy of Excel and the new version of @RISK for Excel that supports project schedules

» An installed copy of Microsoft Project 2003 or higher

» Project schedules in MPP format that they want to analyze for risk

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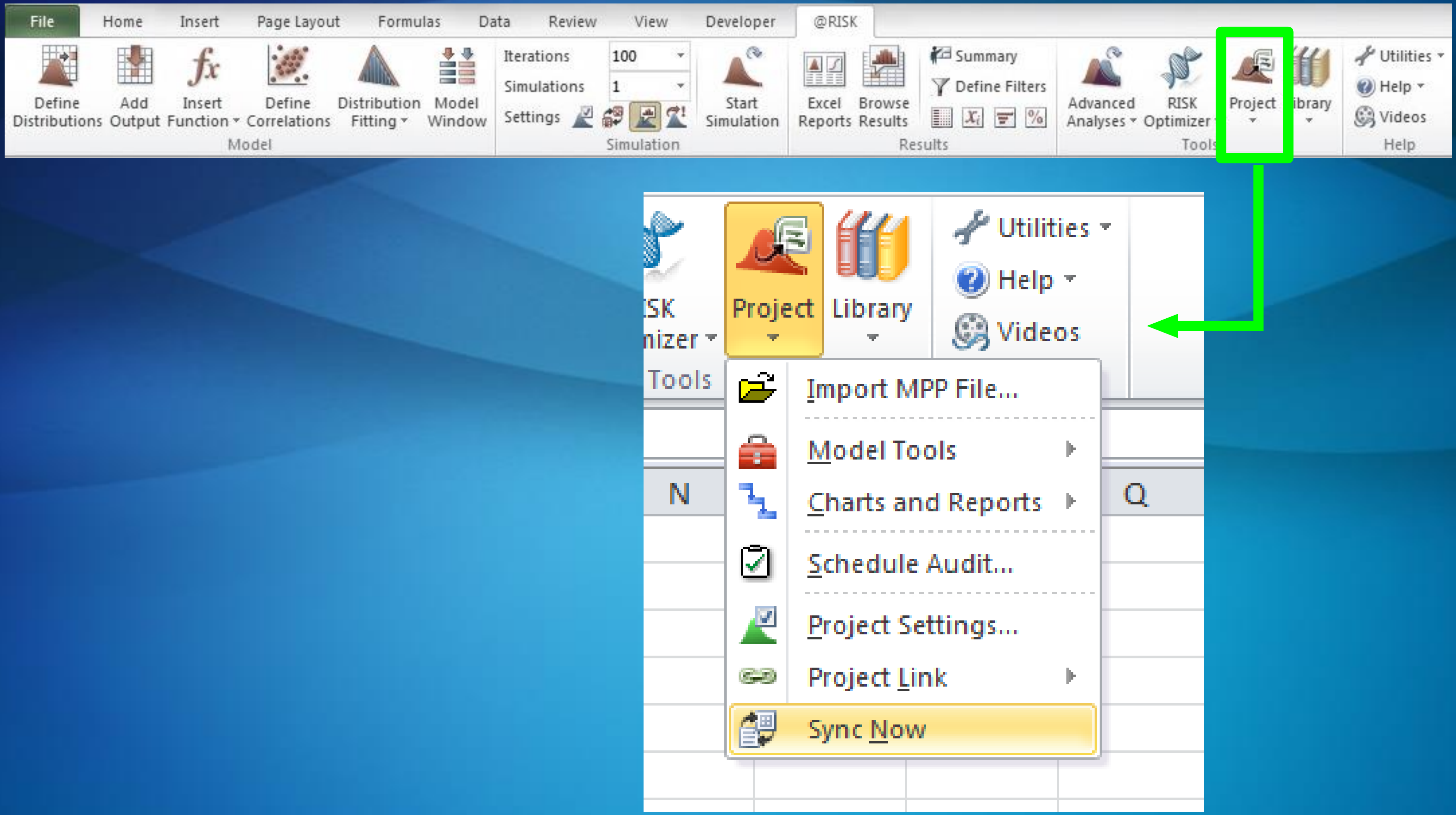
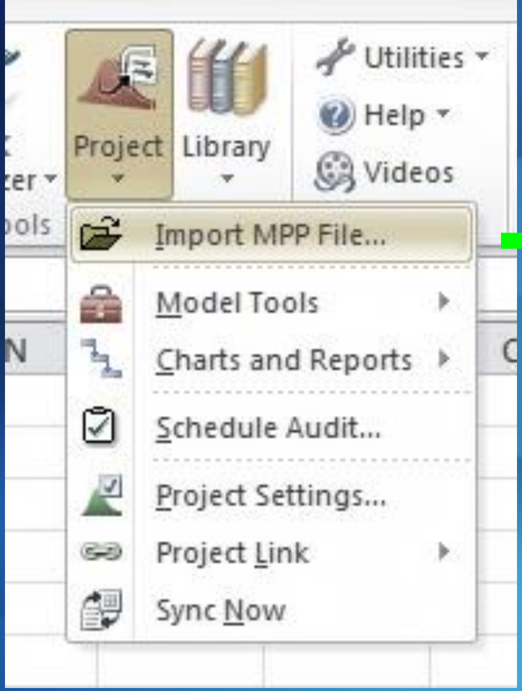
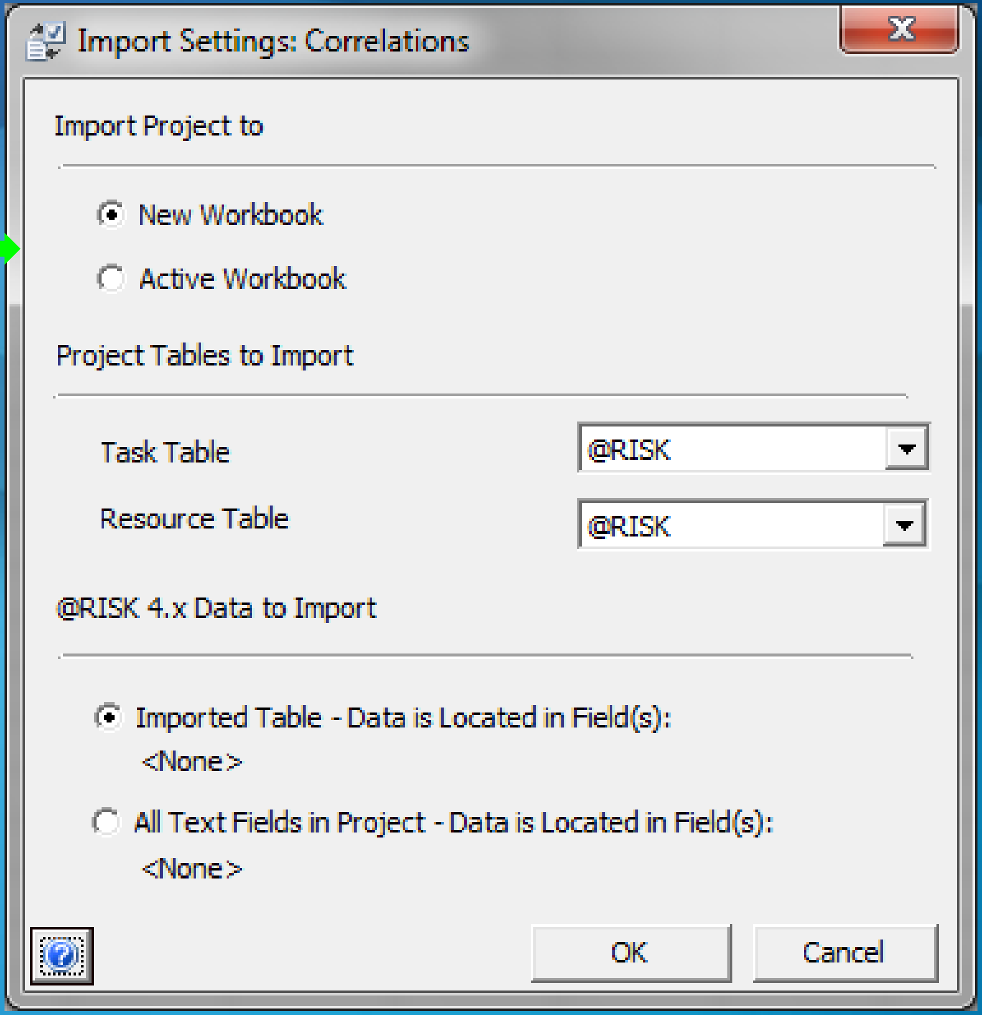
@RISK for Project Interface

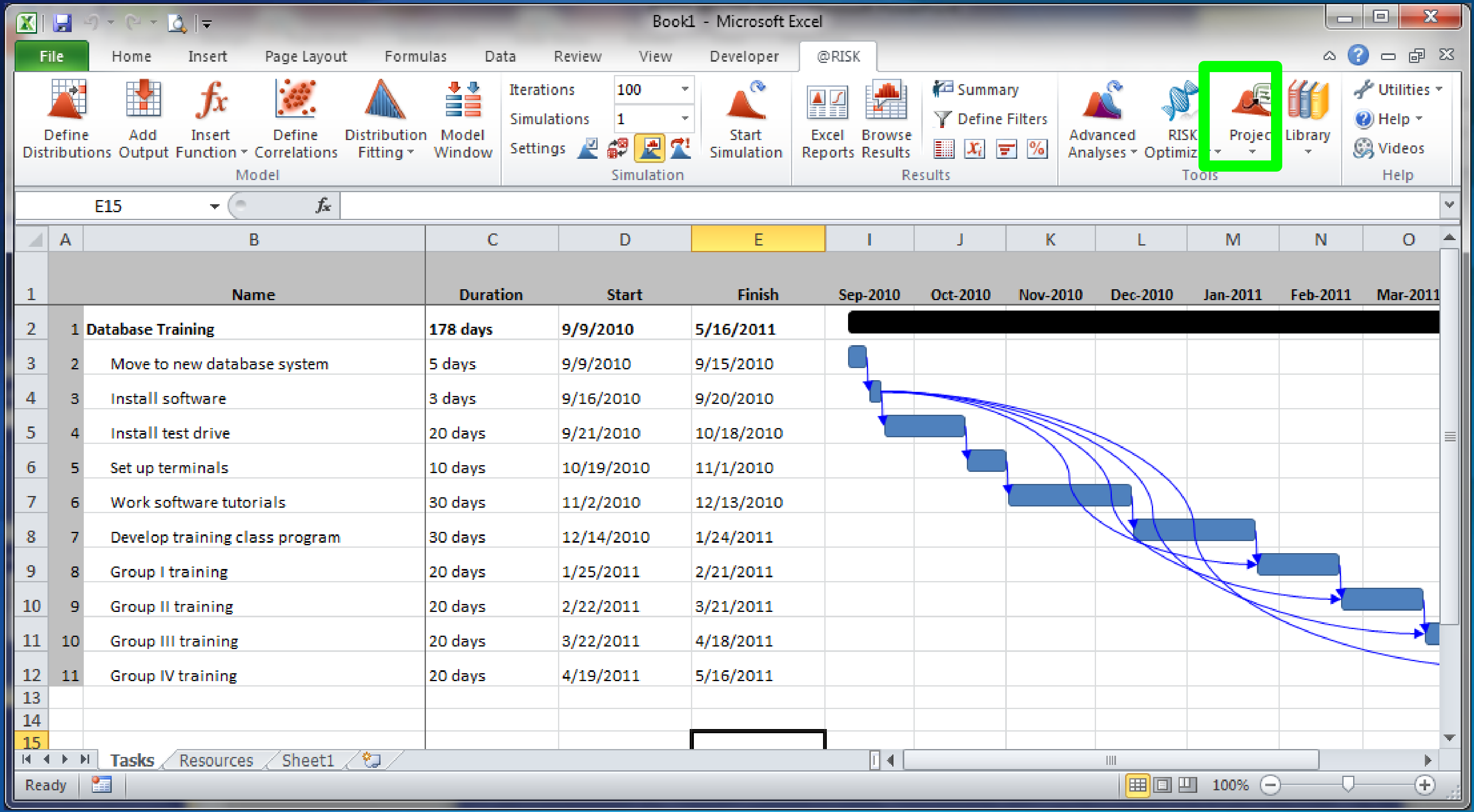


Import MPP File





New Risk for Project Interface



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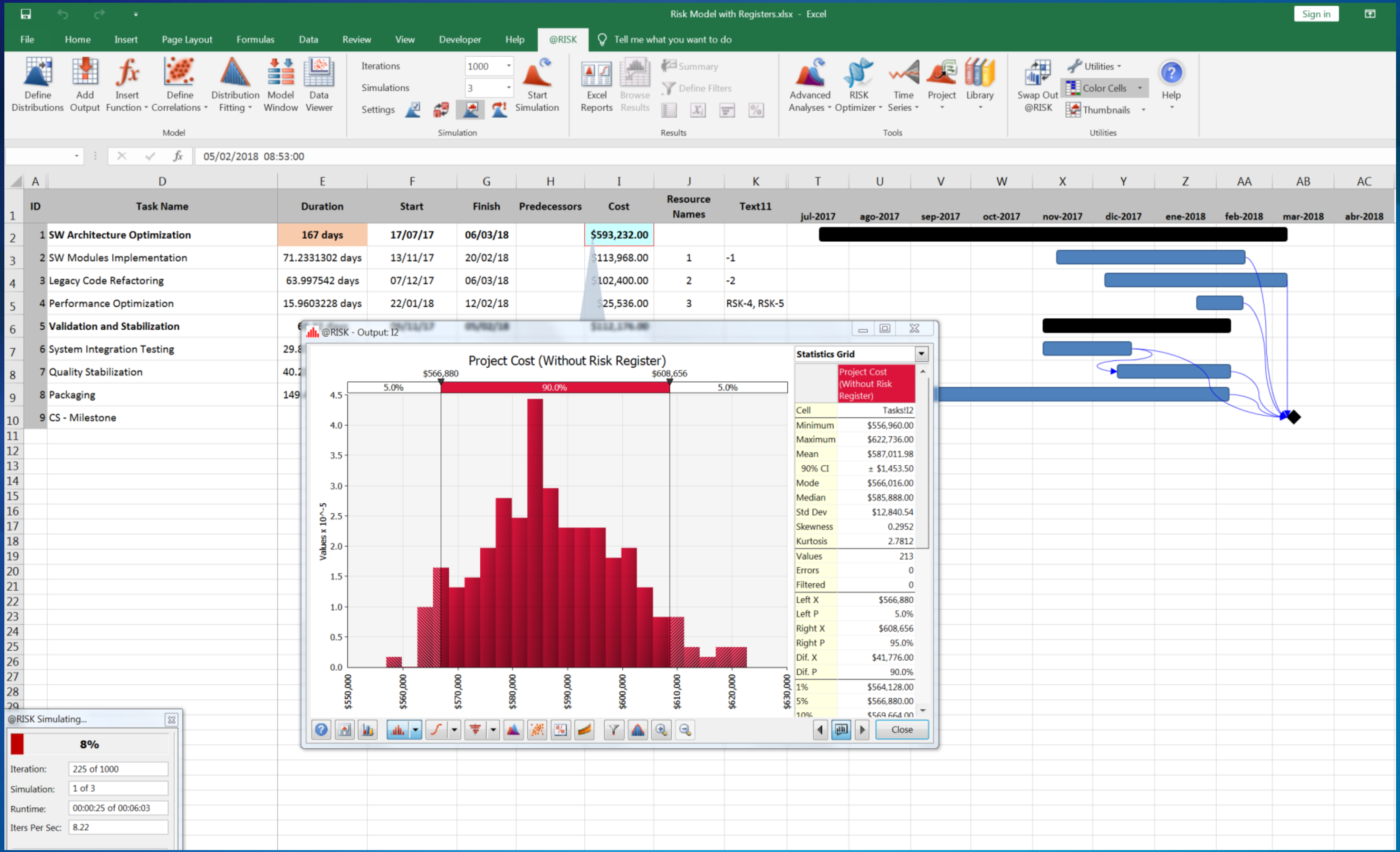
@Risk & MS Project in Action !



@Risk & MS Project in Action !

Quantitative Risk Analysis of Program Schedule and Budget

Program Risk Register

Qualitative Analysis					Quantitative Analysis									
Risks Identification		Deterministic Analysis			Probabilistic Analysis Pre-Mitigation				Probabilistic Analysis Post-Mitigation					
Risk ID	Risk Name	Severity in Days (Most Likely)	Probability	Risk Rank	Severity in Days	Probability	Occurs?	Risk Impact	Mitigation Cost(in days)	Severity in Days	Probability	Occurs?	Risk Impact
RSK-1	New features feasibility research might not have been sufficient	15	0.35	5.25	21.33	0.35	0	0.00	5	7.17	0.2	0	5
RSK-2	The scope of Legacy Code Refactoring effort can be much bigger than expected	20	0.36	7.2	28.83	0.36	0	0.00	10	15.83	0.2	0	10
RSK-3	Not all interdependencies between the subsystems were considered	15	0.35	5.25	17.17	0.35	0	0.00	5	13.00	0.1	0	5
RSK-4	Code Refactoring affects Performance and Quality	15	0.35	5.25	17.17	0.35	0	0.00	4	9.67	0.1	0	4
RSK-5	Performance not meeting specification	25	0.52	13	25.17	0.52	1	25.17	10	11.83	0.1	0	10
RSK-6	Change can cause stability level to fall below acceptable level	25	0.72	18	28.33	0.72	1	28.33	15	11.67	0.3	0	15

Overall Risk Impact due to external risks

Risk Impact	Deterministic (Total Expected Risk)	53.95	Pre-Mitigation (Simulated Risks)	53.50	Post-Mitigation (Simulated Risks)	49

*Post-Mitigation Impact Plus Cost of Mitigation)

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Any questions?

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