SimRisk 2003

A software aid for simulation

User's Guide

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1. Introduction

The ***SimRisk 2003*** software is an educational tool to introduce simulation concepts. The software adds a suite of random number generators to Excel's built-in functions. After running a simulation, the software reports certain statistical attributes about the results, while preserving user access to the data gathered during the simulation.

The software provides a simple and robust introduction to simulation. Simplicity and convenience, not efficiency, are major product attributes.

SimRisk 2003 is the successor to SIMULATE2000. Consequently, some of the dialog boxes in this document may refer to Simulate 2000. However, all such references are equally applicable to ***SimRisk 2003***.

1.1 Acknowledgments

In developing the software, I have benefited from discussions with various people, notably Professor Marshall Freimer at the Simon School of Business at the University of Rochester.

1.2 Authorization: Terms of Use

This software is licensed for use for the duration indicated within the software dialog box. Use of the software outside such period is a violation of the license agreement. By accessing any software-related file, you indicate your acceptance of the license agreement at the end of this document. Please read it carefully before you continue.

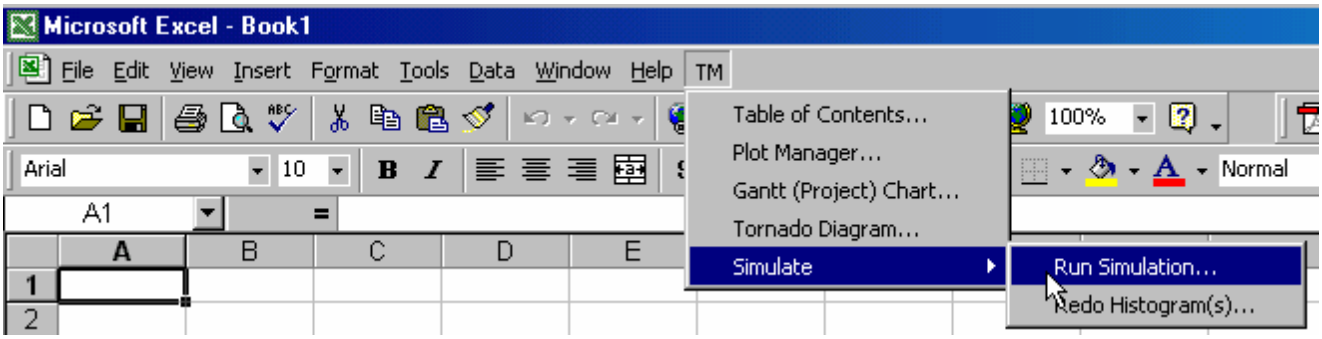
1.3 Software and hardware requirements

The program works on any computer that supports Microsoft Excel 97 or later with a Windows 95 or later operating system. In addition, you must have the Analysis ToolPak (an Excel add-in) installed. If there is sufficient interest in a Macintosh based version, I will be happy to ensure that ***SimRisk 2003*** does work on a Mac.

2. Installation

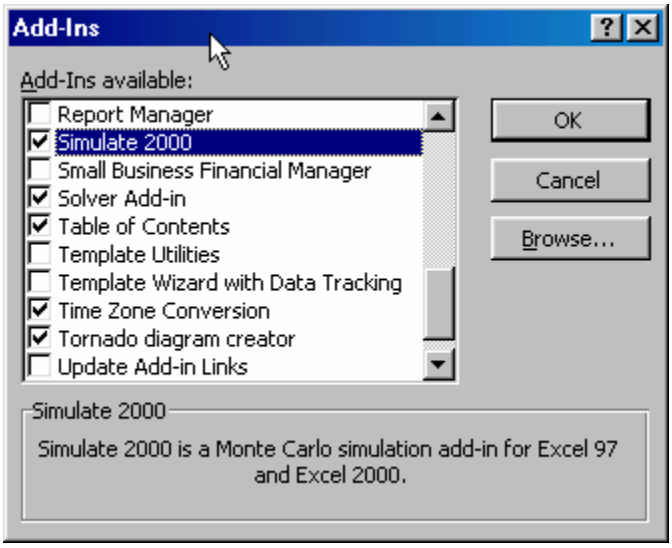
2.1 Do I have to read this Installation *stuff?*

Not if ***SimRisk 2003*** is already installed. You can tell the software is available by checking for the **Simulate** submenu in the **TM** menu of the **Worksheet** toolbar. If you see the submenu items, you are all set.



2.2 OK, so I don't see Simulate► How do I install the software?

1) If you haven't unzipped the downloaded simulate.zip file, do so now. If you need software to do so, visit the http://www.zdnet.com/downloads site or the www.winzip.com site. Put the files that are in the zip file in a directory of your choice.
2) Within Excel, install the add-in by selecting **Tools** | **Add-Ins...**
3) Click the **Browse** button
4) In the next dialog box, *locate* the ***SimRisk 2003*** file you copied in step 1 above and then click the **Open** button.
5) If Excel displays a dialog box asking if you want to copy the file to the 'Excel Add-In Library,' click the **No** button.
6) Ensure the checkbox associated with **SimRisk 2003** is checked.



2.3 I'm done with SimRisk 2003. How do I get rid of it?

1. Select **Tools | Add-Ins...**
2. *Uncheck* the ***SimRisk 2003*** checkbox
3. Click **OK**
4. If you are sure you won't need the software later, delete the SimRisk2003.xla file from the hard disk.

3. An example

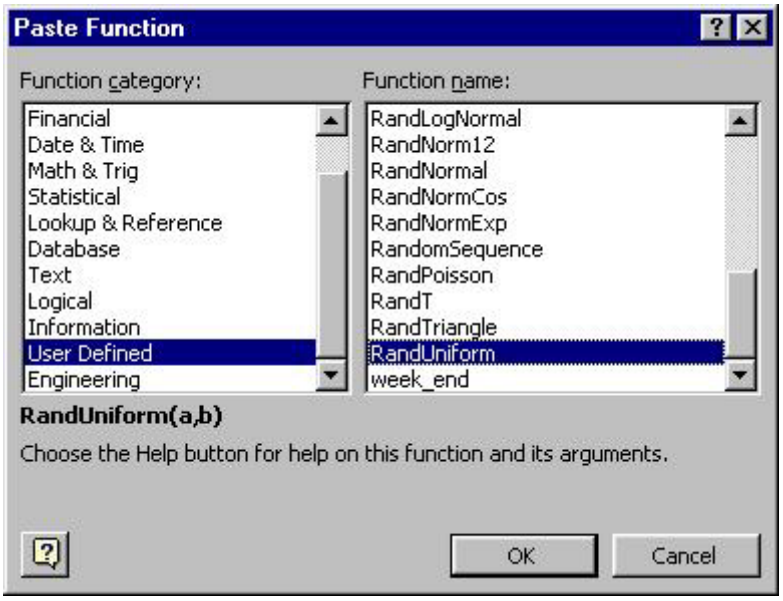
Subsequent sections of the user's guide use an acquisition opportunity to illustrate important features. Cliff Brokers is a small but growing full-service brokerage. It is considering an acquisition, which would significantly change the company's operating structure. The merged firm expects average revenues from a typical customer trade to be between $35 and $50, with all numbers equally likely. It expects the cost of executing each trade to be normally distributed with a mean of $30 and a standard deviation of $5. The projected fixed costs, for a period, are $10,000,000. Each of the 100,000 clients of the new firm trade between 7 and 10 times with equal probability. Management wants to estimate the likelihood of the firm making a profit in the period.

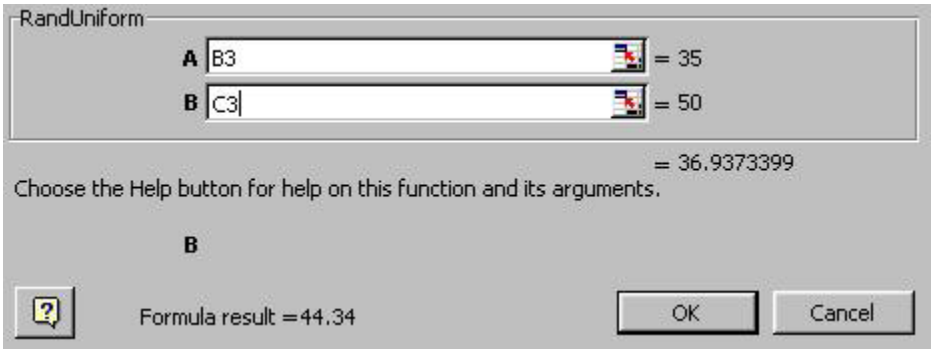
4. Creating a simulation spreadsheet model

If you know how to create a spreadsheet model, you already know how to use *SimRisk 2003's* functions.

The program adds a number of random number generators based on well-known probability distributions. In addition, it allows you to specify custom discrete and (approximations to) continuous distributions. Each time Excel recalculates the spreadsheet, the random number generators pick a different value from the respective distribution. *To have Excel do an immediate recalculation, press F9 on a Windows machine or 'Cmd =' on a Macintosh.*

For example, to generate a random number uniformly distributed from 35 to 50, you would enter the formula "=RandUniform (35, 50)" in a cell – without the quotes. Of course, you could also use the *Function Wizard* to enter the formula. All ***SimRisk 2003*** functions are in the function category *User Defined* and start with the token *Rand*





where cell B3 contains 35 and cell C3 contains 50.

Similarly, to have Excel generate random numbers from a Normal distribution with a mean of 30 and a standard deviation of 5, one would use the formula "=RandNormal(30, 5)"

The complete spreadsheet is:

	A	B	C
1	**Cliff Brokers**		
2	Revenue per trade	44.14	
3		*35*	*50*
4	Cost per trade	23.62	
5		*30*	*5*
6			
7	Trade contribution margin		
8		20.52	
9			
10	Trades per customer	9	
11		*7*	*0.25*
12		*8*	*0.25*
13		*9*	*0.25*
14		*10*	*0.25*
15			
16	Customer contribution margin	184.68	
17			
18	Customer base	100,000	
19			
20	Net income from trades	18,467,998	
21			
22	Fixed cost	10,000,000	
23			
24	Net profit	8,467,998	

where the numbers in italics are the *parameters* for the various functions, **RandUniform**, **RandNormal**, etc.,

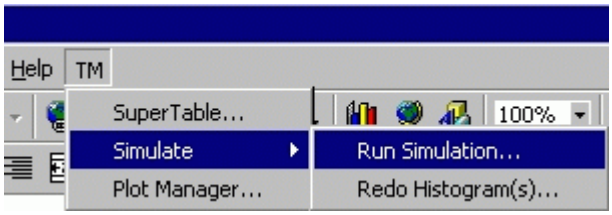
and the formulas in the various cells are:

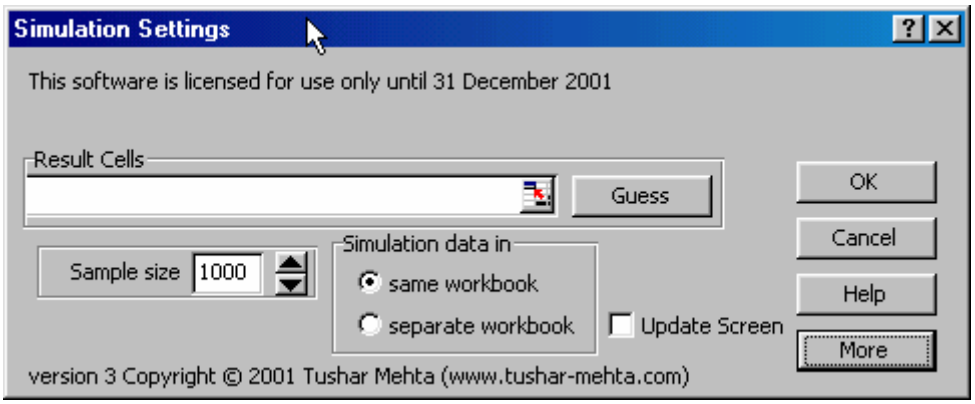
	A	B	C
1	**Cliff Brokers**		
2	Revenue per trade	=RandUniform(B3,C3)	
3		*35*	*50*
4	Cost per trade	=RandNormal(B5,C5)	
5		*30*	*5*
6			
7	Trade contribution margin		
8		=B2-B4	
9			
10	Trades per customer	=RandCustomPDF(B11:B14,C11:C14)	
11		*7*	*=1/4*
12		*8*	*=1/4*
13		*9*	*=1/4*
14		*10*	*=1/4*
15			
16	Customer contribution margin	=B8*B10	
17			
18	Customer base	100000	
19			
20	Net income from trades	=B16*B18	
21			
22	Fixed cost	10000000	
23			
24	Net profit	=B20-B22	

5. Running a Simulation

5.1 The SimRisk 2003... dialog

The software needs certain information before it can run a simulation. Select **TM** | **Simulate** ► **Run Simulation...** to see the simulation dialog box





If you see a dialog box with more fields click the **Less** button to get the above dialog box.

5.1.1 Selecting the result cell(s)

You specify which cells contain data of interest. In the sample problem there is just the one, Net Profit, cell B24. Use Excel's normal method to select one cell or multiple cells.[1]

SimRisk 2003 will monitor, and report on the contents of, the result cell(s).

5.1.2 The GUESS button

The GUESS button uses a special algorithm to guess the result cell(s). Of course, no software can anticipate your need 100% of the time, but it will come close. More information about this feature is in the Advanced Features section later in this document. Clicking the button for our sample problem results in the program correctly selecting B24.

5.1.3 Picking a sample size

Simulations rely on sampling the underlying population and analyzing the sample created. Sample size allows you to specify how large the sample should be. The results from larger samples are more reliable but take longer to create and analyze.

5.1.4 Report Location

'**Simulation data in**' lets you specify whether the data gathered during the simulation should be in a separate workbook or in a new worksheet in the current workbook.

5.1.5 Update screen

With this box checked, the software refreshes the screen as the simulation runs. While it allows you to view the sample generation process, it slows the program significantly.

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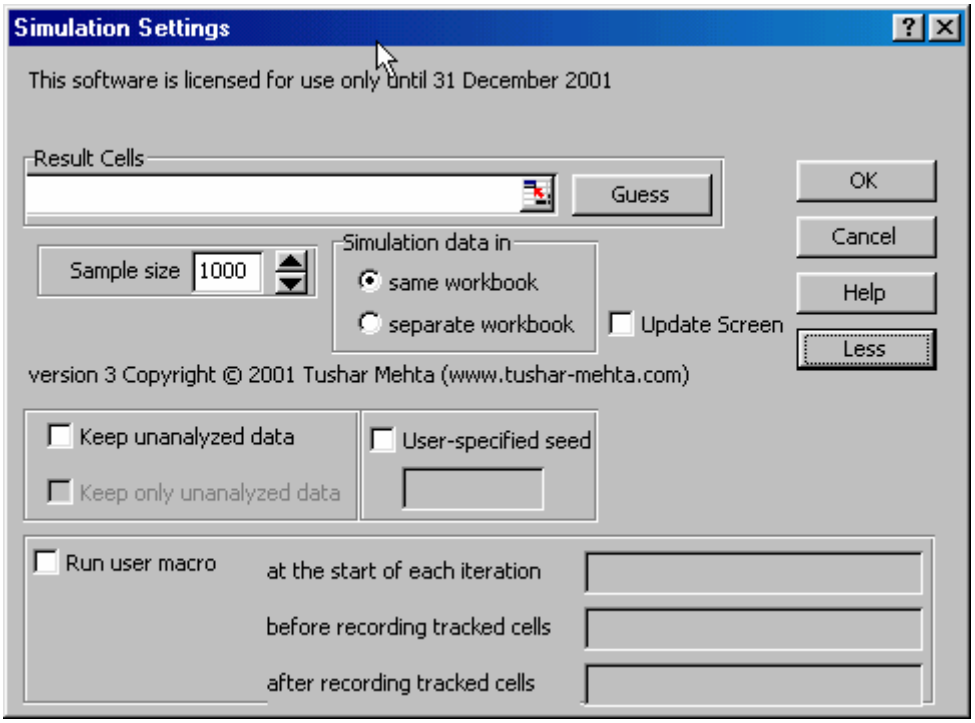
[1] To select a continuous range, click-and-drag, or click on the first cell and shift-click the last cell; to select disjoint cells use control-click in Windows or command-click on a Macintosh).

5.1.6 The 'OK,' 'Cancel,' and 'Help' buttons

What do these buttons do? OK, OK, I know you know! But for the sake of completeness... click the **OK** button to run the simulation; the **Cancel** button to stop without running the simulation, and the **Help** button to get to interactive help.

5.1.7 The 'More' (or 'Less') button

This button displays advanced options that are used to further configure the performance of ***SimRisk 2003***. When the advanced features are shown in the dialog box, the **Less** button replaces the **More** button



5.1.8 Keep unanalyzed data

Normally, the software retains the simulation data it collects after sorting them. These data are in the same sheet as the one with the descriptive statistics, and the various charts. Checking this option, **Keep unanalyzed data**, tells the software to retain the unsorted data. They are in the sequence in which they were collected.

The subordinate option, **Keep only unanalyzed data**, keeps the unanalyzed data as described above and skips all analysis.

See the Advanced Features section later in this document

5.1.9 User specified seed

This is an advanced feature and not for those who are learning simulation. Checking the user-specified seed box lets you specify the starting seed used in the simulation. See the Advanced Features section later in this document.

5.1.10 Running a user written macro

This is an advanced feature and not for those who are learning simulation. It lets you integrate a macro (a Visual Basic program) you've written into the simulation. This is an extremely powerful – and equally dangerous – capability available to the advanced Excel user and Visual Basic developer. The reader should be aware that the power of Visual Basic macros carries with it the same degree of responsibility. ***Misuse, intentional or otherwise, of Visual Basic programs (macros) can result in disastrous consequences ranging from loss of your unsaved work to being unable to use your computer***. See the Advanced Features section later in this document.

6. The Simulation Result

6.1 The result sheet

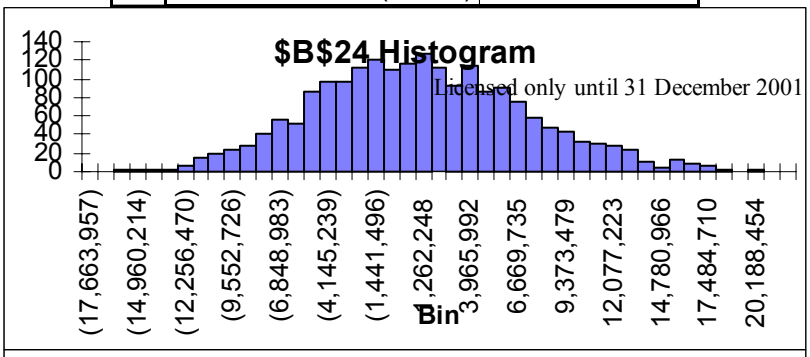
The software adds a new worksheet, named *Sim*, to the current workbook, or to a new workbook it creates (depending on your selection of **Report Location** in the dialog box). If *Sim* already exists, it creates *Sim (1), Sim (2),* etc. However, it will stop after *Sim (4)*. Instead of creating *Sim (5)* it will issue a warning and the new worksheet will be named Sheet<nn> where <nn> is an Excel-assigned number.

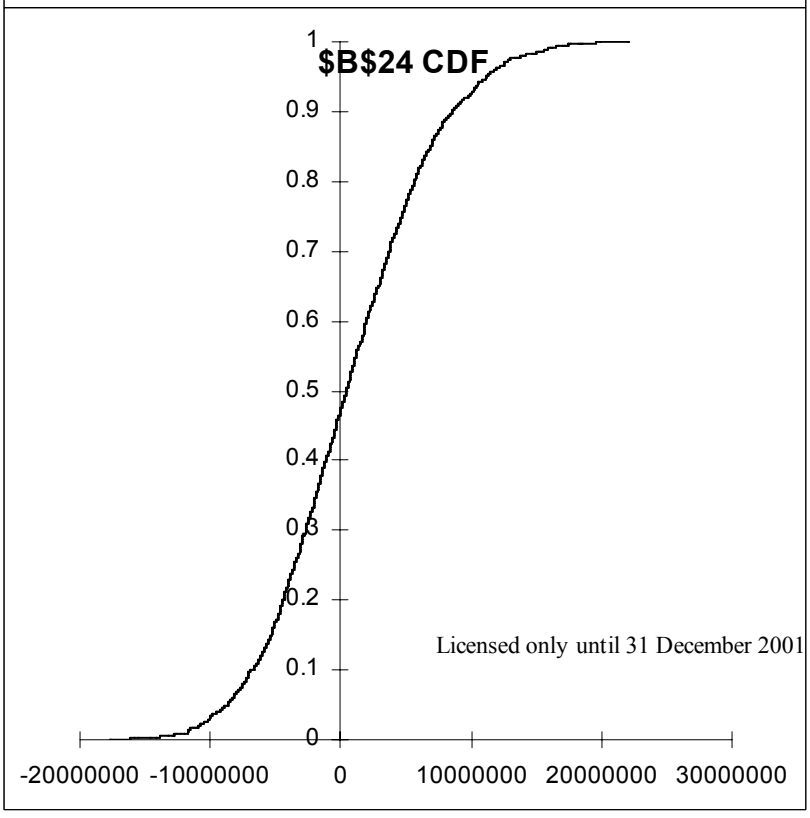
The new worksheet contains the data gathered during the simulation and inferential information. The result includes statistics, a histogram, and a cumulative density function.

6.2 Identifying the result cell(s)

If you use Excel's cell naming capability (**Insert | Name | Define...**) to name a result cell, ***SimRisk 2003*** will use the name to identify the statistical and graphical results. If you don't give the cell a name, ***SimRisk 2003*** uses the cell address (B24 in our example).

	A	B
1	*B24*	
2		
3	Mean	687667.639
4	Standard Error	186053.9182
5	Median	473269.8803
6	Mode	#N/A
7	Standard Deviation	5883541.49
8	Sample Variance	3.46161E+13
9	Kurtosis	-0.004492763
10	Skewness	0.271422508
11	Range	41462839.14
12	Minimum	-18438639.76
13	Maximum	23024199.38
14	Sum	687667639
15	Count	1000
16	Confidence Level(95.0%)	365101.7823





6.3 Analysis of multiple result cells

If you asked ***SimRisk 2003*** to track multiple result cells, all the analysis would be in the same worksheet. 50 rows separate the results. So, if ***SimRisk 2003*** were tracking 3 cells, say A23, B24, and C25, the analysis for cell A23 would start in row 1, that for cell B24 in row 51, and for cell C25 in row 101.

6.4 Simulation Statistics

SimRisk 2003 provides statistics about the simulation run. This information is where the analysis for the *next* result cell would have been. So, if ***SimRisk 2003*** were tracking 3 cells, the sampling summary would be in row 151.

6.5 Descriptive statistics

SimRisk 2003 uses Excel's *Data Analysis* add-in (*Descriptive Statistics* module) to generate the descriptive statistics. The results are in column 'A.'

6.6 Histogram

A histogram, created with Excel's *Data Analysis* add-in (*Histogram* module), of the sample data is in column E. You are welcome to resize the chart or modify the format to suit your preferences.

6.7 The cumulative density function

A cumulative density function of the sample data is below the histogram. Again, you are welcome to resize it or modify the format to suit your preferences.

6.8 The (raw) sample data and intermediate information

*You must not modify the data described here (actually, you should not modify any data in the output worksheet). Doing so **will** corrupt the SimRisk 2003 result.* The sample data are located starting in column AA. Each result cell requires 3 columns of data. The first column contains the samples; the second column contains y-values for the CDF; the third column contains x-axis steps required to draw the 'steps' in the CDF.

Intermediate data, used for the histogram, are located in column N.

7. Post simulation capability

Unless the user changes the default settings, the result of the simulation is a worksheet with the sorted simulation created sample, and for each tracked cell, descriptive statistics, a histogram, and a cdf.

8. Available Random Number Generators

Statistics textbooks such as those prescribed for introductory MBA courses on decision analysis, and "Introduction to the Theory of Statistics," by Mood, Graybill, and Boes document most of the available functions. In addition, the software allows you to create custom distributions, which provide an almost limitless choice of probability density and cumulative density functions.

8.1 'Standard' distributions

Available distributions, both continuous and discrete, are listed in the table below. These functions are well documented in most introductory statistics books.

Distribution	***SimRisk 2003** function*	*parameters*
Beta	RandBeta	alpha, beta, a, b
Binomial	RandBinomial	n, p
Chi-square	RandChiSquare	degrees of freedom
Exponential	RandExponential	lambda
F	RandF	degrees of freedom (numerator), degrees of freedom (denominator)
Gamma	RandGamma	alpha, beta
Log Normal	RandLogNormal	Mean, standard deviation
Normal	RandNormal	Mean, standard deviation
Poisson	RandPoisson	lambda
Students t	RandT	degrees of freedom
Triangle	RandTriangle	a, m, b, (optional) weights
Uniform	RandUniform	a, b
The parameters are 'standard' names commonly used in most statistics books		

8.2 Custom distributions

Two custom functions provide wide latitude in constructing probability distributions

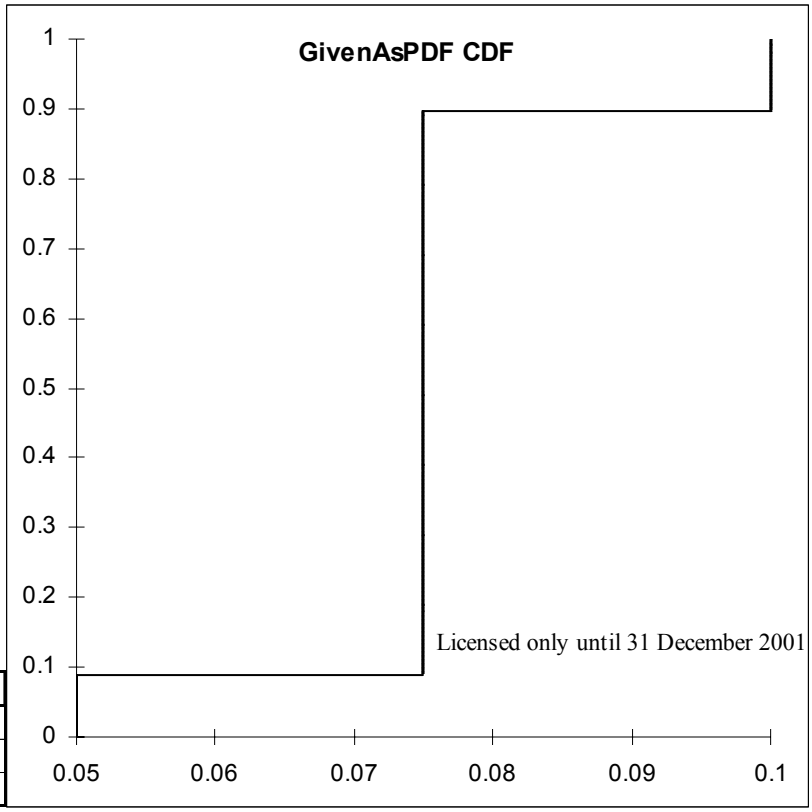
Distribution	***SimRisk 2003** function*	*Parameters*
Custom CDF	RandCustomCDF	values, probabilities, (optional) isDiscrete
Custom PDF	RandCustomPDF	values, probabilities, (optional) isDiscrete
Setting the optional 'isDiscrete' parameter to TRUE results in sampling from a discrete distribution. Specifying isDiscrete as FALSE results in a piecewise-linear distribution. The parameter defaults to true.		

Either function can substitute for the other (with appropriate parameters). For example, a discrete distribution specified as a pdf with values (1, 2, 3) with probability (0.1, 0.8, 0.1) can be written as a cdf with values (1, 2, 3) with probabilies (0.1, 0.9, 1.0),

To create a distribution with a piece-wise linear cdf, the third parameter, *isDiscrete*, should be FALSE. The three step example that follows should clarify how this works.

Consider the problem facing a brand manager of a popular cereal. She learns from her raisin supplier that the price will increase next year. The supplier, who we call Supplier 1, states that a 5% price increase is certain. Further, it is possible for the increase to be 7.5% (80% probability) and a small chance (10%) that the increase could be 10%. The supplier states that for simplicity it will increase the price in only one of these three discrete values (5%, 7.5%, or 10%).

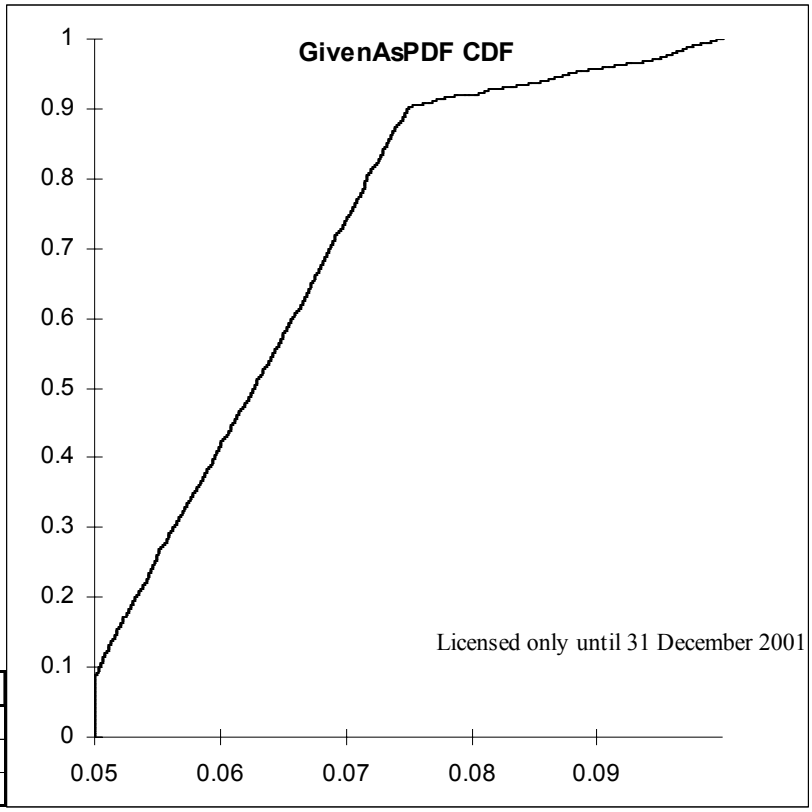
The manager enters the formula "=RandCustomPDF(F4:F6,G4:G6)" – without the quotes – in a cell named GivenAsPDF. The relevant data in cells F4:G6 and the CDF resulting from running ***SimRisk 2003*** are:



	F	G
4	0.05	0.1
5	0.075	0.8
6	0.1	0.1

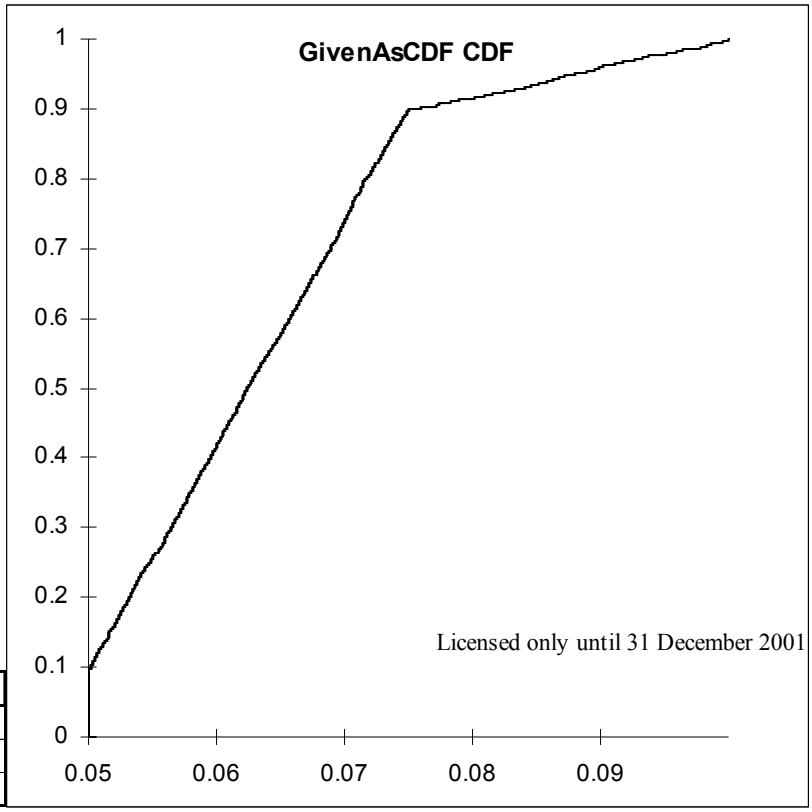
She realizes the median increase will be 7.5% (which is the x-value at which the CDF crosses 50% on the y-axis). Unhappy with the news of the price increase, she checks with one of her alternative suppliers. Supplier 2 informs her that it agrees with Supplier 1 that a 5% increase is inevitable. However, while it confirms Supplier 1's *point* estimates, it will pass through the exact price increase. The salesperson at supplier 2 estimates that all values between 5% and 7.5% are equally likely, just as are all values in the 7.5% to 10% range.

Now, the manager enters in the same cell as above, the formula "=RandCustomPDF(F4:F6,G4:G6,FALSE)." The result is



	F	G
4	0.05	0.1
5	0.075	0.8
6	0.1	0.1

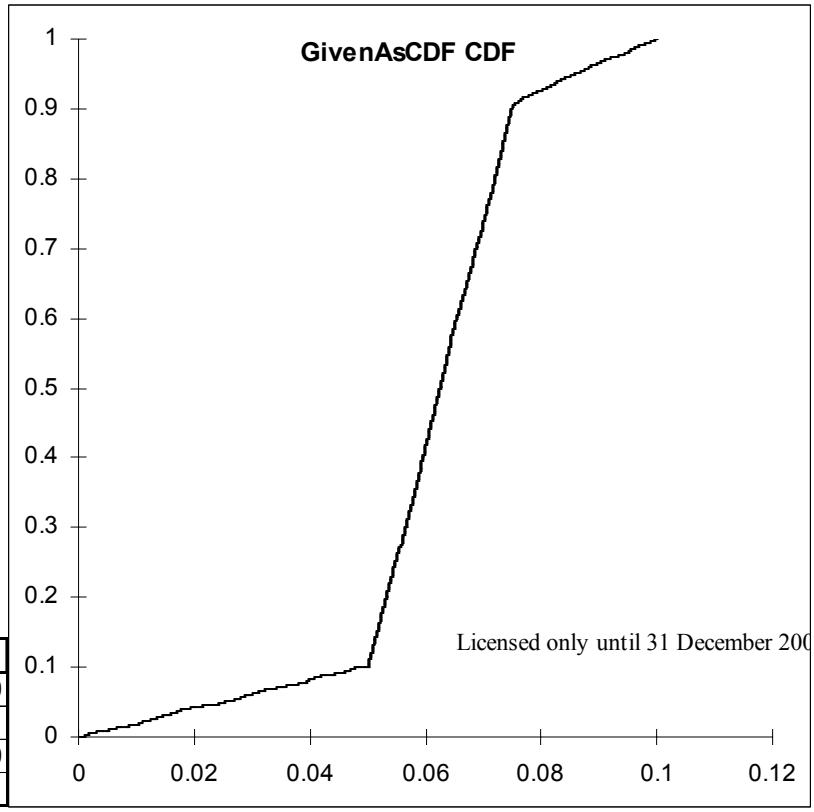
She decides to verify her work using a cumulative density function. In a cell named GivenAsCDF, she enters the formula "=RandCustomCDF(I4:I6,J4:J6,FALSE)." The relevant data in I4:J6 and the resulting CDF are:



	I	J
4	0.05	0.1
5	0.075	0.9
6	0.1	1

Reading off the CDF leads her to the conclusion that the median increase is just under 6.5%. Encouraged by the result she decides to check with a third supplier. This firm tells her it agrees with Supplier 2 except on the inevitability of a 5% increase. It estimates that, just like for the ranges 5%-to-7.5% and 7.5%-to-10%, all values between 0% and 5% are equally likely.

This time the manager uses the formula "=RandCustomCDF(I3:I6,J3:J6,FALSE)" in the cell GivenAsCDF. The *adjusted* data in I3:J6, and the resulting CDF are:



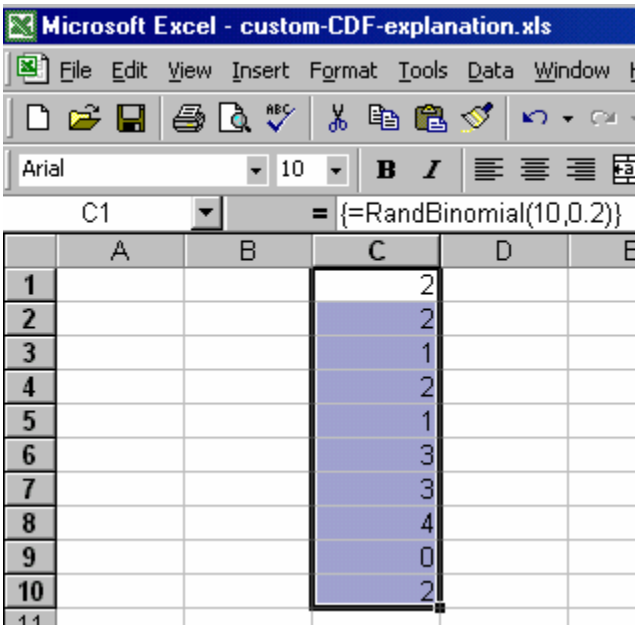
	I	J
3	0	0
4	0.05	0.1
5	0.075	0.9
6	0.1	1

Concluding her analysis, she realizes the median price increase has dropped to 6%.

9. Advanced Features

9.1 Array Formulas

Use ***SimRisk 2003's*** functions in array formulas just as you would use Excel's functions. For example, to enter the formula RandBinomial(10, 0.2) in 10 cells, select the range, enter the formula, and press '*Cmd Enter*' on a Macintosh or '*Ctrl Shift Enter*' in Windows. Using array formulas is quicker for both you and the computer.



Array formulas are identified by the curly brackets around them, i.e., '{' and '}'

9.2 The GUESS feature

The GUESS feature identifies the 'end-point' of each 'formula chain' in a spreadsheet. It then suggests each end-point as a possible result cell. For example, in the following spreadsheet GUESS would identify cells A2 and B1 as result cells (this assumes all other cells are empty).

	A	B
1	=RandExponential(1)	=RandNormal(10,4)
2	=A1+5	

A2 is the end-point of the A1 - A2 formula chain; and B1 is the beginning and the end of the second formula-chain.

9.3 Keep unanalyzed data

Normally, the software stores the simulation data it collects after sorting. These data are in the same sheet as the one with the descriptive statistics, and the various charts. Checking this option causes the software to add the unsorted data to the same sheet. They are in the sequence in which they were collected.

This option is useful when the decision making process involves a set of linked decisions (a vector to the technically oriented). For example, consider an airline planning its operations. Amongst other issues, it must decide how many jet airplanes and how many turbo-prop planes it

must have in service each day. Each alternative decision consists of two components – 'x' jets and 'y' turbo-props. The analyst builds an Excel model which, given the number of planes in service, reports the airline's operating profit. In running the simulation, the analyst tracks three cells – the number of jets, the number of turbo-props, and the profit. For analysis purposes, the simulation software sorts each of the three cells independently. However, that destroys the relation between the profit and the number of jets and turbo-props. Checking the **Keep unanalyzed data** box will do the analysis *and* keep the unsorted data intact.

The subordinate option, **Keep only unanalyzed data**, keeps the unanalyzed data as described above and skips all analysis.

9.4 User specified seed

By default, the system clock is the seed for initializing the Excel random number generator. Those who prefer specifying their own seed should use this ***SimRisk 2003*** capability. You should use this facility only if you are familiar with the underlying subtleties of random number generators.

9.5 User written macro

The user-written macro feature lets you enhance the capability of ***SimRisk 2003*** dramatically. For example, you could incorporate an optimization in a simulation. You should write, in Visual Basic for Applications (VBA), a parameter-less function macro. In the ***SimRisk 2003*** dialog box check the **Run user macro** box. Specify the name of the function you wrote in the associated field and select one of the three associated options on when ***SimRisk 2003*** should call the macro.

To understand the implications of when ***SimRisk 2003*** calls the macro, a tiny detour is required. The collection of each sample data element involves two steps. First, ***SimRisk 2003*** regenerates all the random numbers in the spreadsheet (using the software equivalent of 'Recalculate Now' command). Second, it records the contents of the cells it's tracking. The three timing buttons let you specify when the macro is called – before the random numbers are recalculated, before the tracked cells are recorded, or just after the cell values are recorded. The next sub-sections provide examples on how this feature can be useful.

9.5.1 Running an optimization during sampling

Consider the case where a spreadsheet model requires an optimization each time certain parameters change. If the user writes such an optimization macro, ***SimRisk 2003*** can then call the macro after it changes the random variables and before it records the values of the tracked cells.

Of course, such an optimization macro could be written to do nothing more than call the Microsoft provided SOLVER, the less-sophisticated 'Goal Seek...' function, or some other third-

party software. Irrespective of the optimization method, please read the caveats below (*especially* the one on **volatile** functions).

9.5.2 Using the results of the current iteration the next time around.

The example used to illustrate this capability may seem unrealistic but the lesson remains important. Consider simulating a 5,000 day random walk for a stock market index such as the Dow Jones Industrials Average or an individual stock price. The analyst expects the index at the end of the day to be distributed normally with a mean equal to the value at the end of the previous day, and a standard deviation of 1%

One possible way to do this in Excel is to enter (a normalized value of) 100 in cell A1, the formula "=RandNormal(A1,A1/100)" in cell B1 and copy the formula in B1 into the next 5,000 rows. A scatter plot of the contents of the 5,000 cells will graphically demonstrate the random walk.

Alternately, record a macro that copies the value of cell B1 into cell A1, and use SIMULATE with this macro called **after recording tracked cells**. Check **keep unanalyzed data** and the SIMULATE software will give you the result.

9.5.3 Caveats

9.5.3.1 Caveat 1 Error Protection

Neither this document, nor the software, can help the user with VBA programming. The software assumes the user is aware of the consequences of the code he, or she, writes. ***SimRisk 2003*** calls the user-written macro and *lets it do whatever it is programmed to do*. There are **no safety checks** to protect the user from her, or his, programming errors.

9.5.3.2 Caveat 2 Excel file names

On occasion, Excel's ability to deal with filenames containing non-alphanumeric characters is limited. If ***SimRisk 2003*** complains it cannot locate your macro and you are sure you have the correct name, verify the name of the file containing your macro contains only alphanumeric characters (a-z, A-Z, and 0-9).

9.5.3.3 Caveat 3 Simulation uses 'volatile' functions

The macro you provide must understand the nature of the spreadsheet it is working with. Specifically, each of the formulas that generate a random number is a **volatile** function. That is Excel-speak for the fact that the value of the cell will change each time Excel does a recalculation. This is especially important if your macro, or a function it calls, changes some cells on the spreadsheet and assumes that only those cells have changed.

For example, consider a case where ***SimRisk 2003*** calls the user-specified macro and the user-macro optimizes the spreadsheet by calling the SOLVER add-in. Solver assumes that no cell contains a volatile function. It, in doing its work, changes the decision variables (the 'by

changing cells' in the SOLVER dialog box) and recalculates the spreadsheet. It assumes the recalculated values are exclusively the result of what it changed. However, since the random variables are volatile functions, they will also take on different values with each recalculation. Consequently, it will be an absolute coincidence if SOLVER finds the correct optimal result.

There is a work-around this problem – but it is not easy. The user-macro should copy the formula in each of the random variable cells into a temporary location and replace the content of the cell with the current value. Then, the user-macro calls SOLVER, and once Solver finishes, the user-macro reinstates the formulas in the random variable cells! Again, in doing so, the programmer assumes responsibility of ensuring the integrity of the spreadsheet. Specifically, think of the consequences of a software failure after the values replace the formulas in the random variable cells and before the macro reinstates the formulas.

10. Limits and known problems

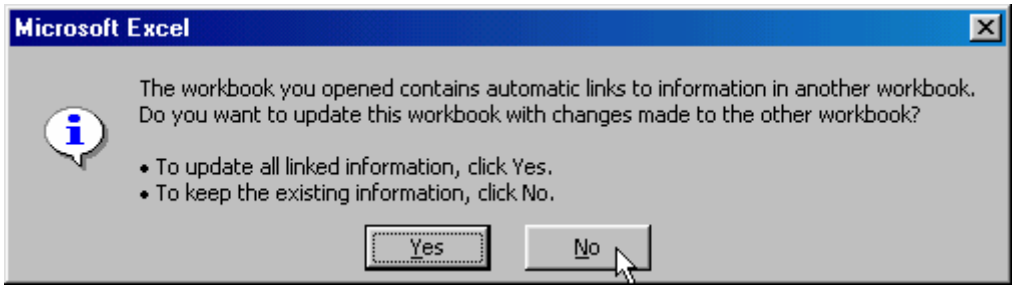
10.1 Maximum sample size

The software is an education tool. In that spirit, the maximum sample size is recommended to be no larger than 2,000. Larger samples might lead to memory-related problems on some computers.

10.2 Moving a spreadsheet from one computer to another

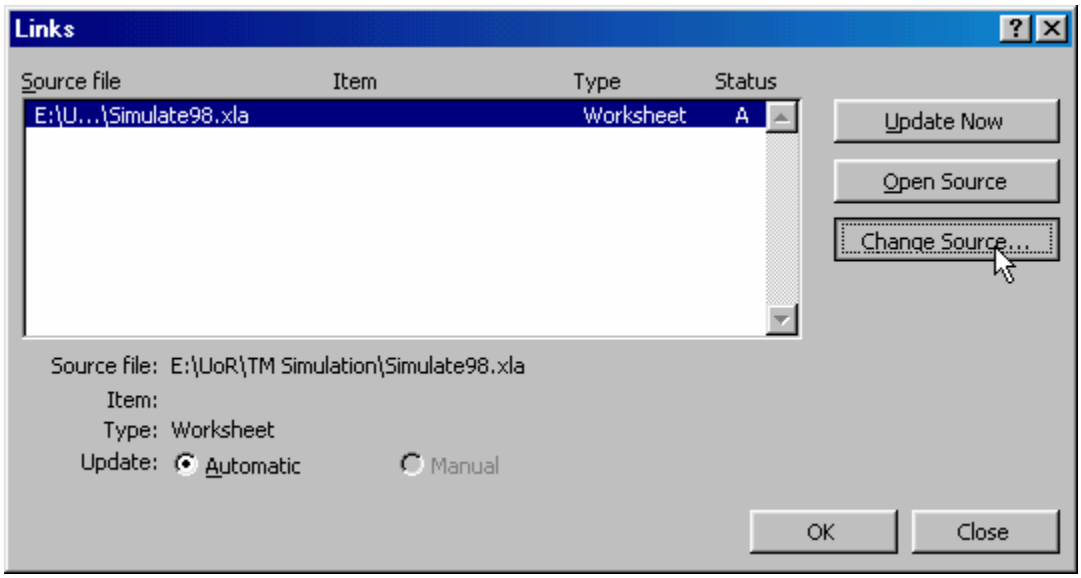
This problem is not *SimRisk 2003* -specific but happens with all add-ins. Moving a spreadsheet with references to an add-in (such as ***SimRisk 2003***) from one computer to another requires extra steps to ensure the add-in links properly.

1) On the new computer, open Excel
2) Ensure the ***SimRisk 2003*** software is available (see section 2 on how to verify availability; and, if necessary, how to install it)
3) Now, open the spreadsheet. Excel may display a dialog box asking if you want to update links. Click the **No** button



4) All cells with references to ***SimRisk 2003*** probability functions will contain #NAME? *Don't panic; at least, not yet.*

5) Select **Edit | Links...** In the dialog box displayed, click on the **SimRisk2003.xla** file entry. This should be the complete file name on the original computer. In the snapshot below it is truncated to *E:\UoR\...\Simulate.xla*. The entire name is listed below the Source file pane. Click the **Change Source...** button



6) In the next dialog box, *locate* the **SimRisk2003.xla** file (see the Installation section above), and click **OK**.

7) In the previous dialog (which will become the active dialog), click the OK button; the spreadsheet should correct itself. *If you have links to other add-ins, you must update all references before the spreadsheet will display the correct values.*

10.3 Deleting (or moving) worksheets on Windows 95

Consider the following scenario: you create a new workbook with 16 sheets named Sheet1, Sheet2, etc. A simulation model is in 'Sheet1.' ***SimRisk 2003*** creates a result sheet named 'Sim.' Now, you move Sheet2 to after Sheet16, or you delete Sheet2. For each ***SimRisk 2003*** formula you used in Sheet1, you will see a dialog box with a message 'Missing object.' The cells in Sheet1 will display '#VALUE?' as the cell value.

Close (save, if necessary) the workbook and reopen it. This fixes the problem!

10.4 Screenupdating and Office 97 (Excel 8.0a)

Even with the 'Update screen' option **unchecked** (for a discussion of ***SimRisk 2003*** options see section 5), Excel displays changes to graphs as they occur. This does not affect the result of the simulation though it does slow the graphing phase of the simulation.

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