Introduction to Excel's What If Techniques

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Introduction

One of the advantages of Excel is the ease with which you can try different values in cells and see the differences these changes make on results.

This can be as simple as changing the inflation figure in a budget and seeing the impact on profit. Excel allows you to easily make these "What If" type changes.

There are also a few built-in features that can assist when doing more complex What If analysis work. This session will introduce the following four What If features.

Goal Seek - the most basic What If feature that can save you time and eliminate a lot of trial and error entries.

Solver - Add-in - A much more complex and flexible version of Goal Seek. It is very powerful and has many useful features. To use Solver you must install the Add-In. It has its own section in the Data ribbon tab.

Data Table - A one or two variable table that can summarise the results of changes very easily. Not to be confused with a data list or a formatted table. This option is under the What If button in the Data ribbon tab.

Scenario Manager - an advanced feature that can be used with financial models to handle different scenarios, eg best case; worst case and base case. This feature will only be looked at briefly in this session.

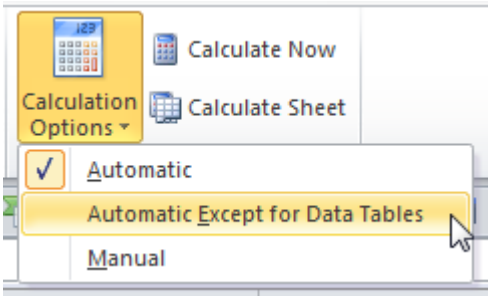
Both Solver and Data Tables can take a few uses to understand and master so be patient.

The examples I will be using will be straight forward. Goal Seek's usefulness is impacted by your formula's complexities and relationships. The more complex formulas are, the less Goal Seek may help.

Solver and Data Tables are impacted by the complexity of the model in terms of speed and how long they take to work.

You may have seen Data Tables mentioned in the Formulas ribbon tab, in the Calculations section. Data Tables can impact calculation time and they are sometimes turned off to speed up calculation time.

See the WARNINGS on the last page regarding Data Tables.



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Goal Seek

Goal Seek is by far the easiest of the What If tools to use and to master. Its premise is very simple. Define a single target cell that needs to be a certain value and then define a single input cell that will be changed to cause the target cell to match the target value. Shortcut, Alt t g pressed in sequence.

In this example the values in column B are all inputs.

The inputs are all used by formulas in column F to create the report.

We want cell F8 (profit % of sales) to be 15%.

We could change any the values in column B to achieve that.

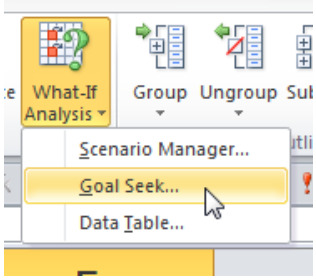
	A	B	C	D	E	F
1		Inputs				Output $
2	Sell Price	$35.00			Sales	$525,000
3	Sales Volume	15,000			Cost of Sales	$315,000
4	Sales Margin	40.00%			Margin	$210,000
5	Admin $	$85,000			Less Admin	$85,000
6	Marketing $	$55,000			Less Marketing	$55,000
7	Cost Factor	100.00%			**Profit Before Tax**	**$70,000**
8					Profit % of Sales	13.33%
9						
10					Profit % Required	15.00%

One of the limitations of Goal Seek is that it uses a simple algorithm to match the target cell to the target value. Sometimes it only gets close. It tries different values and works it ways towards a solution. Goal Seek starts with the value in the cell to be changed value. If that value is a long way from the final result needed, it might only provide a closer result than the existing result.

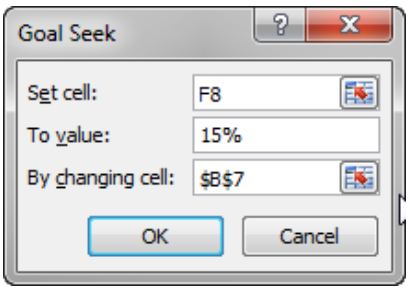
PRACTICE:

1. Click on cell F8, this will be the target cell.

2. Click the Data ribbon tab and the click the What If drop down. Select Goal Seek.

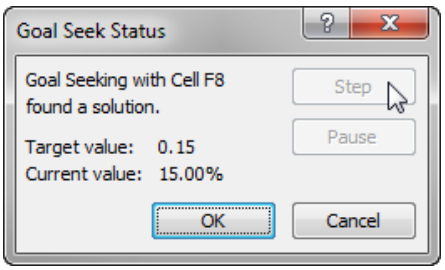


3. Click in the To Value: box and type 15%, then click in the By changing cell; box and use the mouse to select cell B7.
   Cell B7 containes a factor that is mulitplied by the Admin and Marketing costs. It provides a simple way to vary both those costs.



4. Click OK.

5. A dialog will be displayed with the result. Click OK.



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The result is correct. It means that is we drop Admin and Marketing costs by 6.25% (100% - 93.75%) we can achieve the 15% profit target.

5	Admin $	$85,000
6	Marketing $	$55,000
7	Cost Factor	93.75%
8		
9		
10		

Less Admin	$79,688
Less Marketing	$51,563
Profit Before Tax	**$78,750**
Profit % of Sales	15.00%
Profit % Required	15.00%

You can undo the results of a Goal Seek using the Undo command (Ctrl + z) or the Undo button.

Try doing two more Goal Seeks.

First try changing cell B4 (Margin %). Then use undo and change cell B2 (Sell Price) and see the results.

The first change will arrive at the 15% by using a Margin % of 41.67%.

4	Sales Margin	41.67%
5	Admin $	$85,000
6	Marketing $	$55,000
7	Cost Factor	100.00%
8		
9		
10		

Margin	$218,750
Less Admin	$85,000
Less Marketing	$55,000
Profit Before Tax	**$78,750**
Profit % of Sales	15.00%
Profit % Required	15.00%

The second change may not make it to the required 15%.

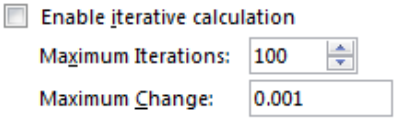
On my computer it got close, but was not exactly 15%.

Because the algorithm is reasonably simple it may struggle if you have complicated relationships between cells.

In those cases it might only get you closer to your result rather than achieving it.

	A	B	C	D	E	F
1		Inputs				Output $
2	Sell Price	$37.21			Sales	$558,141
3	Sales Volume	15,000			Cost of Sales	$334,884
4	Sales Margin	40.00%			Margin	$223,256
5	Admin $	$85,000			Less Admin	$85,000
6	Marketing $	$55,000			Less Marketing	$55,000
7	Cost Factor	100.00%			**Profit Before Tax**	**$83,256**
8					Profit % of Sales	14.92%
9						
10					Profit % Required	15.00%

You can amend how many attempts Goal seek uses by amending a setting in Options. Press in sequence alt t o f and amend the Iterative calculation numbers in the top right.



When we use the Solver feature next we will get to the 15% target.

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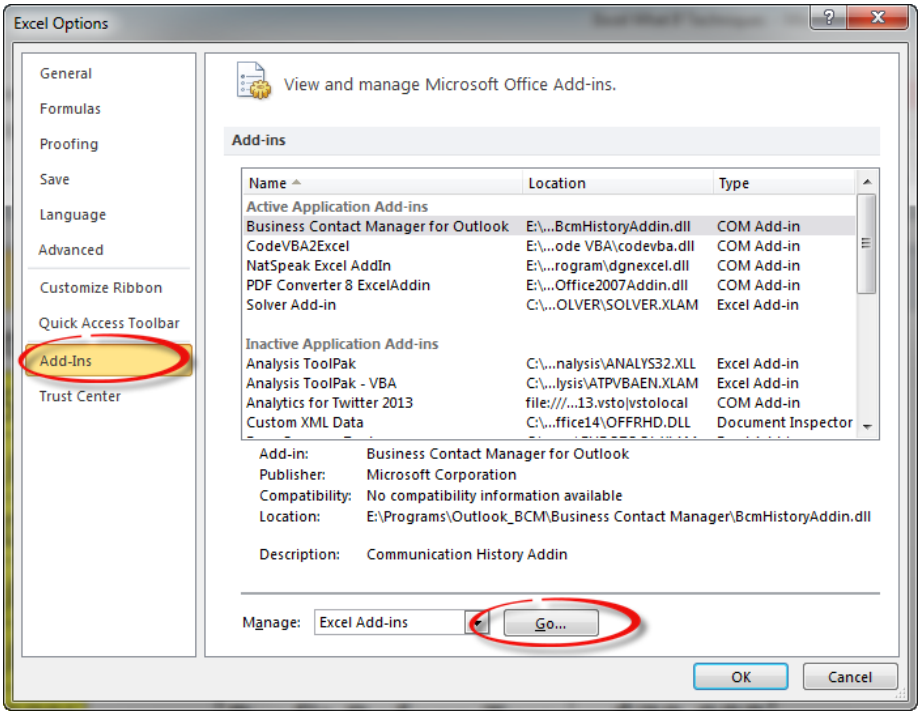
Solver

Solver is an advanced Goal Seek with a lot more flexibility. Solver is not limited to one cell to change. It also allows you to place parameters on the cells that you do change. You can also look to maximise and minimise certain values rather than achieve a certain goal value.

In practice it usually takes a few attempts to arrive at a satisfactory solution with Solver. Solver can get creative and use negatives and other values that aren't practical. It is up to you to set the right parameters to handle Solver's creative tendencies.

Add-In

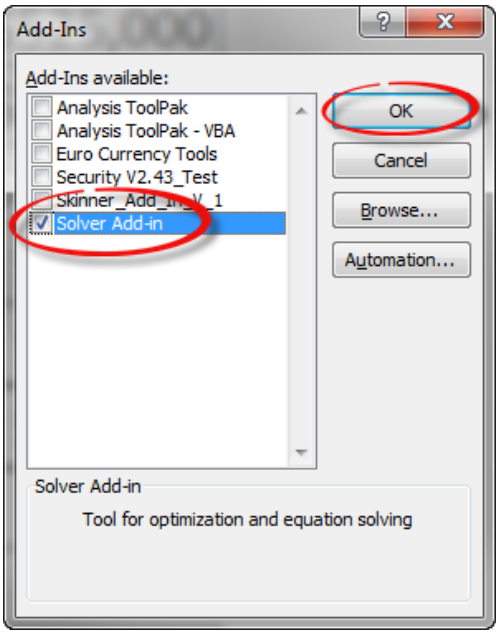
Solver is not installed when Excel is loaded. You must load the Add-in to be able to use it. To do that, follow these instructions



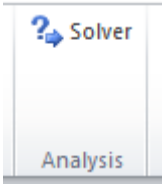
1. Press in sequence Alt t o this opens the Excel Options window

2. Click the Add-Ins option on the left and then click the Go button.

3. Make sure the Solver Add-in option is ticked and click OK.



4. Click OK again and the Add-in will be loaded and ready to use.



It will appear on the far right of the Data ribbon tab.

NOTE: Some Solver screens may vary between versions - I will be using Excel 2010.

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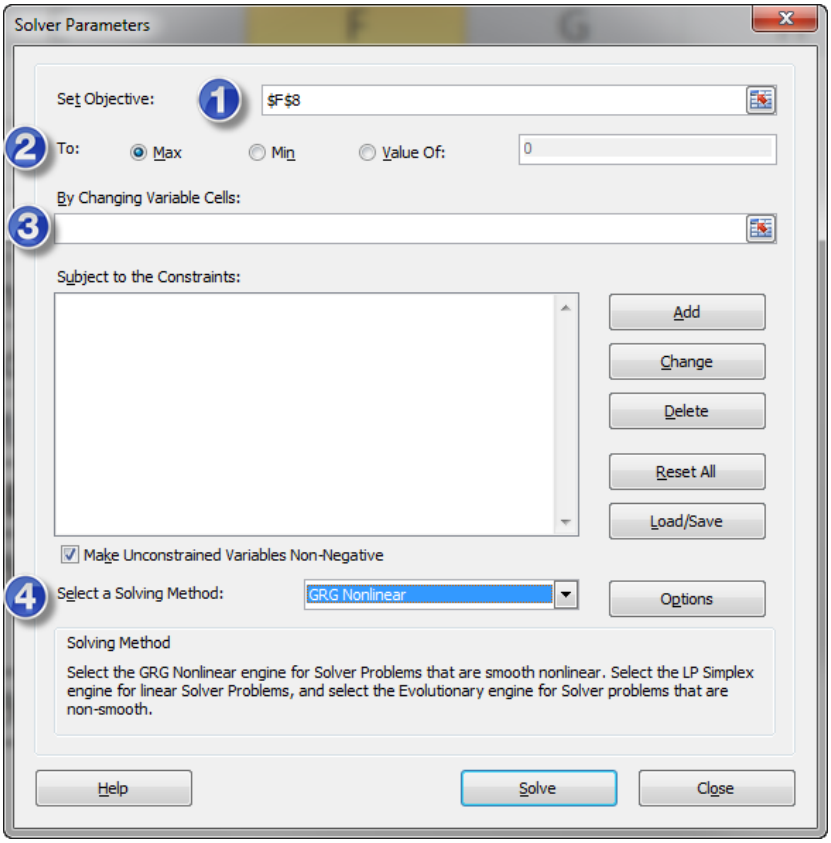
Click the Solver icon and we can review the Solver screen.



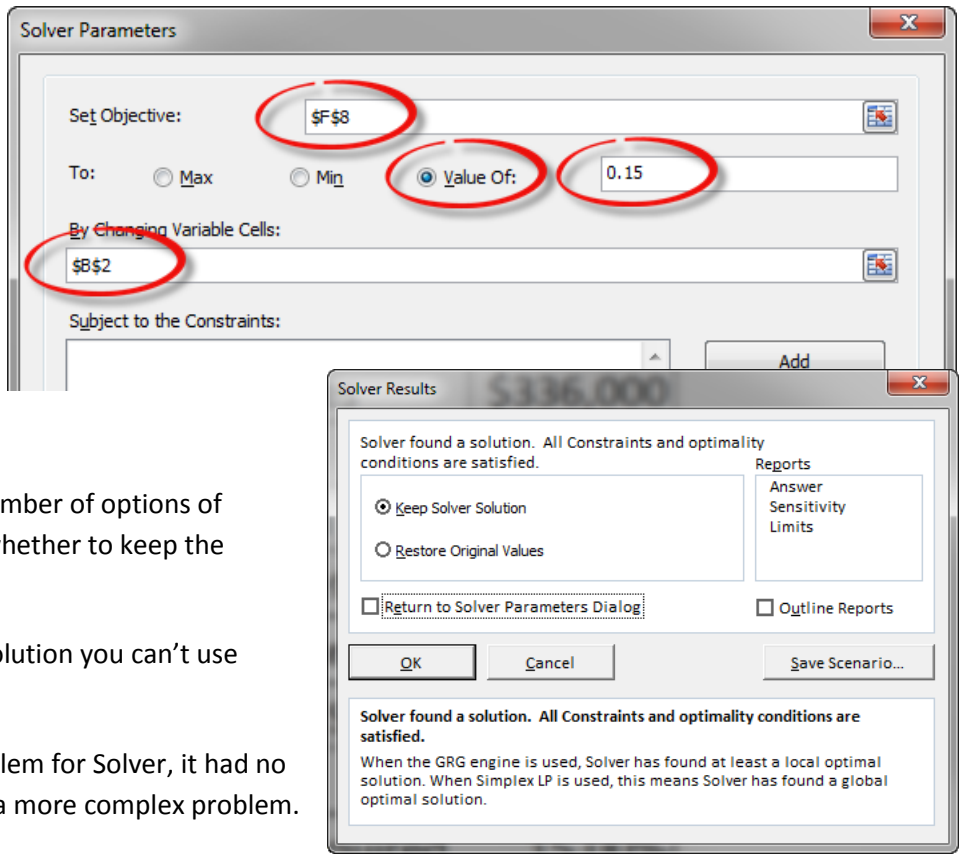
1. The Set Objective cell - Your target cell, the one with the result you are monitoring.

2. You can set a target value like Goal Seek or you can seek to maximise or minimise a cell.

3. You can add multiple cells to change and define constraints (parameters) for the values in those cells eg non-negative or less than a certain value.

4. Choose the type of algorithm to use to solve the problem. Different types may come up with different solutions. It depends on how complex the model is.

Let's review the previous problem from Goal Seek and see if we can achieve a better result with Solver.



Use the options on the right and click the Solve button.

When you click the Solve button a dialog is displayed.

It says whether a solution has been found.

This dialog gives you a number of options of reports to produce and whether to keep the solution.

Note: if you accept the solution you can't use Undo to go back.

This was a very easy problem for Solver, it had no constraints. Let's review a more complex problem.

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This example is based on one I used for an article in 2011. The model contains all the information required to set up Solver.

	A	B	C	D	E	F	G	H	I	J
1	Data	Unit Cost $	Capacity (tonnes)	Average $ per km	Trip Time (hrs)	Trips	Number of Trucks	Total Purchase $	Tonnes Carted	Total Running Cost $
2	Truck 1	150,000	10	9	1	1,840	2	300,000	36,800	1,656,000
3	Truck 2	200,000	12	13	1.1	1,673	3	600,000	60,218	3,262,350
4	Truck 3	300,000	20	14	1.4	1,314	12	3,600,000	315,429	11,037,600
5	Truck 4	450,000	24	15	1.5	1,227	0	0	0	0
6								4,500,000	412,447	15,955,950

7	Constraints	
8	Purchase cost limit $	4,500,000
9	Minimum total tonnes	400,000
10	Round trip distance km	50
11	Maximum hours per truck	1840

Our goal is to minimise the total running costs (cell J6) by optimising the purchase of trucks (yellow cells G2:G5). The total purchase price (H6) must be equal to or below $4.5 million cell (D8). At least 400,000 tonnes (cell D9) must be moved between the two sites with a round trip of 50 km (cell D10). Column E has each truck's trip time. Trucks are assumed to work their maximum hours (cell D11).

The figure on the bottom of the following page shows all the settings.

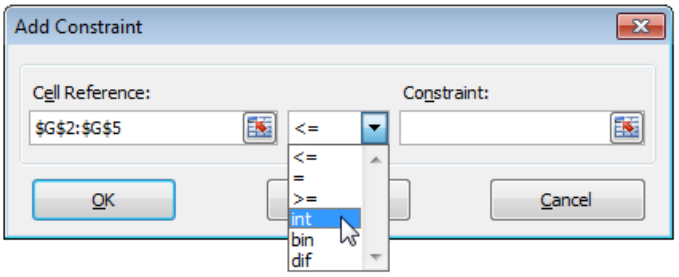
Click Solver in the Data ribbon tab. (Remember some screens may differ between versions)

1. Click inside the *Set Objective:* box and click cell J6.

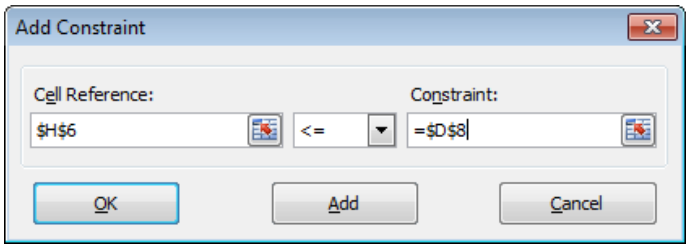
2. Click the *Min* option button underneath.

3. Click inside the *By Changing Cells:* box and select the range G2:G5.

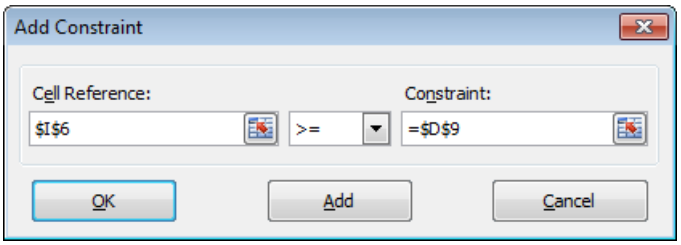
4. To add Constraints (we will need three) click the Add button and click inside the left box (see Figure 3) and select the range G2:G5.



5. Click the middle drop down arrow and select int. This constraint forces values in the range to be integers (whole numbers). This stops Solver buying half a truck.



6. Click the Add button. Click in the blank left box and the select cell H6. Click the middle drop down and select <=. Click in the *Constraint:* box and select cell D8. This is purchase price limitation of $4.5M. Click Add.



7. In the left box select cell I6. In the middle drop down select >=. Click in the *Constraint:* box and select cell D9. This is

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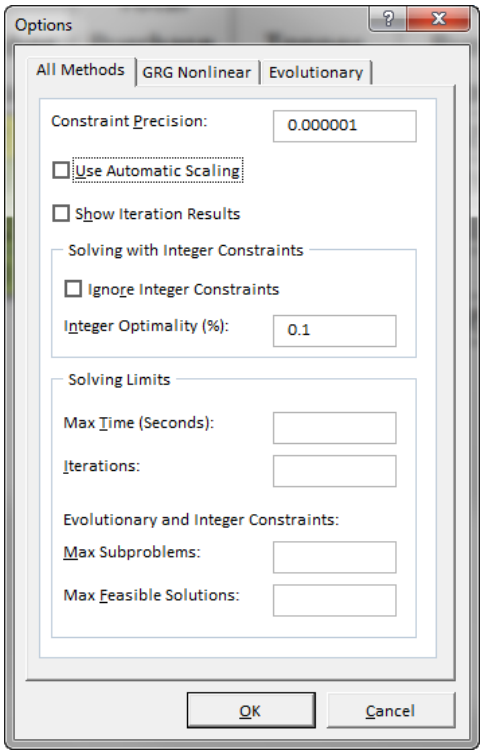
the minimum tonnes limitation of 400,000 tones. Click OK to complete the constraints entry.

8. Click the Options button. When specifying integers in Step 5 you need to set an Integer Optimality to 0.1 and tick the Ignore Integer Constraints option, then click OK.

9. Confirm the Solver Parameters dialog matches the figure in the bottom half of this page and click Solve. A dialog displays informing you that Solver has found a solution.

10. Click on the Save Scenario to save the results. Call the scenario Test_1 and click OK - we will examine that soon.



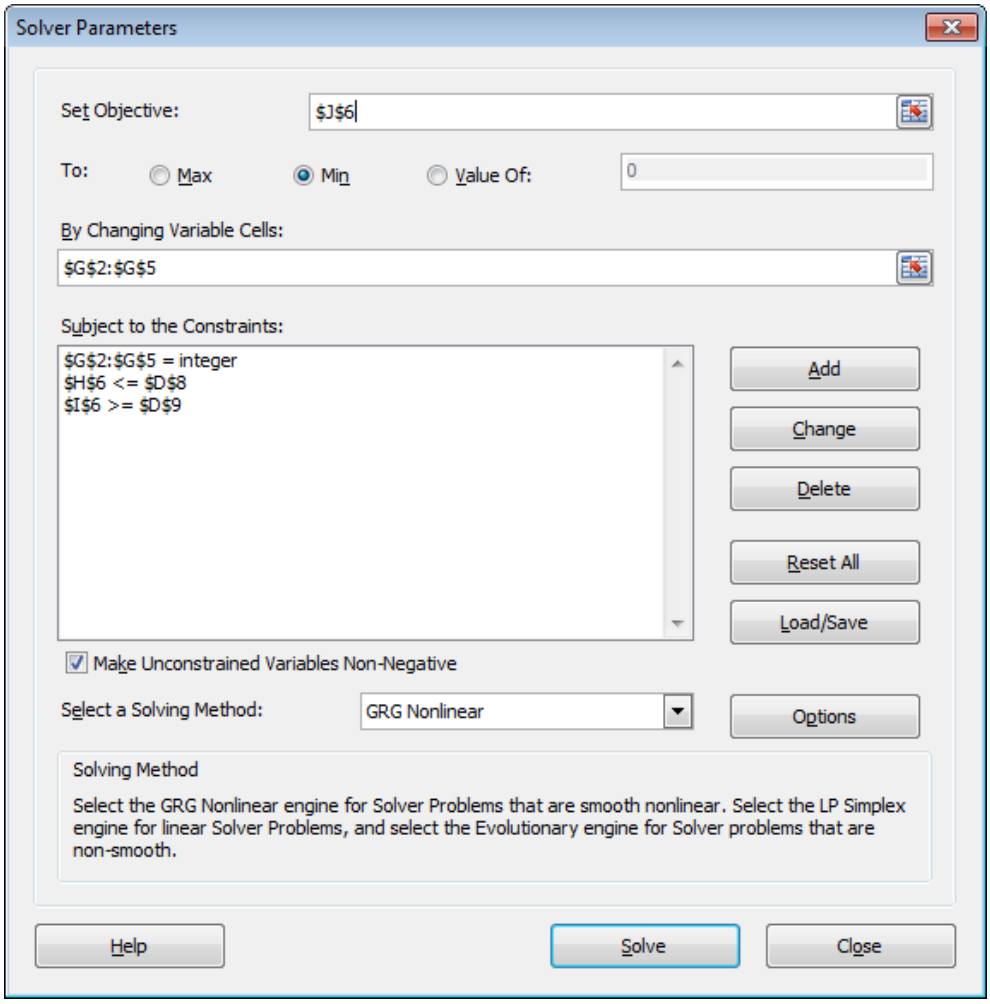
Note: that Truck 2 is the most expensive to run and is not used at all. The results of this model vary greatly with the value in D8.

Whilst Solver can save you from doing trial and error entries, you may have to adjust your constraints and other settings to get a result.

If Excel can't find a solution then increase the *Max Time (Seconds):* and *Iterations:* in Options, Solving Limits Section and try again.

The screen that appears after Solver finishes is shown on the following page.

The solution that I achieved is also shown on the following page.



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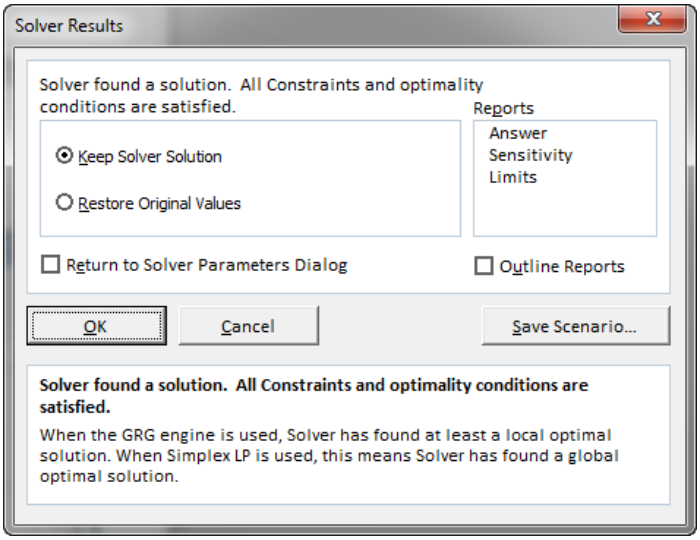
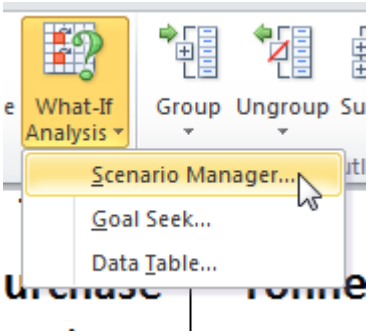


G	H	I	J
Number of Trucks	Total Purchase $	Tonnes Carted	Total Running Cost $
3	450,000	55,200	2,484,000
0	0	0	0
12	3,600,000	315,429	11,037,600
1	450,000	29,440	920,250
	4,500,000	400,069	14,441,850

Scenario Manager



This feature allows you to capture and keep multiple scenarios - values in input cells - and then to easily switch between the different scenarios.

We saved our solution when we used the Save Scenario button and called it Test_1. We can zero our entries and then bring the Solver results back with the scenario.

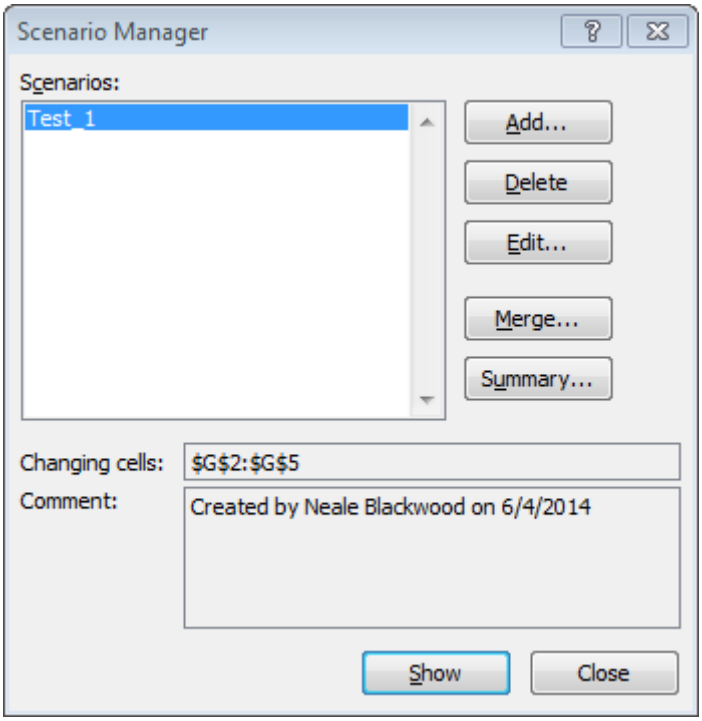
Click the Scenario Manager.

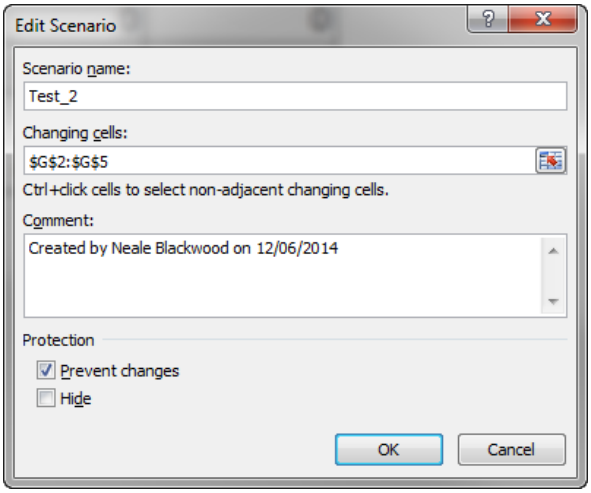
With Test_1 selected click the Show button.

This will revert back to the values from the scenario. This is not re-running Solver, this is only re-inputting the results from Solver.

You could create your own scenario.

We could enter different values in the yellow cells use 3, 0, 12, and 1. Then capture that scenario. Click the Add button and call it Test_2 and click OK.





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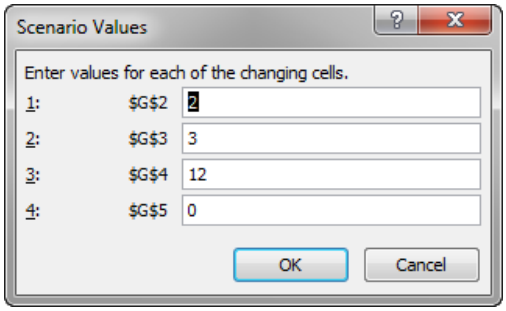
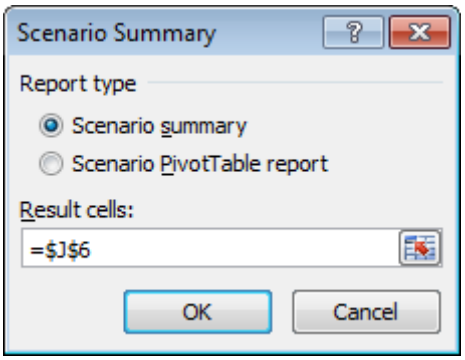


The dialog will show the current values in the cells - you can modify these if required.

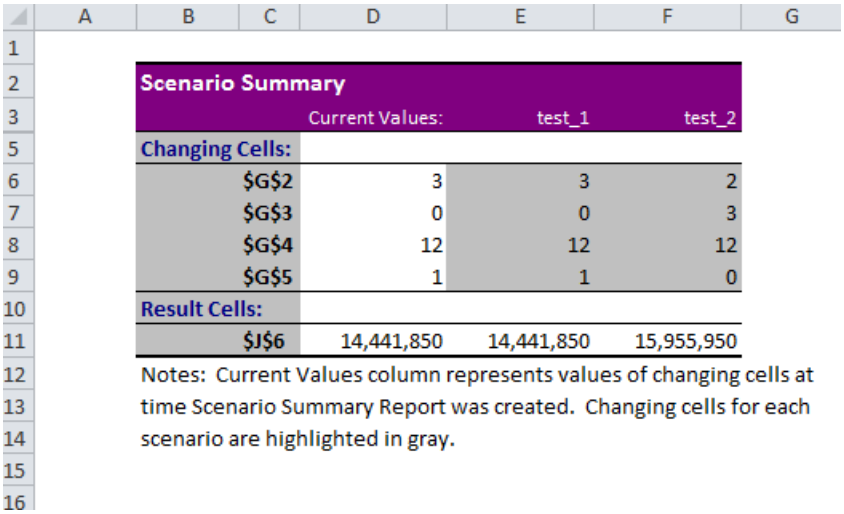
Click OK, this takes you back to the Scenario Manager.

The Summary button in the Scenario Manager allows you to specify a result cell to measure, cell J6 in our case, and see the results in a separate sheet report. See below.



This report is created on a separate sheet.

This is a static report that needs to be re-run if values change.



Scenario Summary			
	Current Values:	test_1	test_2
Changing Cells:			
G2	3	3	2
G3	0	0	3
G4	12	12	12
G5	1	1	0
Result Cells:			
J6	14,441,850	14,441,850	15,955,950

Notes: Current Values column represents values of changing cells at time Scenario Summary Report was created. Changing cells for each scenario are highlighted in gray.

It shows the results of all the scenarios that have been saved.

For more information on Solver and extra functionality check out

www.solver.com

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Data Tables

Just to confirm, this does not relate to formatted data tables. This example is based on one I had published in the INTHEBLACK magazine.

The Data Table feature allows you to summarise the results of changing either one or two input cells in a spreadsheet. Typically this is done in financial models or budgets to see the impact of changes to different inputs. This feature is not very intuitive and does require some preparation to be able to use. The layouts used in Data Tables are important.

There are two types of Data Tables.

- **One Input Data Table** – this Data Table allows you to summarise multiple result cells based on changing a single input cell. In a budget model you could monitor both profit and profit percentage based on changing the average selling price (ASP) assuming the ASP is an input.

- **Two Input Data Table** – this Data Table allows you to summarise the results from a single result cell based on changes to two input cells. In a budget model you could capture the Profit % resulting from changing the ASP and Gross Margin percentage (GM%) assuming the ASP and GM% are both inputs.

We will examine two Data Tables, both based on the simple profit model in the figure below.

Column A contains cell labels. Column B has five yellow input cells and seven grey result cells.

Column C describes the calculations being performed in column B.

Even though this is a basic example, Data Tables can work with the most complex Excel models.

	A	B	C
1	**Assumptions**	**Input**	
2	Average Selling Price	$27.00	
3	Units Sold	15,000	
4	Gross Margin %	40%	
5	Fixed Costs $	$50,000	
6	Variable Costs $ per unit	$5.00	
7			
8	**Outputs**	**Formula**	**Column B Formula**
9	Sales $	$405,000	=B2*B3
10	Margin $	$162,000	=B9*B4
11	Fixed Costs $	$50,000	=B5
12	Variable Costs $	$75,000	=B6*B3
13	Total Costs $	$125,000	=B12+B11
14	Profit $	$37,000	=B10-B13
15	Profit % of Sales	9.14%	=B14/B9

Limitation: The Data Table must be on the same sheet as the input cells

Warning: Creating a Data Table clears the Undo list.

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One Input Data Table Example

In this first example we will change the Units Sold value (cell B3) and monitor three result cells, the Sales value (cell B9); Profit value (cell B14) and Profit as a percentage of Sales (cell B15).

To prepare the sheet for the Data Table you should place labels for the various cells as shown in row 17 in the Figure below. Row 18 has three cells that are linked to the three cells we want to monitor from the model. Cell B18 has the formula =B9, cell C18 has =B14, cell D18 has =B15.

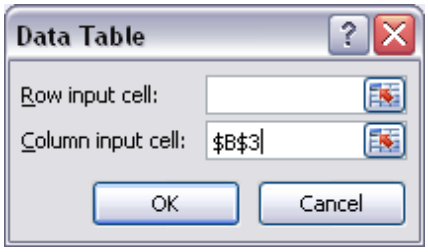
Column A contains the five Units Sold values that we want to test in the model. Typically you have values below and above the base case value.

	A	B	C	D
17	**Units Sold**	**Sales**	**Profit**	**Profit %**
18		$405,000	$37,000	9.14%
19	13,000			
20	14,000			
21	15,000			
22	16,000			
23	17,000			

Five values are listed, but you can have as many as you need. The units sold input is in cell B3. In general these values in Column A should be keyed in. You can't link to a cell you are changing.

This is the standard layout for a one variable Data Table. Row 17 is for information only and is not required, but it makes the report easier to read and understand.

1. Select the range A18:D23, which includes the values to be changed in columns and the cells to be monitored in row 18. Click the Data Ribbon, click the What If button and select Data Table. (Excel 2003 – Click the Data menu then click Table.)
2. In the Data Table dialog - click in the Column Input cell: box and then click cell B3 and click OK. You use the Column input cell box because the values you want to test are all in the first column of the range chosen, column A. Each value in A19:A23 will be placed in B3 and the three results Sales, Profit and Profit % calculated.



The Data Table report will be populated with an array formula.

B19 {=TABLE(,B3)}

	A	B	C	D
17	**Units Sold**	**Sales**	**Profit**	**Profit %**
18		$405,000	$37,000	9.14%
19	13,000	$351,000	$25,400	7.24%
20	14,000	$378,000	$31,200	8.25%
21	15,000	$405,000	$37,000	9.14%
22	16,000	$432,000	$42,800	9.91%
23	17,000	$459,000	$48,600	10.59%

Each row in Column A represents a different Units Sold scenario and displays the three results for that number of Units Sold. Changing any of the yellow input cells (except B3) will affect the results in the Data Table.

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Two Input Data Table Example

The figure below has the layout for a two input Data Table. In the one input example we changed the Sales Volume. In this example we will examine the Profit % result based on changing combinations of the Gross Margin % and the Variable Cost $ per unit.

The top left cell of the table range G18, must be linked to the cell we want to monitor. Cell G18 is linked to cell B15, which is the Profit Percentage.

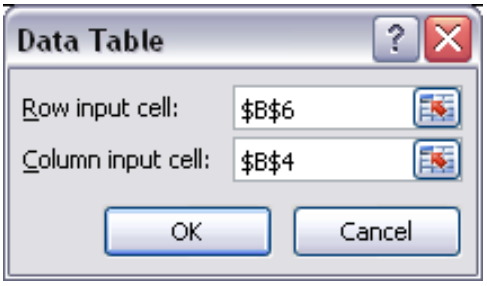
The range H18:J18 has the three Variable Cost per unit $ values we will examine.

The range G19:G23 has the five values for Gross Margin percentages that we want to model.

Again row 17 is just for information and makes the table more readable - it is not used by the data table.

	E	F	G	H	I	J
16						
17			**Profit %**	**Variable cost $ per Unit**		
18			9.14%	$4.80	$5.00	$5.20
19		**Gross Margin %**	38%			
20			39%			
21			40%			
22			41%			
23			42%			

1. To create the two input data table select the range G18:J23 and click the Data Ribbon, click the What If button and select Data Tables.



2. Click in the Row Input cell: box and click cell B6 (the Variable Costs $ per unit cell). The row input cell is used because the variables are in the first row of the table range.

3. Click in the Column input cell: box and click cell B4 (the Gross Margin % cell). You use the Column input because the variables are in the first column of the data table range. Click OK.

Again, the Data Table range will be populated with an array formula.

Each cell in the range H19:J23 represents the Profit % for the combination of a Variable Cost and a Gross Margin %.

For example cell J22 holds the Profit % for a Variable cost of $5.20 and a Gross Margin of 41

H19 {=TABLE(B6,B4)}

	F	G	H	I	J
17		**Profit %**	**Variable cost $ per Unit**		
18		9.14%	$4.80	$5.00	$5.20
19	**Gross Margin %**	38%	7.88%	7.14%	6.40%
20		39%	8.88%	8.14%	7.40%
21		40%	9.88%	9.14%	8.40%
22		41%	10.88%	10.14%	9.40%
23		42%	11.88%	11.14%	10.40%

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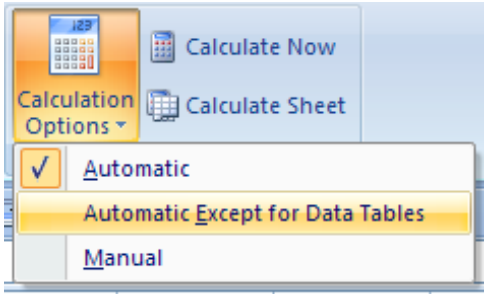
If you want to monitor multiple results you need to create multiple tables.

WARNING: if you have a large model then Data Tables can increase calculation time. If this is an issue there is an option in the Formula Tab in the Calculations Options button to turn off calculation for Data Tables. Pressing F9 will then perform a full calculation including the Data Tables.



In some cases in very large models you may need to use

Ctrl + Alt + F9

or

Ctrl + Alt + Shift + F9

to perform a full calculation.

WARNING: Using a calculation other than Automatic can leave you open to errors if a file is not calculated. You may have to include a procedure to change to Automatics at the end of the review process to ensure values are always updated.

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