



## Modelling with AgenaRisk

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<b>1</b>	<b>INTRODUCTION</b>	<b>4</b>
<b>2</b>	<b>INTRODUCING THE CAR COSTS MODEL</b>	<b>5</b>
<b>3</b>	<b>BUILDING THE CAR COSTS MODEL</b>	<b>6</b>
3.1	Creating Ranked Nodes	6
3.2	Using Weighted Expressions	8
3.3	Using Partitioned Expressions	12
3.4	Customising Risk Graphs	15
3.5	Adding Constants	17
3.6	Using Arithmetic Expressions	19
3.7	Completing the Model	22
<b>4</b>	<b>RUNNING THE CAR COSTS MODEL</b>	<b>26</b>
4.1	Creating and Deleting Scenarios	26
4.2	Adding Observations to Scenarios	27
<b>5</b>	<b>NEXT STEPS</b>	<b>30</b>

## 1 Introduction

This tutorial takes you through the process of building a realistic predictive model using AgenaRisk. In the process of building this model, you will learn about the more advanced and powerful features that AgenaRisk has to offer. You will also gain modelling experience that you can later apply to your own problems.

Before working through this tutorial you should read the basic tutorial called *Getting Started with AgenaRisk* to ensure that you understand how to use the common features of AgenaRisk.

Throughout this tutorial, various formatting conventions are used:

<b>File</b>	A term appearing in bold will sometimes refer to a menu on the toolbar that you are required to select.
<b>OK</b>	Bold is also used to indicate any button that you are required to click.
<b>23</b>	Bold can be used to indicate any value that you are asked to enter or select.
<b>Menu → Menu Item</b>	Two or more bold terms separated by an arrow indicate a path from a toolbar menu (or from the Start menu) down to a menu item that you are required to click.
Ctrl + W	The use of Ctrl, Alt or Shift in conjunction with a + symbol and a letter indicates that the key should be pressed down simultaneously with the letter to invoke a particular function.
<i>Filename.ast</i>	Names of files and directories (used during opening, saving and importing) are indicated by italics.
<i>Directory / Filename.ast</i>	Two or more italicised terms separated by a forward slash indicate a path from a directory (or folder) down to a particular file.
	This icon indicates a tip or other piece of useful information.
	This icon indicates a warning; you should pay particular attention to these.

**Table 1 Formatting conventions**

## 2 Introducing the Car Costs Model

1. You want to predict the running costs of a new car. You have short-listed three different makes of car: Mercedes, Honda and Ford. You want to find out which of these is going to be cheapest to run over time.
2. The important variables under consideration are:
  - *Car type* (small, medium or large)
  - *Reliability* (which impacts on maintenance cost)
  - *Fuel economy* (miles per gallon)
  - *Fuel price*
  - *Annual mileage*

### 3 Building the Car Costs Model

#### 3.1 Creating Ranked Nodes

1. Start AgenaRisk and create a new model by selecting **Create New Model** from either the opening dialog or the **File** menu. Alternatively, you can click on the new model icon on the toolbar:



2. If it is not already selected, toggle the auto-calculate button on the toolbar:

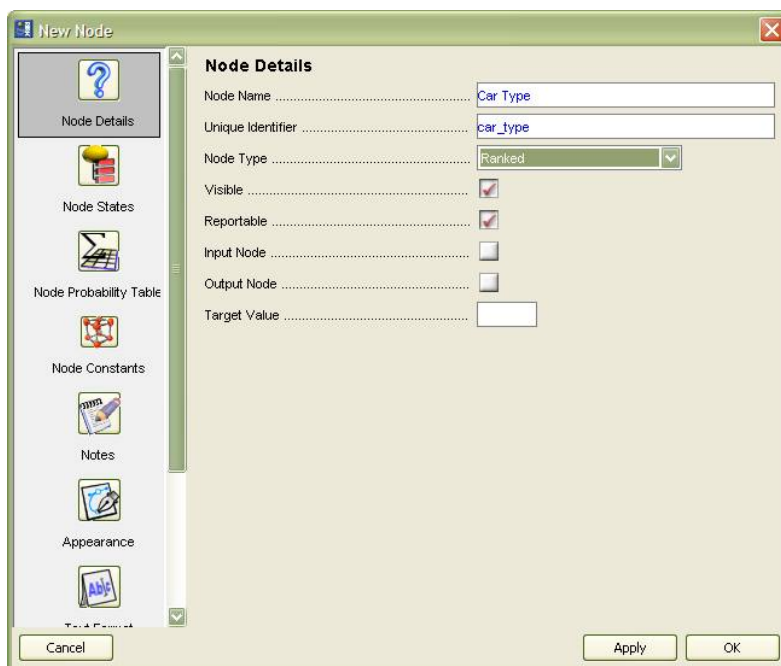


3. Expand the Risk Explorer and select the item called **New Risk Object**. There will be only one Risk Object in this model. Notice that the Risk Object is flagged with a red icon:



You will see this icon in various parts of the AgenaRisk interface. It means that a calculation must be run on the Risk Object in question in order to make it consistent.

4. Right-click on the **New Risk Object** and select **Rename**. In the dialog that appears, type **Car Costs** and click **OK**.
5. Create a new node in the top left corner of the Risk Map. Change its name to **Car Type**, change its type to **Ranked**, change its unique identifier to **car\_type** and then click **Apply**. Your dialog should look like the one shown in Figure 1 below:



**Figure 1 Node Details for Car Type node**

Changing the unique identifier to something short yet meaningful is important because, later on, this node will be used in expressions.

6. Click on the **Node States Tab**. In the **Type** field in the middle of the dialog, choose **Low -> High (3)**. Then, in the **States** text box, replace the values **Low**, **Medium** and **High** with **Small**, **Medium** and **Large**.
7. Click **Apply** and then click on the **Appearance** tab.
8. Select the rounded rectangle at the top of the dialog, change the background colour to dark blue and click **Apply**. (The colour scheme is arbitrary but, in this model, we are going to use dark blue for nodes where the user has to make a choice, medium blue for nodes relating to cost and dark blue for nodes containing assumptions. Colour coding nodes can make models more user-friendly.)
9. Click on the **Text Format** tab.
10. Change the font size to 12, change the text colour to white and then click **OK**.
11. Your node should now look like this:



**Figure 2 Car Type node after editing**

12. Copy the *Car Type* node and paste the copy to the right of *Car Type* on the Risk Map.
13. Change the properties as follows:

<b>Node Name</b>	Reliability
<b>Unique Identifier</b>	reliability
<b>States</b>	High -> Low (3) (leave the states as High, Medium and Low)
<b>Background Colour</b>	Light Blue
<b>Text Colour</b>	Black

**Table 2 Properties for Reliability node**

14. Your two nodes should now look like this:



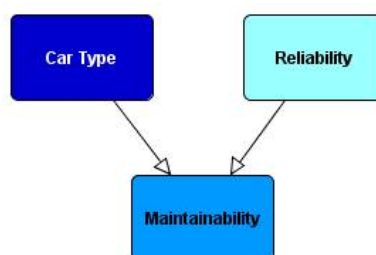
**Figure 3 Risk Map after adding Reliability node**

15. Copy the *Reliability* node and paste it on to the Risk Map beneath the two existing nodes and change the properties as follows:

<b>Node Name</b>	Maintainability
<b>Unique Identifier</b>	maintainability
<b>Background Colour</b>	Medium Blue

**Table 3 Properties for *Maintainability* node**

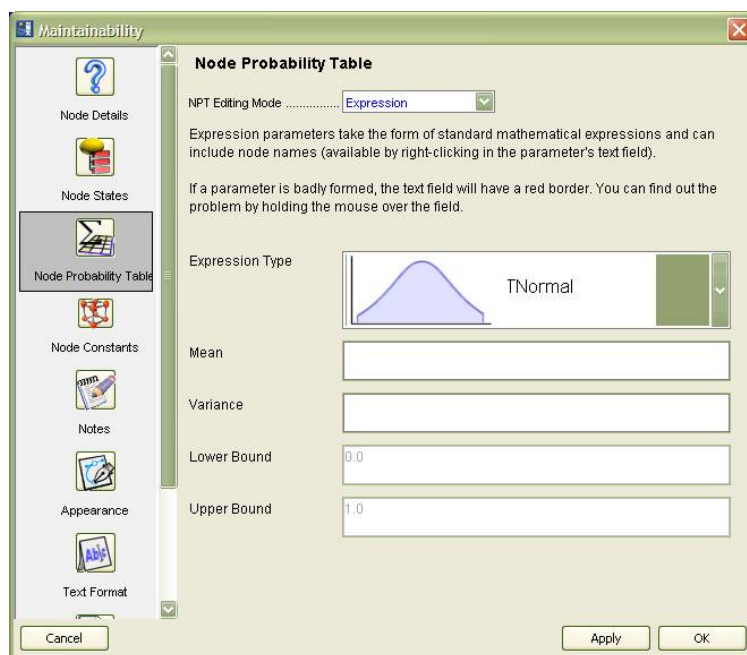
- Draw edges from *Car Type* to *Maintainability* and from *Reliability* to *Maintainability*. This captures the information that *Maintainability* is influenced by both *Car Type* and *Reliability*.
- Your Risk Map should now look like the one shown in Figure 4 below.



**Figure 4 Risk Map after adding *Maintainability* node and edges**

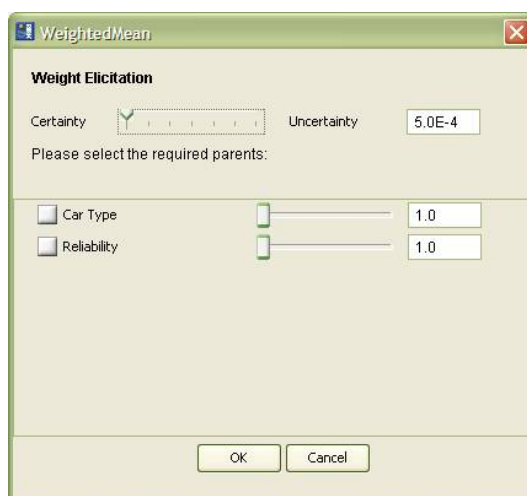
### 3.2 Using Weighted Expressions

- Currently, the model shows the causal relationships between the three nodes, *Car Type*, *Reliability* and *Maintainability*, but for these relationships to be of any use you need to define the Node Probability Table (NPT) of the *Maintainability* node.
- Right-click on the *Maintainability* node, bring up the properties dialog and click on the **Node Probability Table** tab.
- Rather than defining the NPT manually, we are going to make life simpler and use an expression that will, behind the scenes, generate the NPT automatically. In the **NPT Editing Mode** drop-down box, select the value **Expression**. The expression editor will appear in the dialog as shown in Figure 5 below.



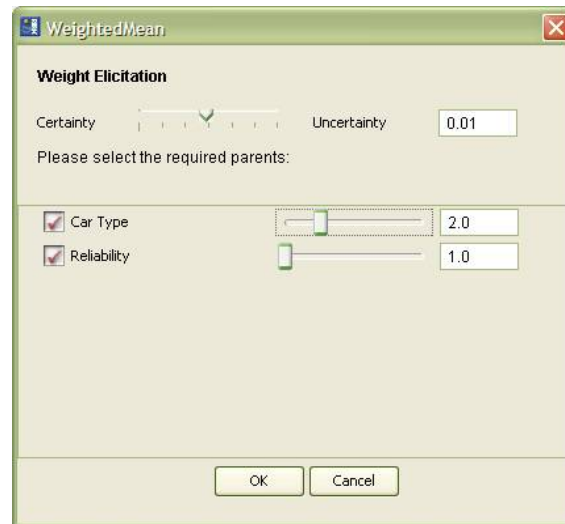
**Figure 5 Expression editor for *Maintainability* node**

4. Click on the **Expression Type** drop-down box and observe that only two types of expression are available for ranked nodes: **TNormal** and **Arithmetic**. We will deal with Arithmetic expressions later. For now, leave the type set to **TNormal**.
5. **TNormal** is short for “Truncated Normal”. This is a Normal distribution where the two ends are cut off or truncated. When the TNormal distribution is used with Ranked nodes, it is always truncated using the values 0 and 1. This is because Ranked nodes are all mapped on to an underlying scale of 0 – 1.
6. You are now going to create a weighted expression that defines the parameters of the TNormal distribution. This weighted expression will reflect the relative strength of influence that the two nodes, *Car Type* and *Reliability*, have on *Maintainability*.
7. Right-click anywhere in the **Mean** text box and choose **Insert weight expression** → **WeightedMean**.
8. You will see a dialog like the one shown in Figure 6 below.



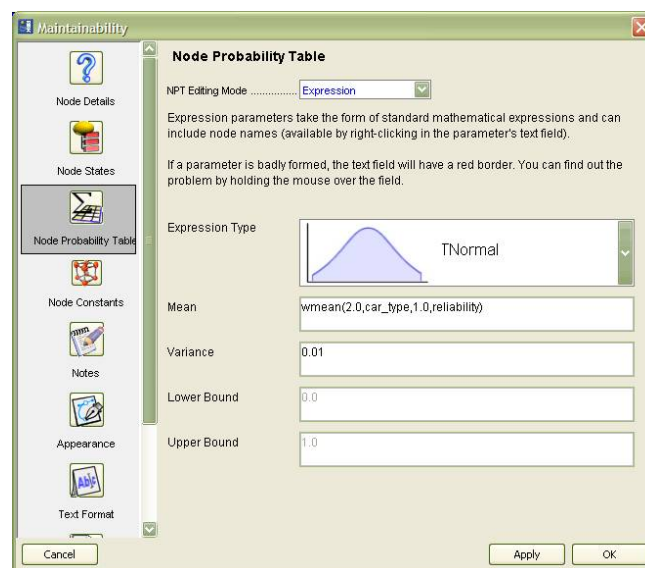
**Figure 6 Dialog for eliciting weighted expression**

- This dialog allows you to select which parents you want to include in the weighted expression and what weighting you want to give them. The slider bar at the top lets you specify how much certainty you have about this weighting. Complete the dialog so that it looks like the one in Figure 7. In this case, the expression says that when defining the maintainability of a car, we are moderately certain that car type is twice as important as reliability.




**Figure 7 Weighted expression dialog for *Maintainability* node**

- Click **OK**. The expression editor should now look like this:



**Figure 8 Expression editor after defining a weighted expression**

- You can see that the level of certainty you specified using the slider bar in the weighted expression dialog is used as the variance for the TNormal distribution. The mean of the TNormal is a formula based upon your choice of parent nodes and their weights. Note that the unique identifiers of the parent nodes are used in the formula rather than their names.

 If you want to edit this expression in future (e.g. if you want to change the weights or variance), you can right-click on the **Mean** text box and select **Insert**

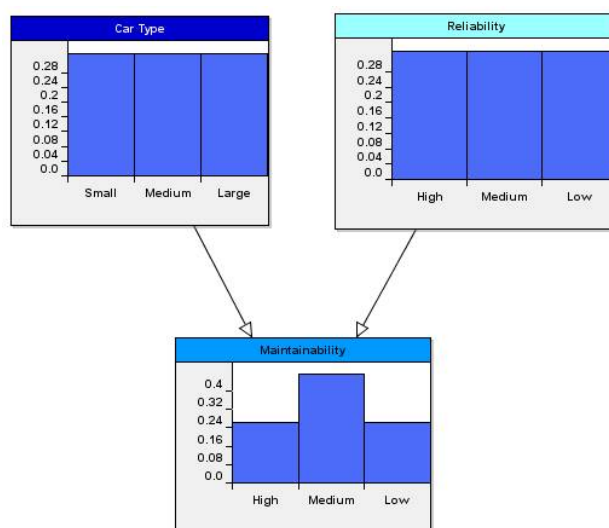
**weight expression** → **WeightedMean**. The existing values will appear in the weighted expression dialog and you can modify them. However, you may find it quicker to edit the variance and mean text boxes by hand.

12. Click on **Apply**. This generates the underlying NPT.
13. You can inspect the NPT that has been created by selecting the value **Manual** in the **NPT Editing Mode** drop-down box. Scroll around the table and look at the values in each of the cells. When you are finished, set the value of the **NPT Editing Mode** drop-down box to **Expression**.
14. Click **OK**.
15. Now you can test this model fragment. Click on the calculate button on the toolbar:



Whenever you generate (or regenerate) an NPT, you will need to run a manual calculation immediately afterwards even if you have the auto-calculate feature switched on. Automatic calculation only happens after you remove or enter observations.

16. Notice that the red icon has now disappeared from the Risk Object in the Risk Explorer. This means that a calculation has been executed and that the model is in a consistent state.
17. Double-click on all three nodes on the Risk Map so that their Risk Graphs appear. Resize the nodes so that you can see the graphs in their entirety. Your Risk Map should like the one in Figure 9.



**Figure 9 Car Type, Reliability and Maintainability after calculation**

18. The *Maintainability* Risk Graph tells us that, when we know nothing at all about *Reliability* or *Car Type*, it is most likely that *Maintainability* will be **Medium**.
19. Try entering different observations for both *Car Type* and *Reliability* and notice how the probability distribution of *Maintainability* changes. Verify, in particular, that when *Car Type* is **Small** and *Reliability* is **Low**, *Maintainability* is skewed towards **High**. This illustrates the increased weighting you gave to *Car Type*.

20. You should also look at the effects of so-called “back propagation”. Clear any observation you may have entered on *Car Type* or *Reliability* and enter the observation **High** for *Maintainability*. Note that the other two distributions both change – *Car Type* moves towards **Small** and *Reliability* moves towards **High** – but *Car Type* is more skewed. In other words, if all we know about a car is that its *Maintainability* is high, then the most likely explanation is that the car is small. Now enter the observation **Large** for *Car Type*. The distribution for *Reliability* changes dramatically; we are now almost certain the *Reliability* must be high.
21. Before continuing, select **Tools** → **Clear Entered Data** → **All** and click **OK** in the confirmation dialog.
22. Now save your model.

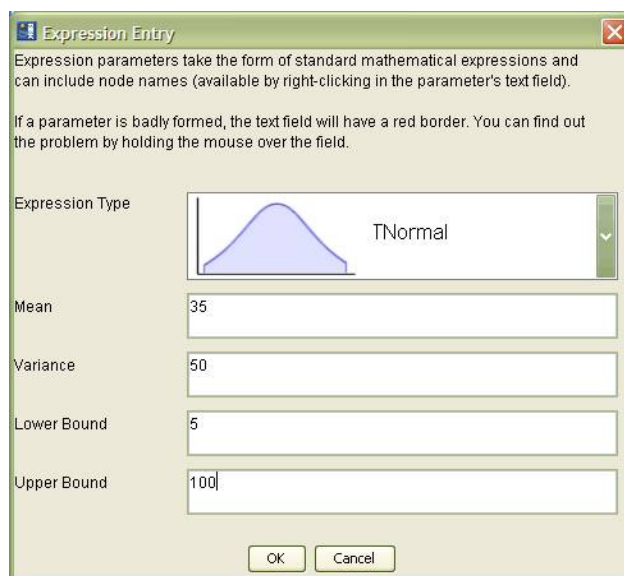
### 3.3 Using Partitioned Expressions

1. Create a new node beneath *Car Type* on the Risk Map. Move the existing nodes to create space as required.
2. Draw an edge from *Car Type* to the node you just created.
3. Bring up the properties dialog for the new node. Change the node's name to *Miles per Gallon*, change the unique identifier to *mpg* and check the box marked **Simulation Node**. By making the node a simulation node, you are telling AgenaRisk to dynamically calculate the optimum set of states that the node should have.
4. Click **Apply** and then click **OK** on the information pop-up that appears. (The pop-up appears because you have made the node a simulation node before defining an expression. Simulation nodes need expressions. The message indicates that a default expression has been created for you.)
5. In the **Appearance** tab, change the background colour of the node to light blue and change its shape to being a rounded rectangle.
6. Click **Apply**.
7. Click on the **Node States** tab. You will see that, by default, this node (of Continuous Interval type) has five states: **0.0 – 10.0**, **10.0 – 20.0**, **20.0 – 30.0**, **30.0 – 40.0** and **40.0 – 50.0**.
8. Because this node is a simulation node, we only need to specify one large interval. This interval will then be divided up intelligently during calculation. Click on the **Remove All States** hyperlink. This will leave just one state, **0.0 – 10.0**.
9. Edit the lower bound and upper bound to be **5** and **100** respectively. The state editor should now look like this:




Figure 10 State editor showing single state

10. Click **Apply**.
11. Now click the **Node Probability Table** tab on the left of the dialog. This initially displays the Uniform expression that was automatically created when you made this node a simulation node earlier.
12. In the **NPT Editing Mode** drop-down box, select **Partitioned Expression**. Partitioned expressions are very powerful. They allow us to generate an NPT using a different expression for each combination of parent states. In this case we can specify a different distribution of miles per gallon for a small car, for a medium car and for a large car. This accurately reflects the real world; one distribution for miles per gallon wouldn't be sufficient to capture these differences.
13. Select *Car Type* in the left-hand list and click the **Add >** button to move it to the right-hand list. This is how we indicate that we want to supply different expressions for each state of the parent node *Car Type*. Notice that there are now three cells in the table below the two lists, one for each state of *Car Type*.
14. Double-click on the first cell. An expression entry dialog appears. In the **Expression Type** field, select **TNormal**. Fill out the parameters so that the dialog looks like that shown in Figure 11.




**Figure 11 Partitioned expression entry dialog**

15. Click **OK**. Notice that the TNormal expression now appears in the first cell in the table.
16. Complete the other two cells in the same way with TNormal expressions. For both expressions, specify the **Lower Bound** to be **5** and the **Upper Bound** to be **100**. For the expression in the **Medium** cell, specify **28** as the **Mean** and **50** as the **Variance**. For the expression in the **Large** cell, specify **18** as the **Mean** and **30** as the **Variance**. This partitioned expression now represents our view that larger cars are less fuel-efficient than smaller cars.



The quickest way of completing multiple cells with a very similar formula is to use copy and paste. Right-click on a completed cell and select **Copy**, then right-click into all the other cells and click **Paste**. Each cell is now identical. Then double-click on each cell to modify it.

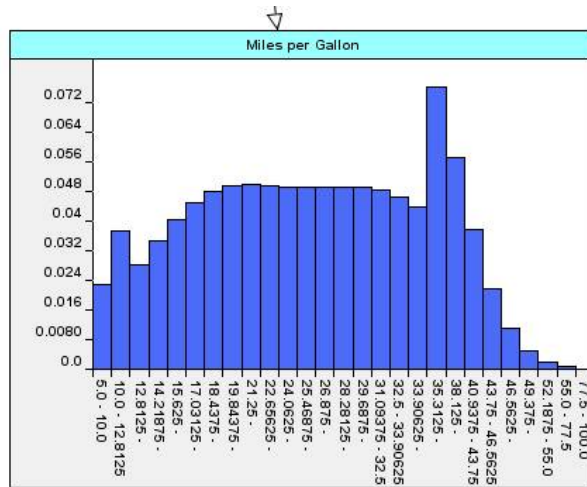
17. Click **OK**.
18. Run a calculation by clicking the calculate button on the toolbar.
19. Double-click on the *Miles per Gallon* node. Recall that you only specified one state for this node. You can now see how simulation has created a number of states automatically. Make the node larger so you can see all the states.
20. Hold your mouse over some of the bars on the graph and notice the information that is available.
21. This information is also available on the Risk Graph Panel. Look at the window on the Risk Graph Panel marked *Miles per Gallon*. Click on the **Expand State List** hyperlink. You will now see a full list of the states and probabilities that exist on this node. (You will need to scroll down to see all of them.)



If you are displaying Risk Graphs on the Risk Graph Panel rather than on the Risk Map, you can still access the information summary by dragging the separator bar on the far left of the graph to the right so that the window splits.

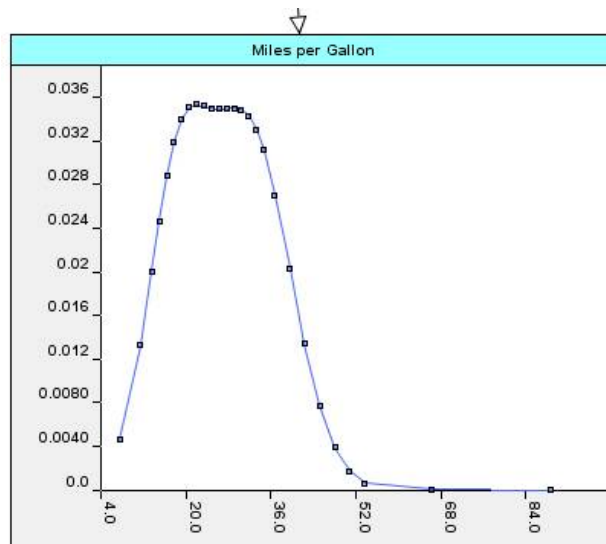
### 3.4 Customising Risk Graphs

1. Because the intervals of each state are not equal, the *Miles per Gallon* Risk Graph takes on a slightly jagged appearance as shown in Figure 12.



**Figure 12 Default Risk Graph for *Miles per Gallon* node**

2. In cases like this, where you have a continuous scale that has been divided up into unequal intervals during simulation, it is best to change the way the Risk Graph is plotted.
3. Right-click on the *Miles per Gallon* node and select **Risk Graph** → **Graph Properties** from the pop-up menu.
4. Check the **Continuous X-Scale** box.
5. Click on the **All Datasets** tab and in the **Graph Type** drop-down box, select **Line**.
6. Click **OK**. The resulting graph is now a much smoother curve as shown in Figure 13.



**Figure 13 Continuous Risk Graph for *Miles per Gallon* node**

To view the details of any point plotted on the graph, just move your mouse over it.

7. The changes you just made to the Risk Graph properties are only temporary. Close the Risk Graph by right-clicking on it and selecting **Risk Graph** → **Close Risk Graph**. When you re-open the Risk Graph (by double-clicking on the node), it will look like it did originally. For this reason, it is better to specify these properties on the node itself. Then, whenever a Risk Graph is shown for the node, it will have the same attributes. Even more usefully, Risk Graph properties can be specified for the whole model. In this way, a set of defaults can apply to all Risk Graphs that are created.
8. The Risk Graph properties system is complex but powerful. It works hierarchically. You specify a set of defaults at the model level. These will apply in all cases except for those nodes in which you choose to override them. Then, for a given node, you can temporarily change the way its Risk Graph is plotted by changing the temporary properties on the Risk Graph itself.
9. Close down the *Miles per Gallon* Risk Graph again (since model-level and node-level properties do not affect any Risk Graphs that are currently being displayed) and then select **File** → **Model Properties** from the menu bar.
10. In the **Graph type for large data set** drop-down box, select **Line**.
11. Check the box marked **Use a Continuous X-Axis**. Click **OK** on the properties dialog and click **OK** on the confirmation pop-up that appears.
12. Double-click on *Miles per Gallon* to open its Risk Graph again. Observe that the Risk Graph is plotted as a continuous line.
13. Now let's assume that you want the *Miles per Gallon* node (and only this node) to have its mean shown whenever its Risk Graph is displayed.
14. Close down the *Miles per Gallon* Risk Graph again.
15. Right-click on the *Miles per Gallon* node, select **Properties** and click on the **Graph Defaults** tab. You can see that the list of properties is the same as the model-level list. The symbol to the left of each property indicates that the property is currently inherited from the model and not being overridden in this node:

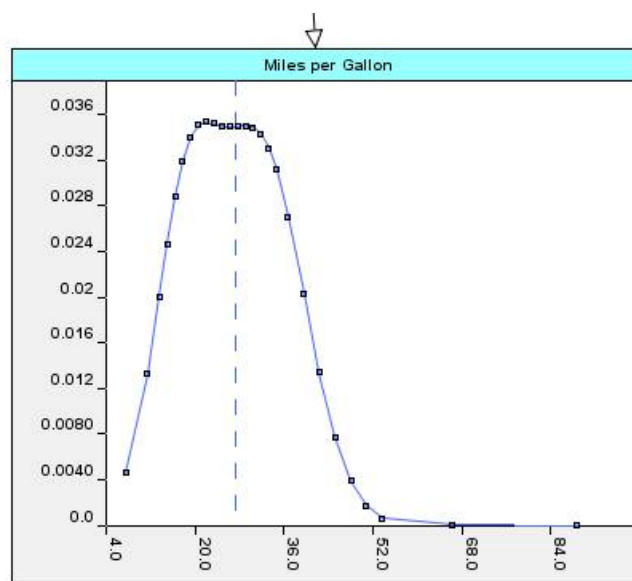


16. Click on the inheritance symbol next to **Mean** in the **Point Values** section of the dialog. The symbol changes to show that the property is now going to be overridden (i.e. it is no longer inherited from the model level):



Check the **Mean** box. This ensures that the mean will now always be shown on the Risk Graph for this node.

17. Click **OK** on the properties dialog and on the confirmation pop-up.
18. Bring up the *Miles per Gallon* Risk Graph. You can now see a vertical dotted line indicating where the mean sits in the distribution:



**Figure 14 Risk Graph for *Miles per Gallon* node showing mean**

The mean will displayed every time you reopen the Risk Graph on this node but the mean will not be displayed for any other nodes.

19. Enter different values for *Car Type* and notice how the *Miles per Gallon* Risk Graph changes.
20. There are some other node-level graph properties to set before you move on. The first three nodes you added, *Car Type*, *Reliability* and *Maintainability*, should not be plotted continuously. Close down the Risk Graphs for these three nodes and reopen them. Notice that the x-axis for each graph now contains a continuous scale rather than the rank labels.
21. To rectify this, you need to turn off continuous plotting for each node. Right-click on *Car Type*, select **Properties** and click on the **Graph Defaults** tab. Click on the inheritance tab next to the **Use a Continuous X-Axis** label, uncheck the adjacent box and click **OK**. Click **OK** on the confirmation pop-up that appears.
22. Turn off continuous plotting for *Reliability* and *Maintainability* in the same way.
23. Clear all observations and save the model.
24. If you have time, try modifying the other Risk Graph properties and experiment with the hierarchical property system. Consult the user manual for more information about any properties that you don't understand.


### 3.5 Adding Constants

1. Add a node to the Risk Map beneath *Miles per Gallon* and bring up its properties dialog.
2. Modify the following properties:

<b>Node Name</b>	Fuel price \$ (gallon)
<b>Unique Identifier</b>	fuel_price
<b>Simulation Node</b>	Ticked
<b>Shape</b>	Rounded Rectangle
<b>Background Colour</b>	Light Blue

**Table 4 Properties for *Fuel price \$ (gallon)* node**

3. Give the node one state with a lower bound of **0.5** and an upper bound of **10**.
4. Click on the **Node Constants** tab. Constants are numbers to which you can assign names so that they can subsequently be used in expressions. The power of constants is that their values can be modified later on via the Risk Table without needing to edit the expressions in which they are involved.
5. Click on the insert button:
 


6. Type **fuel\_price\_const** in the **Constant Name** field and type **3** in the **Default Value** field.
7. Click **Apply**.
8. Click on the **Node Probability Table** tab and then, in the **Expression Type** drop-down box, select **Arithmetic**.
9. Delete the **0.0** value in the **Arithmetic Expression** text box.
10. Right-click on the **Arithmetic Expression** text box, select **Insert constant** → **fuel\_price\_const** and click **OK**.
11. You have now made *Fuel price \$ (gallon)* a constant node. This is because the node is a simulation node and its NPT is generated from the value of the **fuel\_price\_const** constant. This means that, after calculation, *Fuel price \$ (gallon)* will have a single value. This value will either be the default (3) or whatever is specified in the corresponding Risk Table entry.
12. Before the value of the **fuel\_price\_const** constant can be modified, an entry needs to be added to the Risk Table. Click on the Risk Table tab, right-click on the **Fuel price \$ (gallon)** entry and select **Properties**.
13. In the **Connection Type** drop-down box, select **Constant** and then click **OK**. The value of **fuel\_price\_const** can now be changed by editing the contents of this entry's text box.
14. Copy the **Fuel price \$ (gallon)** node, paste it into the Risk Map and move the copy below the original.
15. Open the properties dialog for the newly pasted node, change its name to *Miles per Year* and change its unique identifier to *mpy*.
16. Click on **Apply**.

17. Click on the **Node States** tab. Check the **Make upper bound positive infinity** box. There are now two states. Change the lower bound of the first state to **0**. Change the lower bound of the second state to **1**. The two states should now be **0 – 1** and **1 – inf**.
18. Click on **Apply**.
19. Click on the **Node Constants** tab, change the value of the **Constant Name** field to **miles\_per\_year\_const** and change the **Default Value** to **10000**.
20. In the **Node Probability Table** tab, verify that the expression now contains the modified constant name, **miles\_per\_year\_const**.
21. Click **OK**.
22. Look in the Risk Table and notice that a new entry has been created for **miles\_per\_year\_const**:

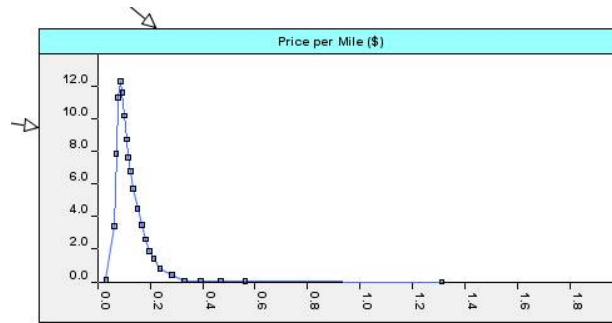
Car Costs	
Car Type	No Answer
Reliability	No Answer
Maintainability	No Answer
Miles per Gallon	
fuel_price_const	
miles_per_year_const	

Figure 15 Risk Table showing entries for constants

23. Save your model.

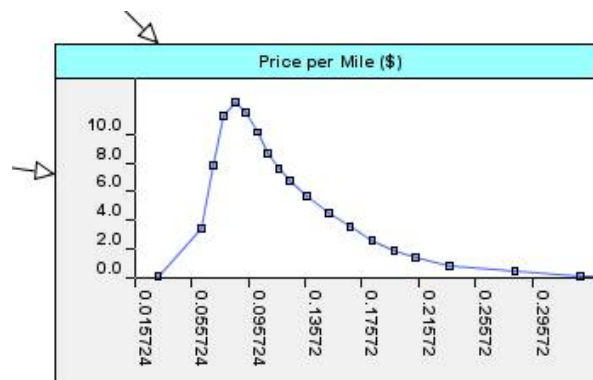
### 3.6 Using Arithmetic Expressions

1. Copy the *Fuel price \$ (gallon)* node, paste the copy and place it to the right of the original.
2. Draw edges from *Fuel price \$ (gallon)* and *Miles per Gallon* to this node.
3. Open the properties dialog for the copy, change its name to *Price per Mile (\$)* and change its unique identifier to *ppm*.
4. Click on the **Node States** tab. Change the lower bound of the single state to **0**.
5. Click on **Apply**.
6. Click on the **Node Constants** tab. Right-click on the constant and choose **Delete Selected**. You don't need any constants defined on this node.
7. Click on the **Node Probability Table** tab. The expression used for generating the NPT of *Price per Mile (\$)* is going to be a simple division of *Fuel price \$ (gallon)* by *Miles per Gallon*.
8. Clear the **Arithmetic Expression** text box and then right-click inside it. Select **Insert parent** → **Fuel price \$ (gallon) (fuel\_price)**. Then type the division symbol: */*. Finally, select **Insert parent** → **Miles per Gallon (mpg)**.
9. Click **OK**.
10. Run a calculation.
11. Double-click on the *Price per Mile (\$)* node to bring up its Risk Graph and resize it so that you can see it all. The graph should look like the one shown in Figure 16.



**Figure 16 Risk Graph for *Price per Mile (\$)* with long tail**

12. There is a very long tail on this distribution that isn't of interest. You can modify the Risk Graph properties for just this node so that the tail isn't displayed. This allows you to focus more clearly on the main area of the distribution.
13. Close the Risk Graph and bring up the properties for the *Price per Mile (\$)* node. Select the **Graph Defaults** tab. Click the override icons next to **Treat Min/Max X as percentiles**, **Lower percentile X Bound** and **Upper percentile X Bound**. Check the **Treat Min/Max X as percentiles** box, type **0.1** in the **Lower percentile X Bound** box and type **98** in the **Upper percentile X Bound** box. This configures the graph so that the first 0.1% and the last 2% of probability mass are not shown.
14. Click **OK** on the properties dialog and on the confirmation pop-up that appears afterwards.
15. Double-click on the *Price per Mile (\$)* node. You should see a graph that looks like the one in Figure 17 below.



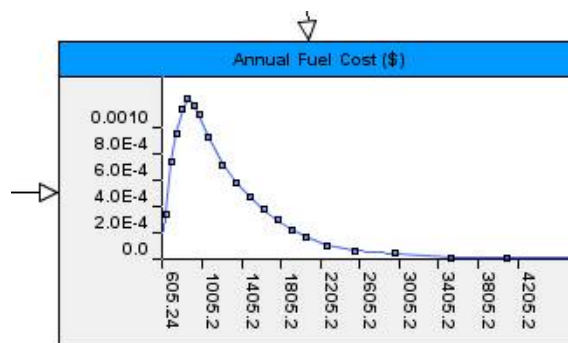
**Figure 17 Risk Graph for *Price per Mile (\$)* after changing graph properties**

16. If you have time, enter different values of *Car Type* and observe the effects on *Price per Mile (\$)*. Before continuing, clear all observations.
17. Create a new node below and to the right of *Price per Mile (\$)*. Draw edges from *Price per Mile (\$)* and *Miles per Year* to this new node.
18. Open the properties dialog for the new node and supply the following property values using the techniques you have previously learned:

<b>Node Name</b>	Annual Fuel Cost (\$)
<b>Unique Identifier</b>	afc
<b>Simulation Node</b>	Ticked
<b>Node States</b>	0 – 10, 10 – inf
<b>NPT (Expression)</b>	Price per Mile (ppm) * Miles per Year (mpy)
<b>Shape</b>	Rounded Rectangle
<b>Background Colour</b>	Medium Blue
<b>Treat Min/Max X as percentiles</b>	Ticked
<b>Lower percentile X Bound</b>	1
<b>Upper percentile X Bound</b>	99

**Table 5 Properties for *Annual Fuel Cost (\$)* node**

19. Run a calculation.
20. Double-click on *Annual Fuel Cost (\$)* and resize the Risk Graph so you can see all of it. It should look like this:



**Figure 18 Risk Graph for *Annual Fuel Cost (\$)***

Remember that you can get more screen space by decreasing the width of the Risk Graph panel and Risk Explorer (or by retracting them completely).

21. Your Risk Map should now look something like the one in Figure 19.

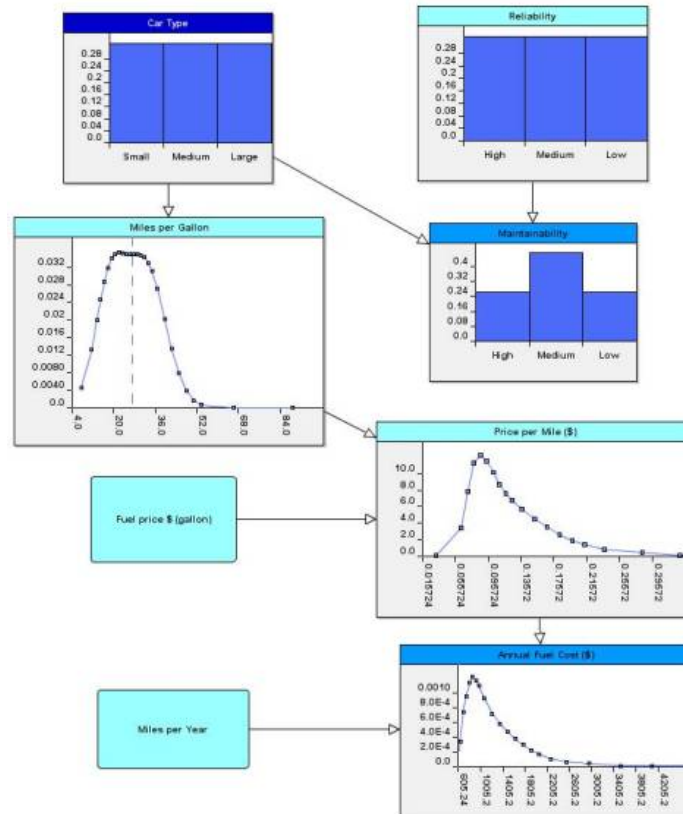


Figure 19 Partially complete Car Costs Risk Map

22. Save your model.

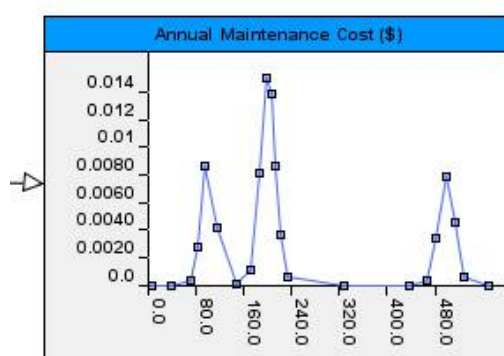
### 3.7 Completing the Model

1. There are now just two nodes left to add; then the Car Costs model will be complete and you can start using it and viewing its predictions.
2. Add a node to the right of *Maintainability*. Make *Maintainability* the parent of this new node by adding an edge between them.
3. Open the properties dialog for the new node and supply the following property values:

<b>Node Name</b>	Annual Maintenance Cost (\$)
<b>Unique Identifier</b>	amc
<b>Simulation Node</b>	Ticked
<b>Node States</b>	0 – 600
<b>Background Colour</b>	Medium Blue
<b>Shape</b>	Rounded Rectangle
<b>Treat Min/Max X as percentiles</b>	Ticked
<b>Lower percentile X Bound</b>	1
<b>Upper percentile X Bound</b>	99

**Table 6 Properties for Annual Maintenance Cost (\$) node**

4. The NPT is specified using a Partitioned Expression. Specify a TNormal expression for each state of the parent, *Maintainability*.
5. When *Maintainability* is **High**, use a TNormal with a mean of **100**, a variance of **100**, a lower bound of **0** and an upper bound of **600**.
6. When *Maintainability* is **Medium**, use a TNormal with a mean of **200**, a variance of **150**, a lower bound of **0** and an upper bound of **600**.
7. When *Maintainability* is **Low**, use a TNormal with a mean of **500**, a variance of **150**, a lower bound of **0** and an upper bound of **600**.
8. Run a calculation.
9. Double-click on *Annual Maintenance Cost (\$)*, resize the Risk Graph and verify that it looks like the one in Figure 20.



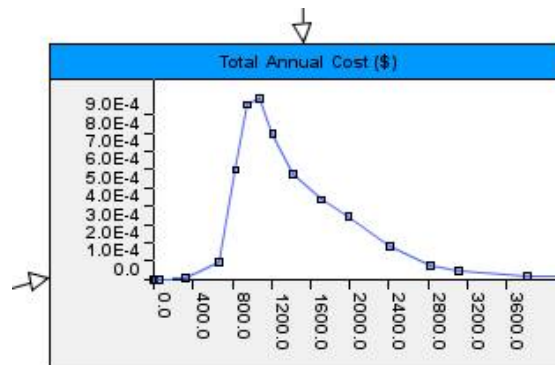
**Figure 20 Risk Graph for Annual Maintenance Cost (\$)**

10. Add a node below *Maintainability* on the Risk Map. Make *Annual Maintenance Cost (\$)* and *Annual Fuel Cost (\$)* the parents of this new node by adding edges between them.
11. Open the properties dialog for the new node and supply the following property values:

<b>Node Name</b>	Total Annual Cost (\$)
<b>Unique Identifier</b>	total_annual_cost
<b>Simulation Node</b>	Ticked
<b>Node States</b>	0 – 10, 10 – inf
<b>NPT (Expression)</b>	Annual Maintenance Cost (\$) (amc) + Annual Fuel Cost \$ (afc)
<b>Background Colour</b>	Medium Blue
<b>Shape</b>	Rounded Rectangle
<b>Treat Min/Max X as percentiles</b>	Ticked
<b>Lower percentile X Bound</b>	0
<b>Upper percentile X Bound</b>	98

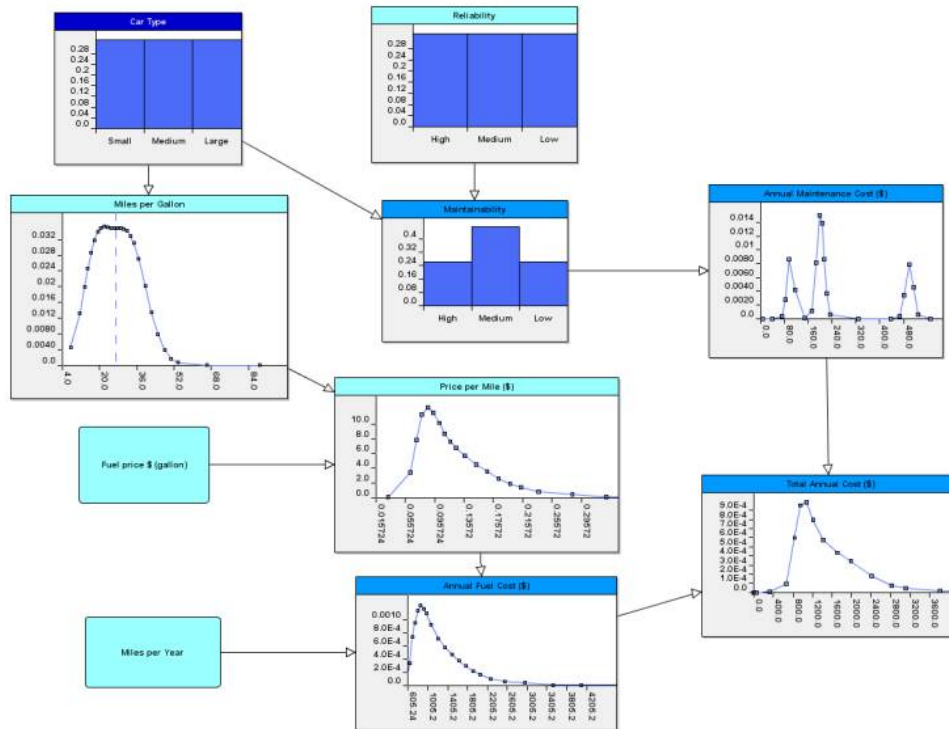
**Table 7 Properties for *Total Annual Cost (\$)* node**

12. Run a calculation.
13. Double-click on *Total Annual Cost (\$)*, resize the Risk Graph and verify that it looks like the one in Figure 21.



**Figure 21 Risk Graph for *Total Annual Cost (\$)***

14. The model is now complete. The Risk Map should look something like this:



**Figure 22 Completed Risk Map of Car Costs model**

15. Save your model. In the next section, you will interact with the model and use it to generate predictions about the expected running costs of your three short-listed makes of car.
16. Before proceeding to the next section you might wish to check your solution against the correct solution which can be found here: *Examples / Tutorials / Car Costs.ast*

## 4 Running the Car Costs Model

### 4.1 Creating and Deleting Scenarios

1. One of the most powerful features of AgenaRisk is the ability to compare different scenarios side by side. You are going to use scenarios to compare the three car makes on your short-list: Mercedes, Honda and Ford.
2. Before continuing, turn off the auto-calculate feature by toggling the auto-calculate button:



You will be adding and removing a lot of observations in this section of the tutorial and you don't want a calculation to occur automatically after each change.

3. Click on the downward arrow at the top of the screen next to **Risk Scenarios**:



4. This expands what is known as the Scenario Manager. Currently, the Scenario Manager contains only one Scenario as shown in Figure 23 below.



**Figure 23 Scenario Manager showing one scenario**

When a new model is created, it has just one scenario. This scenario is active, which means it is displayed in the Risk Table and that observations in this scenario are shown on the Risk Map. In addition, the scenario is displayed on Risk Graphs.

5. Click on the **Scenario 1** text. You will see that it is editable. Using the Backspace key, remove the text and type **Mercedes**.
6. Right-click anywhere in the Scenario Manager and choose **Add a New Scenario**. Rename this scenario **Honda**.
7. Add another new scenario and name this one **Ford**.
8. Click on the Risk Table tab below the Scenario Manager. Notice that the column of fields is called **Mercedes**. This corresponds to the first scenario you added.
9. By default, only the first scenario in a model is marked as active. In order to see the other two scenarios on the Risk Table, click their **Active** boxes. You should now see all three scenarios:

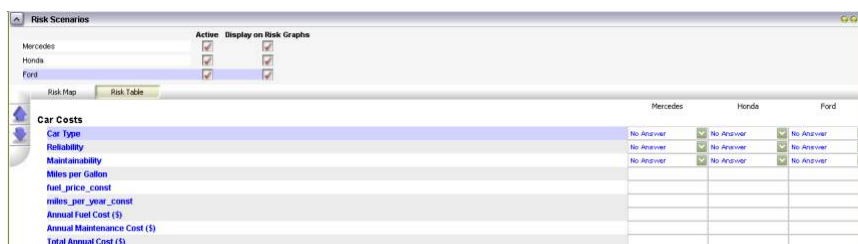



Figure 24 Scenario Manager showing three scenarios

10. Scenarios can also be deleted from the Scenario Manager. Add two new scenarios and then select both of them by holding down the Ctrl key between clicks.
11. Right-click on the scenarios and select **Delete Selected Scenario(s)**. Verify that the Scenario Manager now contains just the three scenarios created earlier.

 If you have a scenario containing a lot of observations, the quickest way of creating another scenario that is only slightly different is to right-click on the scenario and select **Clone Selected Scenario(s)**. This will create a copy of the scenario that can then be renamed and modified.


## 4.2 Adding Observations to Scenarios

1. Observations can be added to scenarios either via the Risk Map or the Risk Table. The only exception to this is values for constants; they can only be entered via the Risk Table.
2. You will enter the constant observations first.
3. For all three makes of car, fuel price and annual mileage are going to be the same. In the row entitled **fuel\_price\_const** enter the value **3** in each scenario's text box. Likewise, enter **10000** in all three boxes in the **miles\_per\_year\_const** row. Your Risk Table should now look like this:

	Mercedes	Honda	Ford
<b>Car Costs</b>			
Car Type	No Answer	No Answer	No Answer
Reliability	No Answer	No Answer	No Answer
Maintainability	No Answer	No Answer	No Answer
Miles per Gallon			
fuel_price_const	3	3	3
miles_per_year_const	10000	10000	10000
Annual Fuel Cost (\$)			
Annual Maintenance Cost (\$)			
Total Annual Cost (\$)			

Figure 25 Risk Table with constant values entered for three scenarios

4. Now enter the **Car Type** for each scenario. Select **Large** in the drop-down box for **Mercedes**, select **Medium** for **Honda** and select **Small** for **Ford**.
5. Similarly, enter the **Reliability** for each make of car. For **Honda**, select **High** and for **Ford** select **Low**.
6. For **Mercedes**, you are going to enter soft evidence. Double-click on the **Reliability** entry to expand it. Enter **1** in the **Medium** and **Low** text boxes.

 Soft evidence can only be entered on the first active scenario in the Risk Table. To enter soft evidence on any other scenario, you need to make any other scenarios temporarily inactive.

7. Your Risk Table should now look like the one in Figure 26.

	Mercedes	Honda	Ford
<b>Car Costs</b>			
<b>Car Type</b>	Large	Medium	Small
<b>Reliability</b>	Soft Evidence	High	Low
<b>New Node</b>			
<b>D.O.</b>	High		
<b>T.O.</b>	Medium		
<b>L.O.</b>	Low		
<b>Maintainability</b>	No Answer	No Answer	No Answer
<b>Miles per Gallon</b>			
<b>Fuel price const</b>	3	3	3
<b>miles_per_year_const</b>	10000	10000	10000
<b>Annual Fuel Cost (\$)</b>			
<b>Annual Maintenance Cost (\$)</b>			
<b>Total Annual Cost (\$)</b>			

Figure 26 Risk Table with constants, hard evidence and soft evidence

- Run a calculation.
- When the calculation is complete, switch to the Risk Map view. Your Risk Map should look like this:

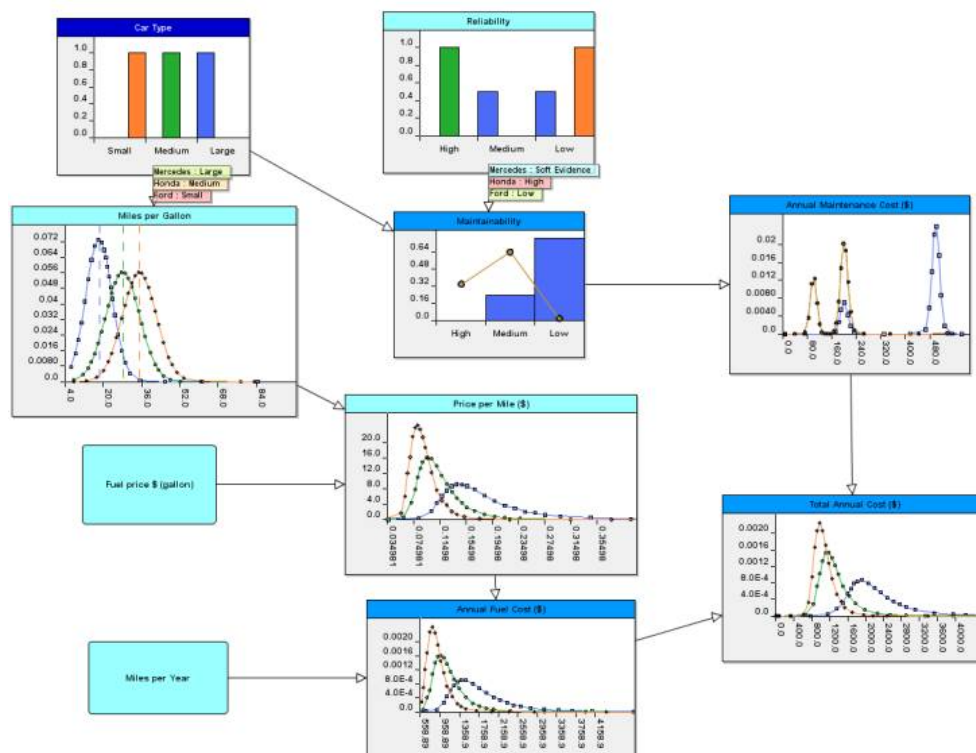


Figure 27 Risk Map showing three scenarios

- Observe that each Risk Graph now shows all three scenarios. Look at the *Total Annual Cost (\$)* node and compare the three makes of car. Move your mouse over the lines to view the summary information. Given the information we have entered so far, the model tells us that owning a Mercedes will have the highest annual cost (mean = **\$2286.50**) followed by Honda (mean = **\$1344.90**). Ford is the cheapest (mean = **\$1017.30**).
- The narrower a distribution, the more confident we are that the mean represents the “true” value of the node. Notice that the distribution for Ford is the narrowest; we can be fairly confident that the actual annual cost of owning a Ford will be close to **\$1017.30**. Conversely, the Mercedes distribution shows the greatest spread; the actual annual cost of owning a Mercedes could be significantly higher or lower than **\$2286.50**.
- Look at the two nodes *Car Type* and *Reliability*. Remember that we entered observations for these nodes in the Risk Table. Each scenario is represented by a

label sitting on top of the node. In the case of *Reliability*, notice that the label for the Mercedes scenario says **Soft Evidence** and that this scenario has two corresponding bars on the Risk Graph. The two bars show the information that you entered; namely, that a Mercedes could just as likely have high or medium reliability.

13. Imagine now that, having read a glowing review in a car magazine, you believe the reliability of Mercedes cars to be high. Right-click on the *Reliability* node and select **Enter Observation** → **Mercedes** → **High**.
14. Run a calculation.
15. Observe how the mean total annual cost of owning a Mercedes has decreased slightly to **\$2156.10**. Despite the improved reliability, however, owning a Mercedes is still likely to cost more than owning either of the other two cars.
16. Return to the Risk Table view and try entering different values for *Fuel price \$ (gallon)* and *Miles per Year*. Remember to run a calculation when you have finished making your changes. Return to the Risk Map to view the updated Risk Graphs (or expand the Risk Explorer so that you can see the graphs while you are still in the Risk Table view). Note what effects the changes have had on the *Total Annual Cost (\$)* node.
17. Try entering different constant values for each scenario. For example, you might decide that, if you owned a Ford, you would drive it a lot more than if you owned a Honda and that, if you owned a Honda, you might drive it slightly more than you would drive a Mercedes. You would represent this information by specifying different values for **miles\_per\_year\_const** (**18000** for Ford, **10000** for Honda and **8000** for Mercedes, say). Under these circumstances, a Ford costs the most to run.

## 5 Next Steps

This tutorial has shown you step-by-step how to build a reasonably complex model using AgenaRisk. There are, however, still many ways of using the tool that have not been covered. In order to learn more about these different uses you should you should work through the more advanced tutorial, *Advanced Modelling with AgenaRisk*, and explore the range of well-documented example models that come with the tool.