Decision Trees Using TreePlan

16

16.1 TREEPLAN OVERVIEW

TreePlan is a decision tree add-in for Microsoft Excel 2007 & 2010 & 2013 & 2016 (Windows) and Microsoft Excel 2011 & 2016 (Macintosh).

TreePlan helps you build a decision tree diagram in an Excel worksheet using dialog boxes. Decision trees are useful for analyzing sequential decision problems under uncertainty. Your decision tree model may include various controllable alternatives (e.g., whether to introduce a new product, whether to bid on a new project) and uncontrollable uncertainties (e.g., possible demand for a product, whether you're awarded a contract), arranged in chronological order. TreePlan automatically includes formulas for summing cash flows to obtain outcome values and for calculating rollback values for determining the optimal strategy.

To use TreePlan, you
> (1) open a new worksheet,
> (2) press Ctrl+Shift+T (or Option+Command+t) to build a new decision tree diagram,
> (3) select a node to change the structure of your decision tree,
> (4) enter branch names, cash flows, and probabilities, and
> (5) determine the optimal strategy from TreePlan's results.

All of TreePlan's functionality, including its built-in help, is a part of the TreePlan XLAM file. There is no separate setup file or help file. When you use TreePlan on a Windows computer, TreePlan does not create any Windows Registry entries (although Excel may use such entries to keep track of its add-ins).

16.2 BUILDING A DECISION TREE IN TREEPLAN

With Windows Excel 2007 & 2010 & 2013 & 2016, you can start TreePlan either by choosing Add-ins > TreePlan Decision Tree or by pressing **Ctrl+Shift+T** (hold down the Ctrl and Shift keys and press T).

With Mac Excel 2011, you can start TreePlan either by choosing **Tools > TreePlan Decision Tree** from the menu or by pressing **Option+Cmd+t** (hold down the Option and Command keys and press t).

With Mac Excel 2016, you can start TreePlan by pressing **Option+Cmd+t**.

If the worksheet doesn't have a decision tree, TreePlan prompts you with a dialog box with three options; choose **New Tree** to begin a new tree. TreePlan draws a default initial decision tree with

its upper left corner at the selected cell. For example, the figure below shows the initial tree when cell C3 is selected before creating the new tree. (Note that TreePlan writes over existing values in the spreadsheet: begin your tree to the *right* of the area where your data is stored, and *do not subsequently add or delete rows or columns in the tree-diagram area*.)

Figure 16.1 TreePlan Initial Default Decision Tree
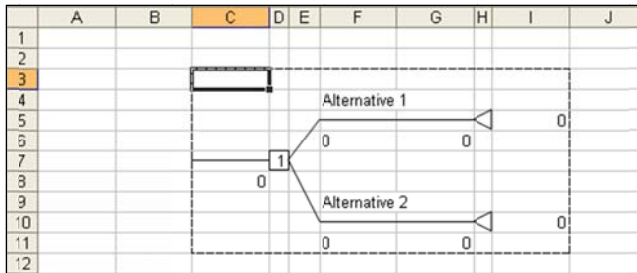
Build up a tree by adding or modifying branches or nodes in the default tree. To change the branch labels or probabilities, click on the cell containing the label or probability and type the new label or probability. To modify the structure of the tree (e.g., add or delete branches or nodes in the tree), select the node or the cell containing the node in the tree to modify, and press **Ctrl+Shift+T** (or **Option+Cmd+t**). TreePlan will then present a dialog box showing the available commands.

For example, to add an event node to the top branch of the tree shown above, select cell H5 or select the triangle shape, and press **Ctrl+Shift+T** (or **Option+Cmd+t**). TreePlan then presents this dialog box.

Figure 16.2 TreePlan Terminal Node dialog box
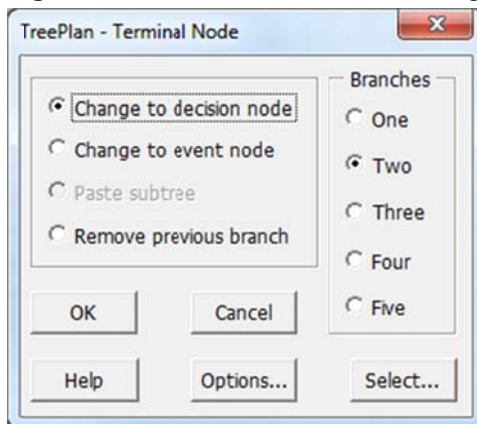
To add an event node to the branch, we change the selected terminal node to an event node by selecting **Change to event node** in the dialog box, selecting the number of branches (here two), and pressing **OK**. TreePlan then redraws the tree with a chance node in place of the terminal node.

Figure 16.3 Initial Decision Tree Diagram
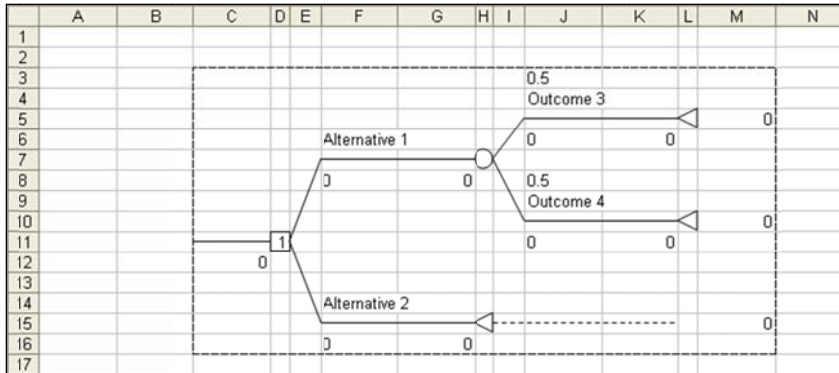
The dialog boxes presented by TreePlan vary depending on what you have selected when you press **Ctrl+Shift+T** (or **Option+Cmd+t**). With an event node selected, the dialog box shown below is presented when you press **Ctrl+Shift+T** (or **Option+Cmd+t**); a similar dialog box is presented when you select a decision node. If you want to add a branch to the selected node, choose **Add branch** and press **OK**. If you want to insert a decision or event node before the selected node, choose **Insert decision** or **Insert event** and press **OK**. To get a description of the available commands, click on the **Help** button.

Figure 16.4 TreePlan Event Dialog Box
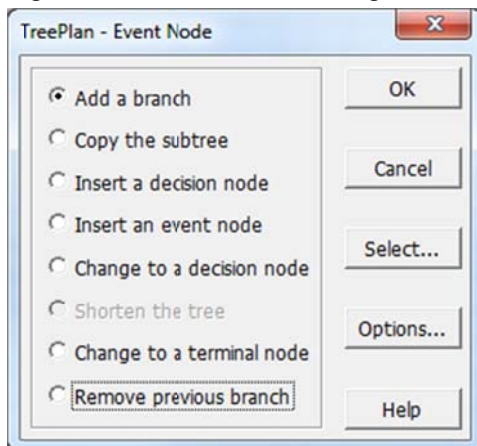
The **Copy subtree** command is particularly useful when building large trees. If two or more parts of the tree are similar, you can copy and paste "subtrees" rather than building up each part separately. To copy a subtree, select the node at the root of the subtree and choose **Copy subtree**. This tells TreePlan to copy the selected node and everything to the right of it in the tree. To paste this subtree, select a terminal node and choose **Paste subtree**. TreePlan then duplicates the specified subtree at the selected terminal node.

Since TreePlan decision trees are built directly in Excel, you can use Excel's commands to format your tree. For example, you can use bold or italic fonts for branch labels: select the cells you want to format and change them using Excel's formatting commands. To help you, TreePlan provides a

Select dialog box that appears when you press **Ctrl+Shift+T** (or **Option+Cmd+t**) without a node selected. You can also bring up this dialog box by pressing the **Select** button on the **Node** dialog box. From here, you can select all items of a particular type in the tree. For example, if you choose **Probabilities** and press **OK**, TreePlan selects all cells containing probabilities in the tree. You can then format all of the probabilities simultaneously using Excel's formatting commands. (Because of limitations in Excel, the **Select** dialog box may not be available when working with very large trees.)

16.3 ANATOMY OF A TREEPLAN DECISION TREE

An example of a TreePlan decision tree is shown below. In the example, a firm must decide (1) whether to prepare a proposal for a possible contract and (2) which method to use to satisfy the contract. The tree consists of decision nodes, event nodes and terminal nodes connected by branches. Each branch is surrounded by cells containing formulas, cell references, or labels pertaining to that branch. You may edit the labels, probabilities, and partial cash flows associated with each branch. The partial cash flows are the amount the firm "gets paid" to go down that branch. For the scenario with terminal value $30,000, the firm pays $50,000 if it decides to prepare the proposal, receives $250,000 up front if awarded the contract, spends $50,000 to try the electronic method, and spends $120,000 on the mechanical method if the electronic method fails.

Figure 16.5 Nodes, Labels, Cash Flows, and Probabilities
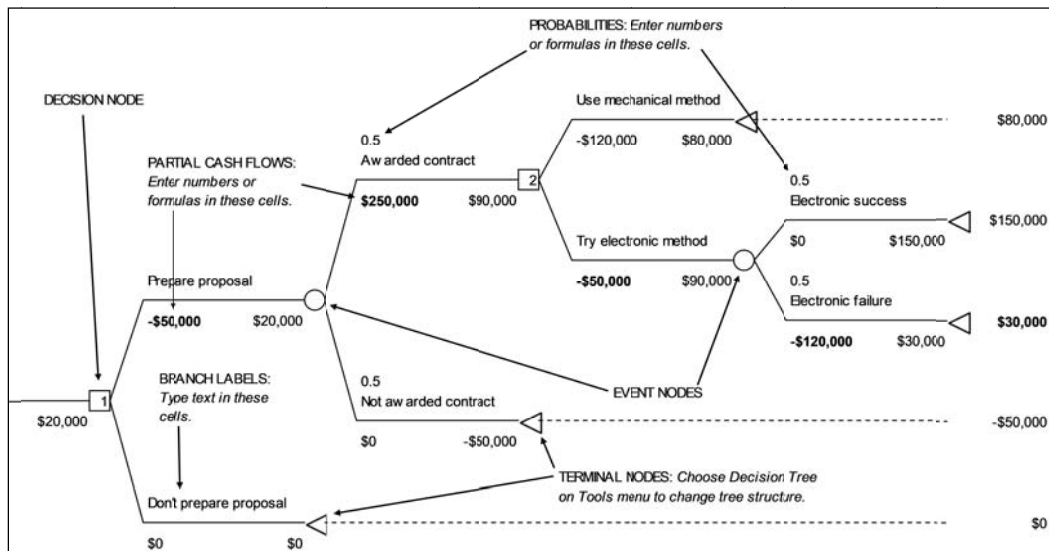
The trees are "solved" using formulas embedded in the spreadsheet. The *terminal values* sum all the partial cash flows along the path leading to that terminal node. The tree is then "rolled back" by computing expected values at event nodes and by maximizing at decision nodes; the *rollback EVs* appear next to each node and show the expected value at that point in the tree. The numbers in the decision nodes indicate which alternative is optimal for that decision. In the example, the "1" in the first decision node indicates that it is optimal to prepare the proposal, and the "2" in the second decision node indicates the firm should try the electronic method because that alternative leads to a higher expected value, $90,000, than the mechanical method, $80,000.

Figure 16.6 Terminal Values, Rollback EVs, and Choice Indicators
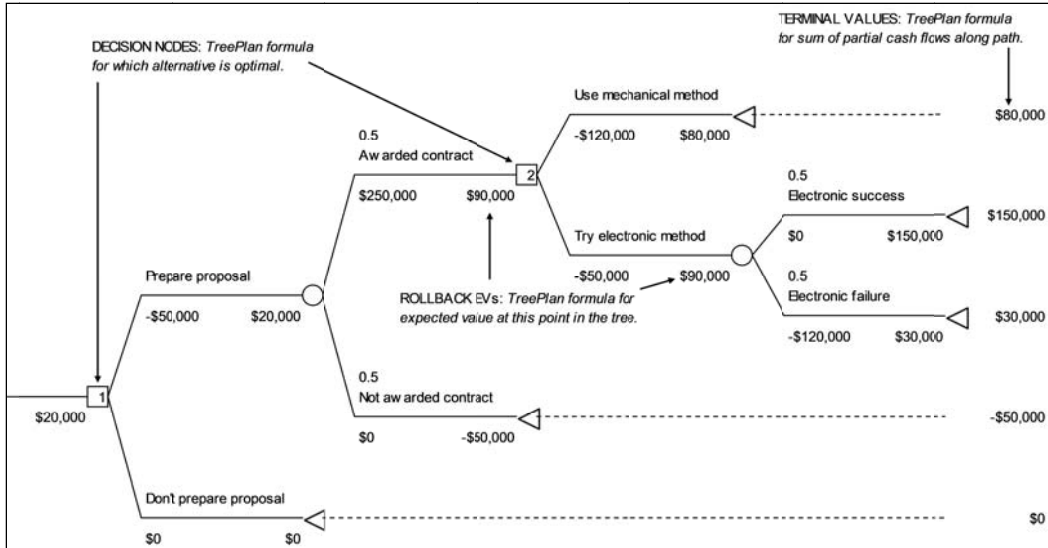
TreePlan has a few options that control the way calculations are done in the tree. To select these options, press the **Options** button in any of TreePlan's dialog boxes. The first choice is whether to **Use Expected Values** or **Use Exponential Utility Function** for computing certain equivalents. The default is to rollback the tree using expected values. If you choose to use exponential utilities, TreePlan will compute utilities of endpoint cash flows at the terminal nodes and compute expected utilities instead of expected values at event nodes. Expected utilities are calculated in the cell below the certain equivalents. You may also choose to **Maximize (profits)** or **Minimize (costs)** at decision nodes; the default is to maximize profits. If you choose to minimize costs instead, the cash flows are interpreted as costs, and decisions are made by choosing the minimum expected value or certain equivalent rather than the maximum. See the Help file for details on these options.

16.4 TREEPLAN INPUTS AND FORMULAS

Figure 16.7 Influence Chart of TreePlan Inputs and Formulas

Branch Inputs   Cell Formulas   Defined Name

Cash Flow →(Optional)→ Terminal Node Endpoint Value

Probability → Event Node Rollback Value ←(Optional)← RT (Risk Tolerance)

Decision Node Rollback Value

Decision Node Choice Indicator
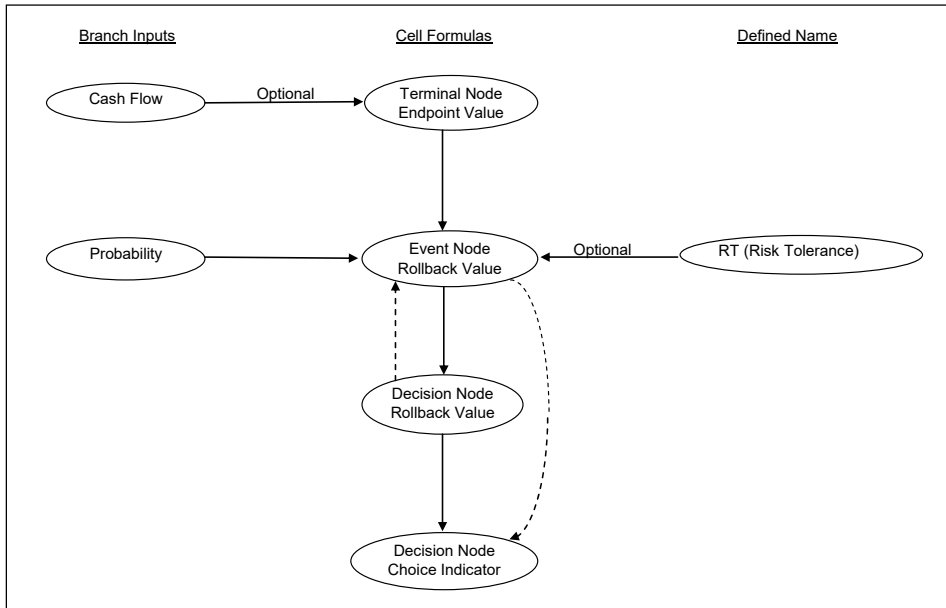
Figure 16.8 Explanation of Formulas

Location	Formula
Endpoint Value at Terminal Node	**SUM of branch cash flows**
Rollback Value at Event Node	**IF probabilities SUM to approximately one, then SUM the products of probabilities times subsequent rollback values**
Rollback Value at Decision Node	**MAX or MIN of subsequent rollback values**
Choice Indicator at Decision Node	**Nested IF functions**

16.5 STEP-BY-STEP TREEPLAN TUTORIAL

A decision tree can be used as a model for a sequential decision problems under uncertainty. A decision tree describes graphically the decisions to be made, the events that may occur, and the outcomes associated with combinations of decisions and events. Probabilities are assigned to the events, and values are determined for each outcome. A major goal of the analysis is to determine the best decisions.

Decision tree models include such concepts as nodes, branches, terminal values, strategy, payoff distribution, certain equivalent, and the rollback method. The following problem illustrates the basic concepts.

DriveTek Problem

DriveTek Research Institute discovers that a computer company wants a new storage device for a proposed new computer system. Since the computer company does not have research people available to develop the new storage device, it will subcontract the development to an independent research firm. The computer company has offered a fee of $250,000 for the best proposal for developing the new storage device. The contract will go to the firm with the best technical plan and the highest reputation for technical competence.

DriveTek Research Institute wants to enter the competition. Management estimates a cost of $50,000 to prepare a proposal with a fifty-fifty chance of winning the contract.

However, DriveTek's engineers are not sure about how they will develop the storage device if they are awarded the contract. Three alternative approaches can be tried. The first approach is a mechanical method with a cost of $120,000, and the engineers are certain they can develop a successful model with this approach. A second approach involves electronic components. The engineers estimate that the electronic approach will cost only $50,000 to develop a model of the storage device, but with only a 50 percent chance of satisfactory results. A third approach uses magnetic components; this costs $80,000, with a 70 percent chance of success.

DriveTek Research can work on only one approach at a time and has time to try only two approaches. If it tries either the magnetic or electronic method and the attempt fails, the second choice must be the mechanical method to guarantee a successful model.

The management of DriveTek Research needs help in incorporating this information into a decision to proceed or not.

[Source: The storage device example is adapted from Spurr and Bonini, *Statistical Analysis for Business Decisions*, Irwin.]

Nodes and Branches

Decision trees have three kinds of nodes and two kinds of branches. A decision node is a point where a choice must be made; it is shown as a square. The branches extending from a decision node are decision branches, each branch representing one of the possible alternatives or courses of action available at that point. The set of alternatives must be mutually exclusive (if one is chosen, the others cannot be chosen) and collectively exhaustive (all possible alternatives must be included in the set).

There are two major decisions in the DriveTek problem. First, the company must decide whether or not to prepare a proposal. Second, if it prepares a proposal and is awarded the contract, it must decide which of the three approaches to try to satisfy the contract.

An event node is a point where uncertainty is resolved (a point where the decision maker learns about the occurrence of an event). An event node, sometimes called a "chance node," is shown as a circle. The event set consists of the event branches extending from an event node, each branch representing one of the possible events that may occur at that point. The set of events must be mutually exclusive (if one occurs, the others cannot occur) and collectively exhaustive (all possible events must be included in the set). Each event is assigned a subjective probability; the sum of probabilities for the events in a set must equal one.

The three sources of uncertainty in the DriveTek problem are: whether it is awarded the contract or not, whether the electronic approach succeeds or fails, and whether the magnetic approach succeeds or fails.

In general, decision nodes and branches represent the controllable factors in a decision problem; event nodes and branches represent uncontrollable factors.

Decision nodes and event nodes are arranged in order of subjective chronology. For example, the position of an event node corresponds to the time when the decision maker learns the outcome of the event (not necessarily when the event occurs).

The third kind of node is a terminal node, representing the final result of a combination of decisions and events. Terminal nodes are the endpoints of a decision tree, shown as the end of a branch on hand-drawn diagrams and as a triangle on computer-generated diagrams.

The following table shows the three kinds of nodes and two kinds of branches used to represent a decision tree.

Figure 16.9 Nodes and Symbols

Type of Node	Written Symbol	Computer Symbol	Node Successor
Decision	square	square	decision branches
Event	circle	circle	event branches
Terminal	endpoint	triangle or bar	terminal value

Terminal Values

Each terminal node has an associated terminal value, sometimes called a payoff value, outcome value, or endpoint value. Each terminal value measures the result of a *scenario*: the sequence of decisions and events on a unique path leading from the initial decision node to a specific terminal node.

To determine the terminal value, one approach assigns a cash flow value to each decision branch and event branch and then sum the cash flow values on the branches leading to a terminal node to determine the terminal value. In the DriveTek problem, there are distinct cash flows associated with many of the decision and event branches. Some problems require a more elaborate value model to determine the terminal values.

The following diagram shows the arrangement of branch names, probabilities, and cash flow values on an unsolved tree.

Figure 16.10 DriveTek Decision Tree Diagram
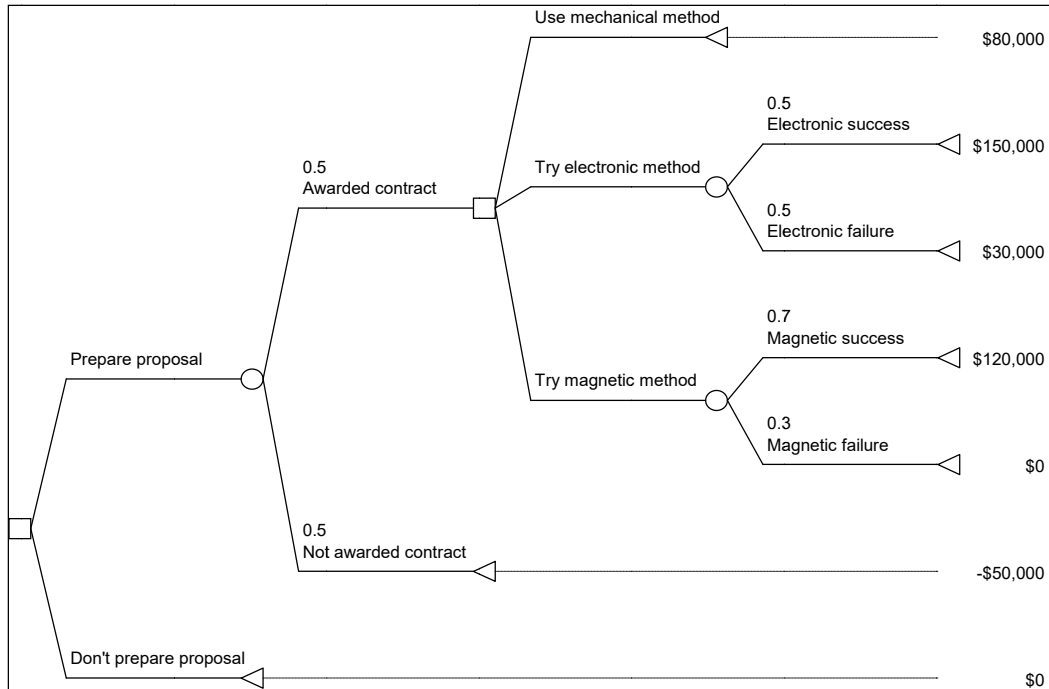
To build the decision tree, you use TreePlan's dialog boxes to develop the structure. You enter a branch name, branch cash flow, and branch probability (for an event) in the cells above and below the left side of each branch. As you build the tree diagram, TreePlan enters formulas in other cells.

Building the Tree Diagram

1. Start with a new worksheet. (If no workbook is open, choose File > New. If a workbook is open, choose Insert > Worksheet.)

2. Select cell A1. In Excel 2007 & 2010 & 2013 & 2016, choose Add-ins > TreePlan Decision Tree; in Mac Excel 2011, choose Tools > TreePlan Decision Tree. Or, in any Windows version, press Ctrl+Shift+T. In Mac Excel 2011 & 2016, press Option+Cmd+t. Subsequent instructions refer only to the Windows shortcut key. In the TreePlan New Tree dialog box, click the New Tree button. A decision node with two branches appears.

Figure 16.11 TreePlan New Tree Dialog Box
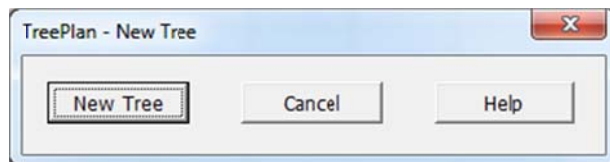
Figure 16.12 Initial Decision Tree Diagram

	A	B	C	D	E	F	G
1							
2				Alternative 1			
3							0
4				0	0		
5		1					
6		0					
7				Alternative 2			
8							0
9				0	0		

3. Select cell D2, and enter **Prepare proposal**. Select cell D4, and enter **–50000**. Select cell D7, and enter **Don't prepare proposal**.

Figure 16.13 Branch Names and Cash Flow

	A	B	C	D	E	F	G
1							
2				Prepare proposal			
3							-50000
4				-50000	-50000		
5		2					
6		0					
7				Don't prepare proposal			
8							0
9				0	0		

4. Select cell F3. Press Ctrl+Shift+T. In the TreePlan Terminal Node dialog box, select Change To Event Node, select Two Branches, and click OK. The tree is redrawn.

Figure 16.14 TreePlan Terminal Node Dialog Box
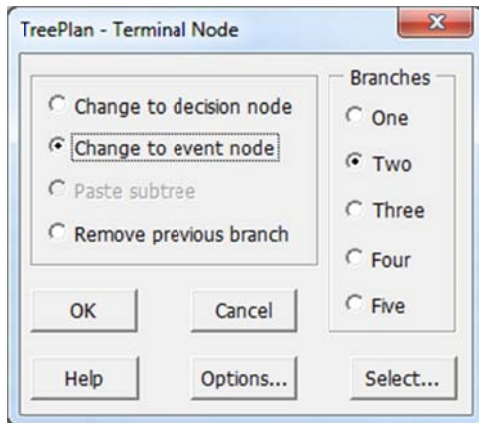
Figure 16.15 Initial Event Branches

	A	B	C	D	E	F	G	H	I	J	K
1								0.5			
2								Outcome 3			
3											-50000
4				Prepare proposal				0	-50000		
5											
6				-50000	-50000			0.5			
7								Outcome 4			
8											-50000
9			2					0	-50000		
10		0									
11											
12				Don't prepare proposal							
13											0
14				0	0						

5. Select cell H2, and enter **Awarded contract**. Select cell H4, and enter **250000**. Select cell H7, and enter **Not awarded contract**.

Figure 16.16 Event Branches With Names and Cash Flow

	A	B	C	D	E	F	G	H	I	J	K
1								0.5			
2								Awarded contract			
3											200000
4				Prepare proposal				250000	200000		
5											
6				-50000	75000			0.5			
7								Not awarded contract			
8											-50000
9			1					0	-50000		
10		75000									
11											
12				Don't prepare proposal							
13											0
14				0	0						

6. Select cell J3. Press Ctrl+Shift+T. In the TreePlan Terminal Node dialog box, select Change To Decision Node, select Three Branches, and click OK. The tree is redrawn.

Figure 16.17 Subsequent Decision Branches

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1															
2												Alternative 5			
3															200000
4												0	200000		
5															
6								0.5							
7								Awarded contract				Alternative 6			
8										1					200000
9								250000	200000			0	200000		
10															
11															
12				Prepare proposal								Alternative 7			
13						○									200000
14				-50000	75000							0	200000		
15															
16								0.5							
17								Not awarded contract							
18			1												-50000
19	75000							0	-50000						
20															
21															
22				Don't prepare proposal											
23															0
24				0	0										
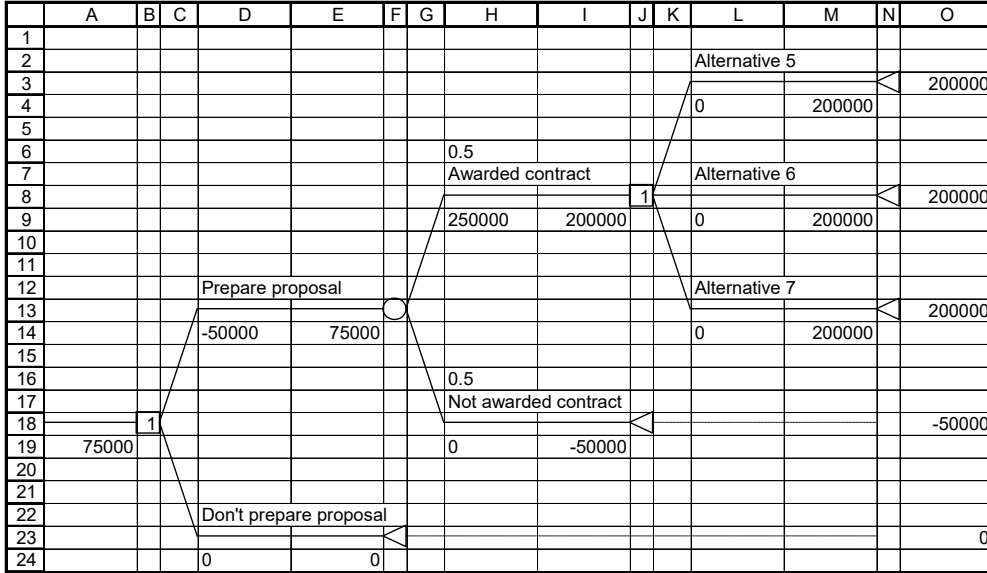
7. Select cell L2, and enter **Use mechanical method**. Select cell L4, and enter **–120000**. Select cell L7, and enter **Try electronic method**. Select cell L9, and enter **–50000**. Select cell L12, and enter **Try magnetic method**. Select cell L14, and enter **–80000**.

Figure 16.18 Subsequent Decision Branches With Names and Cash Flows

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1															
2												Use mechanical method			
3															80000
4												-120000	80000		
5															
6								0.5							
7								Awarded contract				Try electronic method			
8										2					150000
9								250000	150000			-50000	150000		
10															
11															
12				Prepare proposal								Try magnetic method			
13						○									120000
14				-50000	50000							-80000	120000		
15															
16								0.5							
17								Not awarded contract							
18			1												-50000
19	50000							0	-50000						
20															
21															
22				Don't prepare proposal											
23															0
24				0	0										

8. Select cell N8. Press Ctrl+Shift+T. In the TreePlan Terminal Node dialog box, select Change To Event Node, select Two Branches, and click OK. The tree is redrawn.

Figure 16.19 Branches for Electronic Method Uncertainty

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1																			
2												Use mechanical method							
3																			80000
4												-120000	80000						
5																			
6																0.5			
7																Outcome 8			
8								0.5											150000
9								Awarded contract				Try electronic method				0	150000		
10										2									
11								250000	150000			-50000	150000			0.5			
12																Outcome 9			
13																			150000
14																0	150000		
15				Prepare proposal															
16																			
17				-50000	50000							Try magnetic method							
18																			120000
19												-80000	120000						
20																			
21								0.5											
22			1					Not awarded contract											
23	50000																		-50000
24								0	-50000										
25																			
26																			
27				Don't prepare proposal															
28																			0
29				0	0														

9. Select cell P7, and enter **Electronic success**. Select cell P12, and enter **Electronic failure**. Select cell P14, and enter **–120000**.

Figure 16.20 Branch Names and Cash Flows for Electronic Method Uncertainty

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1																			
2												Use mechanical method							
3																			80000
4												-120000	80000						
5																			
6																0.5			
7																Electronic success			
8								0.5											150000
9								Awarded contract				Try electronic method				0	150000		
10										3									
11								250000	120000			-50000	90000			0.5			
12																Electronic failure			
13																			30000
14																-120000	30000		
15				Prepare proposal															
16																			
17				-50000	35000							Try magnetic method							
18																			120000
19												-80000	120000						
20																			
21								0.5											
22			1					Not awarded contract											
23	35000																		-50000
24								0	-50000										
25																			
26																			
27				Don't prepare proposal															
28																			0
29				0	0														

10. Select cell N18. Press Ctrl+Shift+T. In the TreePlan Terminal Node dialog box, select Change To Event Node, select Two Branches, and click OK. The tree is redrawn.
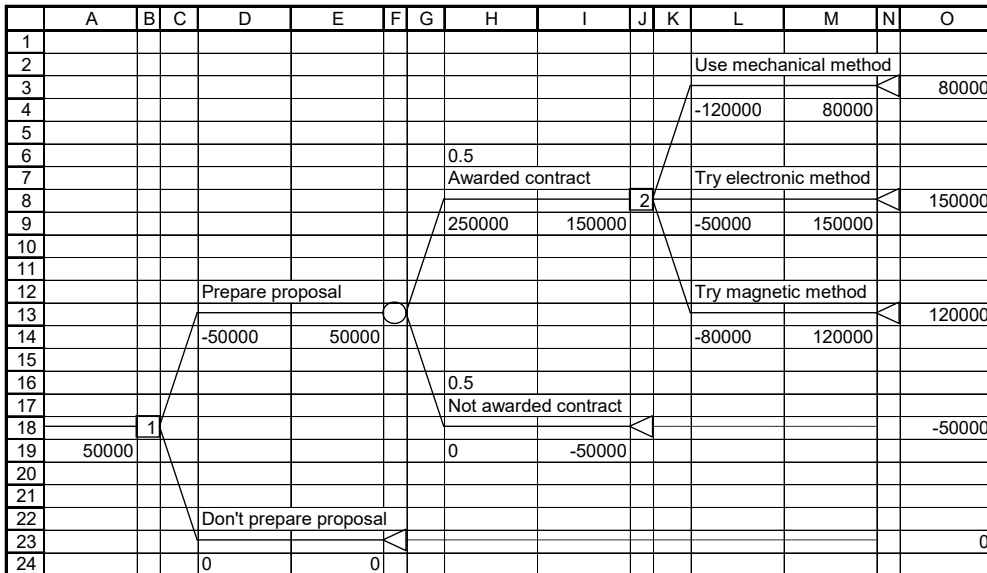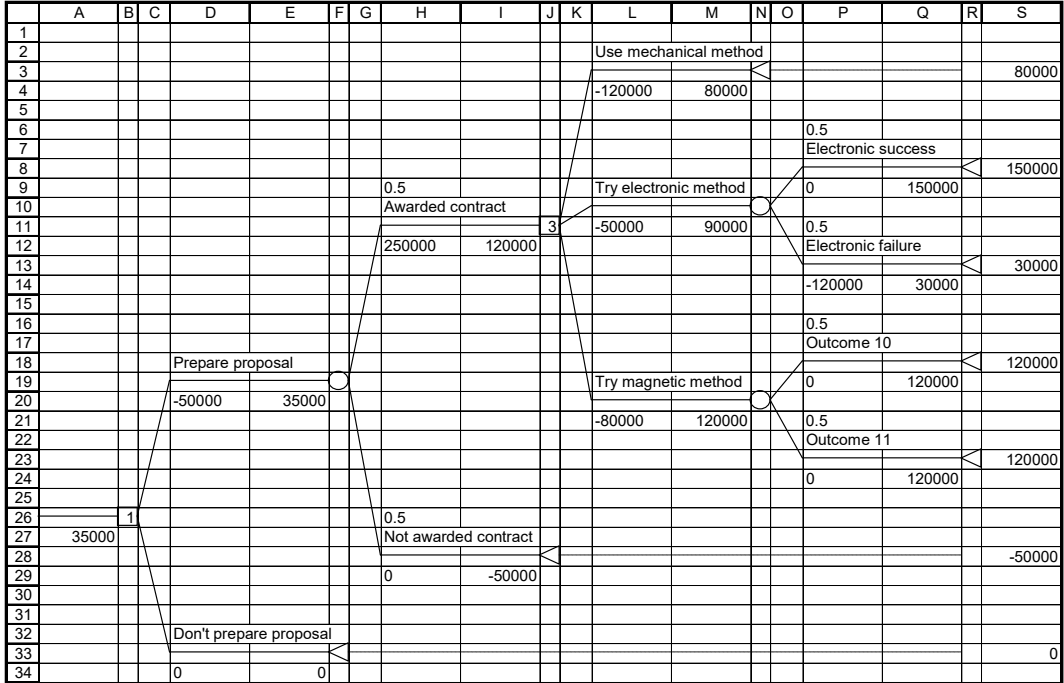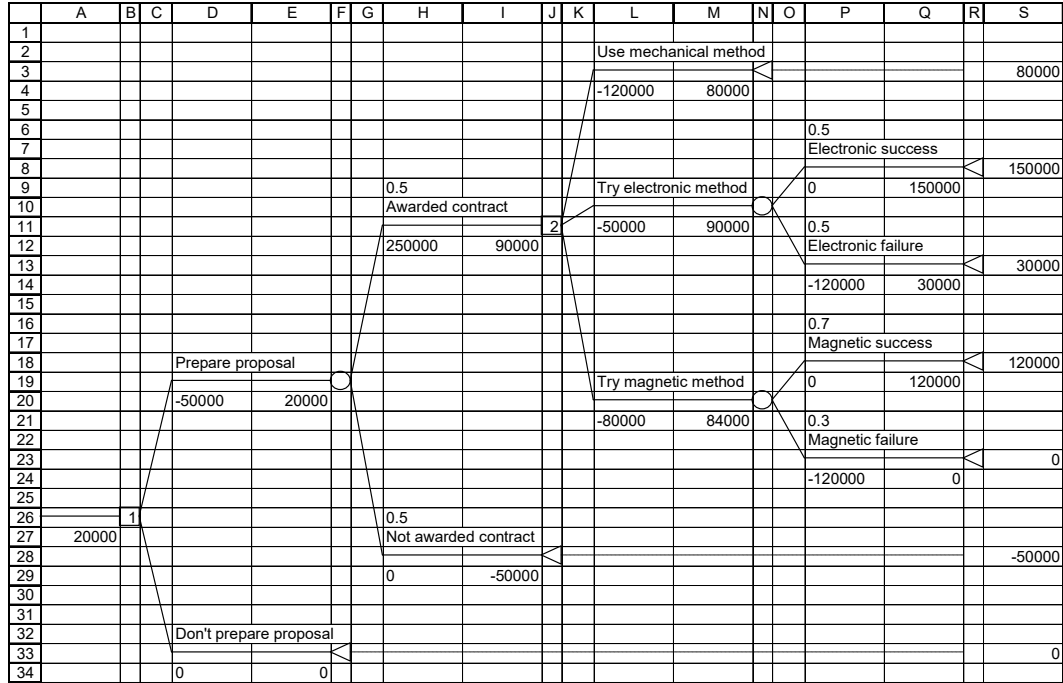
Figure 16.21 Branches for Magnetic Method Uncertainty

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1																			
2												Use mechanical method							
3																			80000
4												-120000	80000						
5																			
6																0.5			
7																Electronic success			
8																			150000
9								0.5				Try electronic method				0	150000		
10								Awarded contract											
11											3	-50000	90000			0.5			
12								250000	120000							Electronic failure			
13																			30000
14																-120000	30000		
15																			
16																0.5			
17																Outcome 10			
18				Prepare proposal															120000
19												Try magnetic method				0	120000		
20				-50000	35000														
21												-80000	120000			0.5			
22																Outcome 11			
23																			120000
24																0	120000		
25																			
26		1						0.5											
27	35000							Not awarded contract											
28																			-50000
29								0	-50000										
30																			
31																			
32				Don't prepare proposal															
33																			0
34				0	0														

11. Select cell P16, and enter **.7**. Select cell P17, and enter **Magnetic success**. Select cell P21, and enter **.3**. Select cell P22, and enter **Magnetic failure**. Select cell P24, and enter **–120000**.

Figure 16.22 Complete Diagram Before Formatting

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1																			
2												Use mechanical method							
3																			80000
4												-120000	80000						
5																			
6																0.5			
7																Electronic success			
8																			150000
9								0.5				Try electronic method				0	150000		
10								Awarded contract											
11											2	-50000	90000			0.5			
12								250000	90000							Electronic failure			
13																			30000
14																-120000	30000		
15																			
16																0.7			
17																Magnetic success			
18				Prepare proposal															120000
19												Try magnetic method				0	120000		
20				-50000	20000														
21												-80000	84000			0.3			
22																Magnetic failure			
23																			0
24																-120000	0		
25																			
26			1					0.5											
27	20000							Not awarded contract											
28																			-50000
29								0	-50000										
30																			
31																			
32				Don't prepare proposal															
33																			0
34				0	0														

12. Double-click the sheet tab (or right-click the sheet tab and choose Rename from the shortcut menu), and enter **Original**. Save the workbook.

Interpreting the Results

The $30,000 terminal value on the far right of the diagram in cell S13 is associated with the following scenario:

Figure 16.23 Evaluation of a Scenario

Branch Type	Branch Name	Cash Flow
Decision	Prepare proposal	–$50,000
Event	Awarded contract	$250,000
Decision	Try electronic method	–$50,000
Event	Electronic failure (Use mechanical method)	–$120,000
	Terminal value	$30,000

TreePlan put the formula =SUM(P14,L11,H12,D20) into cell S13 for determining the terminal value.

Other formulas, called rollback formulas, are in cells below and to the left of each node. These formulas are used to determine the optimal choice at each decision node.

In cell B26, a formula displays 1, indicating that the first branch is the optimal choice. Thus, the initial choice is to prepare the proposal. In cell J11, a formula displays 2, indicating that the

second branch (numbered 1, 2, and 3, from top to bottom) is the optimal choice. If awarded the contract, DriveTek should try the electronic method. A subsequent chapter provides more details about interpretation.

Formatting the Tree Diagram

The following steps show how to use TreePlan and Excel features to format the tree diagram. You may choose to use other formats for your own tree diagrams.

13. From the Edit menu, choose Move or Copy Sheet (or right-click the sheet tab and choose Move Or Copy from the shortcut menu). In the lower left corner of the Move Or Copy dialog box, check the Create A Copy box, and click OK.

14. On sheet Original (2), if the probabilities are not left-aligned, select cell H9. Press Ctrl+Shift+T. In the TreePlan Select dialog box, verify that the option button for Cells with Probabilities is selected, and click OK. With all probability cells selected, click the Align Left button.

Figure 16.24 TreePlan Select Dialog Box
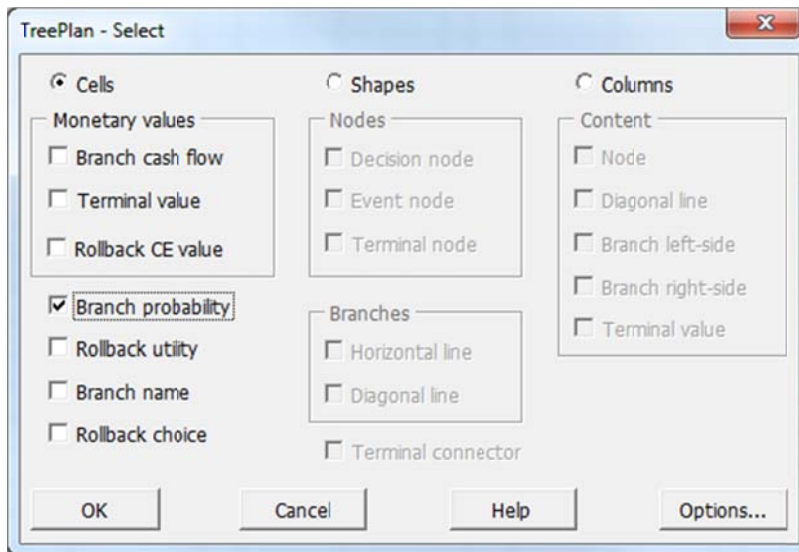
15. Select cell H12. Press Ctrl+Shift+T. In the TreePlan Select dialog box, verify that the option button for Cells with Partial Cash Flows is selected, and click OK. With all partial cash flow cells selected, if the cash flows are not left-aligned, click the Align Left button. With those cells still selected, choose Home > Format > Format Cells. In the Format Cells dialog box, click the Number tab. In the Category list box, choose Currency; type **0** (zero) for Decimal Places; select $ in the Symbol list box; select -$1,234 for Negative Numbers. Click OK.

Figure 16.25 Excel Format Cells Dialog Box
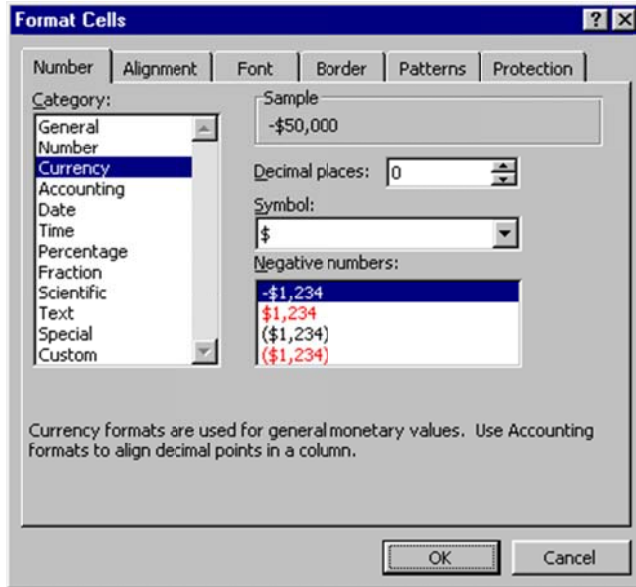
16.   Select cell I12. Press Ctrl+Shift+T. In the TreePlan Select dialog box, verify that the option button for Cells with Rollback EVs/CEs is selected, and click OK. With all rollback cells selected, choose Format > Cells. Repeat the Currency formatting of step 16 above.

17.   Select cell S3. Press Ctrl+Shift+T. In the TreePlan Select dialog box, verify that the option button for Cells with Terminal Values is selected, and click OK. With all terminal value cells selected, choose Format > Cells. Repeat the Currency formatting of step 16 above.

Figure 16.26 Complete DriveTek Decision Tree

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1																			
2												Use mechanical method							
3																			$80,000
4												-$120,000	$80,000						
5																			
6																0.5			
7																Electronic success			
8																			$150,000
9								0.5				Try electronic method				$0	$150,000		
10								Awarded contract											
11											2	-$50,000	$90,000			0.5			
12				$250,000	$90,000											Electronic failure			
13																			$30,000
14																-$120,000	$30,000		
15																			
16																0.7			
17																Magnetic success			
18				Prepare proposal															$120,000
19												Try magnetic method				$0	$120,000		
20				-$50,000	$20,000														
21												-$80,000	$84,000			0.3			
22																Magnetic failure			
23																			$0
24																-$120,000	$0		
25																			
26			1					0.5											
27	$20,000							Not awarded contract											
28																			-$50,000
29								$0	-$50,000										
30																			
31																			
32				Don't prepare proposal															
33																			$0
34				$0	$0														

18. Double-click the Original (2) sheet tab (or right-click the sheet tab and choose Rename from the shortcut menu), and enter **Formatted**. Save the workbook.

Displaying Model Inputs

When you build a decision tree model, you may want to discuss the model and its assumptions with co-workers or a client. For such communication it may be preferable to hide the results of formulas that show rollback values and decision node choices. The following steps show how to display only the model inputs.

19. From the Edit menu, choose Move or Copy Sheet (or right-click the sheet tab and choose Move Or Copy from the shortcut menu). In the lower left corner of the Move Or Copy dialog box, check the Create A Copy box, and click OK.

20. On sheet Formatted (2), select cell B1. Press Ctrl+Shift+T. In the TreePlan Select dialog box, verify that the option button for Columns with Nodes is selected, and click OK. With all node columns selected, choose Format > Cells > Number or Home > Format > Format Cells > Number. In the Category list box, select Custom. Select the entry in the Type edit box, and type **;;;** (three semicolons). Click OK.

Figure 16.27 Excel Format Cells Dialog Box
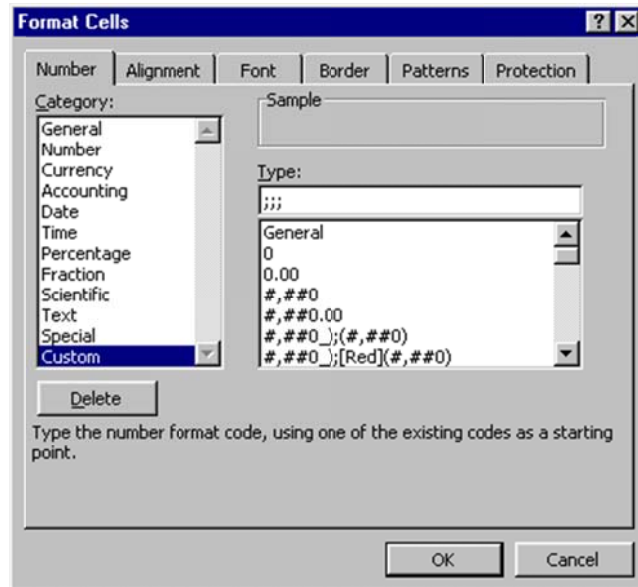
Explanation: A custom number format has four sections of format codes. The sections are separated by semicolons, and they define the formats for positive numbers, negative numbers, zero values, and text, in that order. When you specify three semicolons without format codes, Excel does not display positive numbers, negative numbers, zero values, or text. The formula remains in the cell, but its result is not displayed. Later, if you want to display the result, you can change the format without having to enter the formula again. Editing an existing format does not delete it. All formats are saved with the workbook unless you explicitly delete a format.

21. Select cell A27. Press Ctrl+Shift+T. In the TreePlan Select dialog box, verify that the option button for Cells with Rollback EVs/CEs is selected, and click OK. With all rollback values selected, choose Format > Cells > Number or Home > Format > Format Cells > Number. In the Category list box, select Custom. Scroll to the bottom of the Type list box, and select the three-semicolon entry. Click OK.

22. Double-click the Formatted (2) sheet tab (or right-click the sheet tab and choose Rename from the shortcut menu), and enter **Model Inputs**. Save the workbook.

Printing the Tree Diagram

23. In the Name Box list box, select TreeDiagram (or select cells A1:S34).

24. To print the tree diagram from Excel, with the tree diagram range selected, in Excel 2007 & 2010 & 2013 & 2016, choose Page Layout > Print Area > Set Print Area. Then choose Office Button or File > Print Preview > Page Setup. In the Page Setup dialog box, click the Page tab; for Orientation click the option button for Landscape, and for Scaling click the option button for Fit To 1 Page Wide By 1 Page Tall. Click the Header/Footer tab; in the Header list box select None, and in the Footer list box select None (or select other appropriate headers and footers). Click the Sheet tab; clear the check box for Gridlines,

and clear the check box for Row And Column Headings. Click OK. Choose File > Print and click OK.

25. To print the tree diagram from Word, clear the check boxes for Gridlines and for Row And Column Headings on Excel's Page Setup dialog box Sheet tab. Select the tree diagram range. In Excel 2007 & 2010 & 2013 & 2016, choose Home > Paste > As Picture > Copy as Picture. In the Copy Picture dialog box, click the option button As Shown When Printed, and click OK. In Word select the location where you want to paste the tree diagram and choose Edit > Paste.

Figure 16.28 DriveTek Without Rollback Values
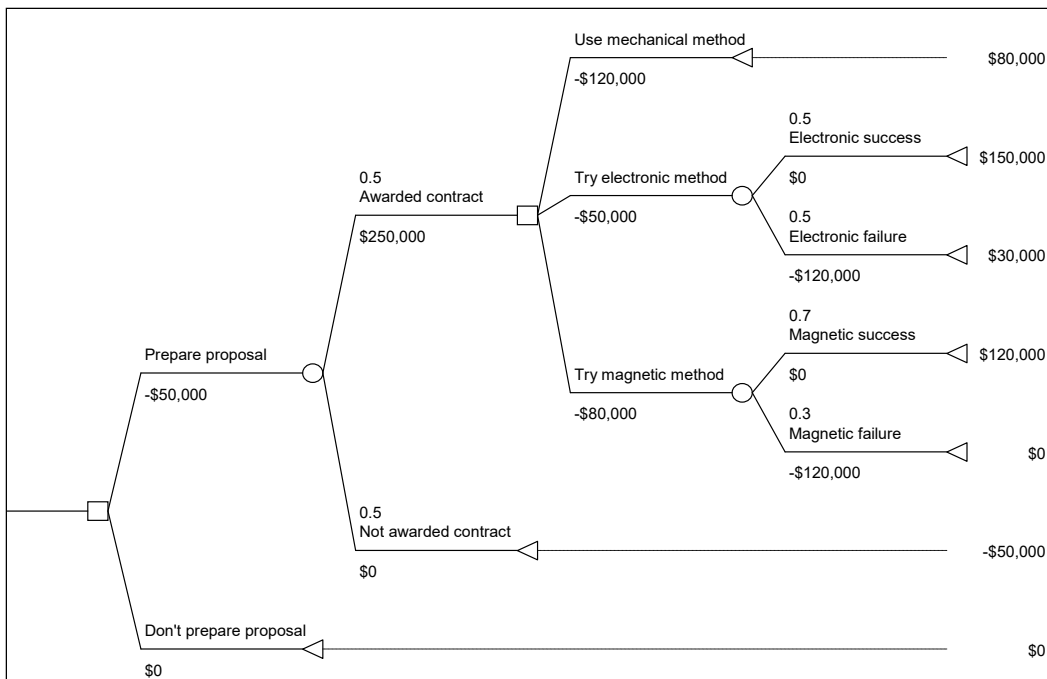
Alternative Model

If you want to emphasize that the time constraint forces DriveTek to use the mechanical approach if they try either of the uncertain approaches and experience a failure, you can change the terminal nodes in cells R13 and R23 to decision nodes, each with a single branch.

Figure 16.29 Alternative DriveTek Decision Tree
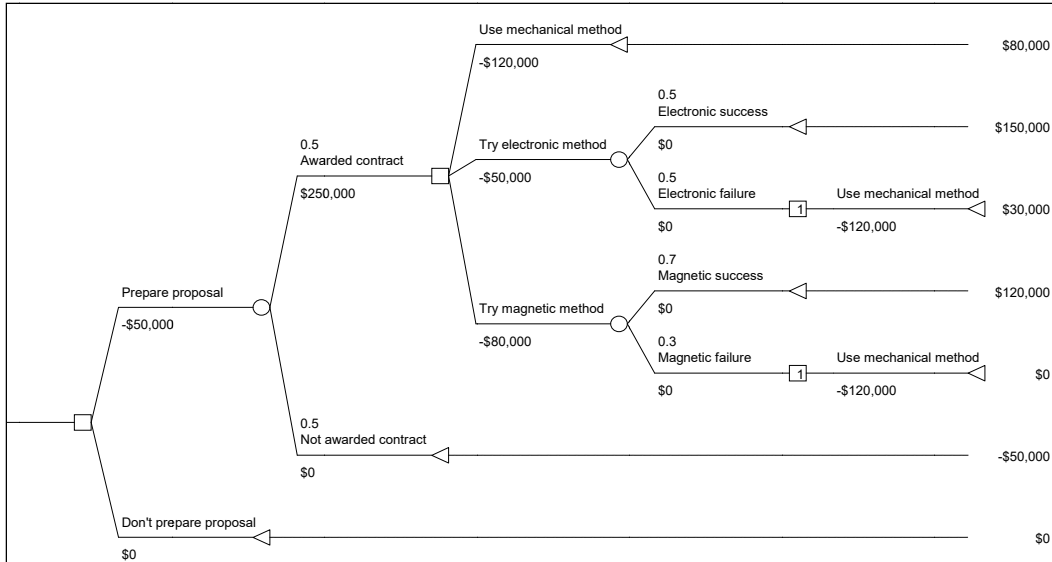
16.6 EXPONENTIAL UTILITY AND TREEPLAN

TreePlan's default is to rollback the tree using expected value (probability-weighted average) at an event node and maximum of successor values at a decision node. If you choose to use exponential utilities in TreePlan's Options dialog box, TreePlan will redraw the decision tree diagram with formulas for computing the utility and certain equivalent at each node.

Figure 16.30 TreePlan Options Dialog Box
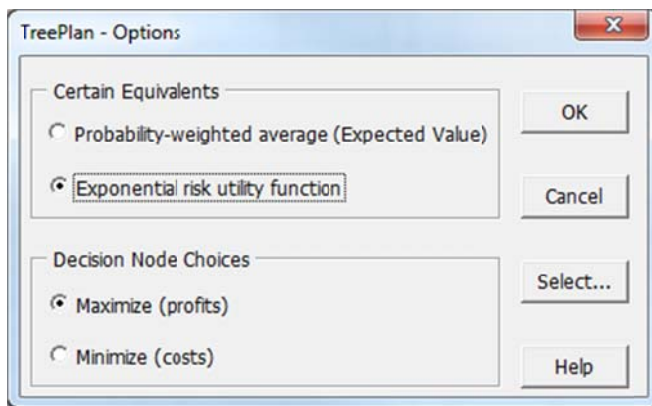
For the Maximize option with exponential utility, the rollback formulas are
U = A–B*EXP(-X/RT) and CE = -LN((A-EU)/B)*RT, where X and EU are cell references.

For the Minimize option with exponential utility, the formulas are
U = A-B*EXP(X/RT) and CE = LN((A-EU)/B)*RT.

TreePlan uses the name RT to represent the risk tolerance parameter of the exponential utility function. The names A and B determine scaling. When you choose to use exponential utility, if the names A, B, and RT do not already exist in the worksheet or workbook, they are initially defined as A=1, B=1, and RT=999999999999.

In Windows Excel you can change the values of defined names using Formulas > Name Manager.

In Mac Excel 2016 you can change the values of defined names by choosing (from the topmost menu) Insert > Name > Define Name. In the Define Name dialog box, after you select a name in the "Names in workbook" list box, enter a new value in the "Select the range of cells" edit box, and click the OK button.

16.7 ACKNOWLEDGEMENT

TreePlan was developed by Professor Michael R. Middleton at the University of San Francisco (using the Excel 4 XLM macro programming language) and modified for use at Fuqua (Duke University) by Professor James E. Smith. Mike Middleton rewrote portions using VBA during 2008–2016.