Decision Maker User Guide

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ABSTRACT

Decision Maker is a prototype software tool developed by Maritime Platforms Division (MPD) of the Defence Science and Technology Organisation (DSTO) that can be applied to most multi-criteria decision-making problems. Decision Maker is a software implementation of the Criteria Importance Through Intercriteria Correlation (CRITIC) decision-making technique. The decision-making problems use a set of criteria and objectives to select the most preferred alternative in a set of alternatives. In most problems there are conflicting criteria/objectives and therefore, complex trade-offs have to be made between competing alternatives. This is where Decision Maker can be used. This user guide will assist and inform users on how they can structure their decision problems in the required format for Decision Maker.

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Executive Summary

Decision Maker is an objective decision-making tool that can be used in most multi-criteria decision-making problems, in particular, where a holistic approach is required in preference to the subjective and ad-hoc processes that are often applied. *Decision Maker* will help defence planners deal with the complexities of military planning by providing a sound scientific platform to assist in decision analysis in a timely manner, as well as providing the decision-maker with a documented quantifiable justification for their decision basis. Examples where *Decision Maker* can be applied include:

- selecting the most preferred product, tender, service or company that best satisfies the specified requirements, criteria or objectives (i.e. procurement); and
- ranking the performance of systems, components or items using combinations of several performance measurements.

Unlike most other products, the key to *Decision Maker* is that it does not use subjective criteria to aid in the decision-making process. At the time of writing, there is no other software on the market that incorporates all of the features of *Decision Maker*, in particular, the use of the objective criteria weight method and genetic algorithms for sensitivity analysis. The essential elements of *Decision Maker* include:

- the use of sophisticated mathematical analysis techniques to identify conflicts in data input by the user;
- criteria and objectives do not have to be independent;
- a cardinal and ordinal ranking of alternatives;
- the removal of dependency on personal preferences of the decision-maker, which results in informed and quantifiable decision choices;
- a unique sensitivity analysis component using leading edge Artificial Intelligence techniques to provide analysis for 'what if' situations;
- a simulation engine that allows the decision to be modelled with uncertainties and tolerance levels for criteria;
- advanced simulation reporting analysis in tabular and graphical format that provides a method to quickly identify the superior alternatives;
- advanced graphical analysis tools that allow the decision-maker to compare alternative criteria and objectives in a meaningful and timely manner; and
- graphical analysis tools that provide a method of determining complex relationships and trends within the criteria/objective data.

This user guide will assist and inform users on how they can structure their decision problems in the required format for *Decision Maker*.

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Contents

Glossary

ADO	Australian Defence Organisation
AI	Artificial Intelligence
CD	Compact Disc
CRITIC	Criteria Importance Through Intercriteria Correlation
CWViewer	Cobweb Plot Viewer
DGMARSPT	Director General Maritime Support
DMO	Defence Materiel Organisation
DSTO	Defence Science and Technology Organisation
GUI	Graphical User Interface
MTBF	Mean Time Between Failure
MTTR	Mean Time To Repair
MTTS	Mean Time To Supply
NaN	Not a Number
PrOACT	Problem, Objectives, Alternatives, Consequences, Trade-offs
RCM	Reliability Centred Maintenance
RMIT	Royal Melbourne Institute of Technology
SOAP	Simple Object Access Protocol
SPO	Systems Program Office
XML	Extended Mark-up Language

The following two symbols are used throughout this User Guide to highlight points that are helpful or are essential to know when using *Decision Maker*.

The ***Light Bulb*** symbol is used throughout this User Guide to indicate information that is useful to know when using *Decision Maker*.

The ***Exclamation*** symbol is used throughout this User Guide to indicate information that is essential to know when using *Decision Maker*.

Disclaimer: *Decision Maker* is a functional prototype and as such there remain formatting, spelling and grammatical errors in the user interface and this is reflected in the screen shots presented in this user guide. *Decision Maker* will function as described but, at the time of writing, there are no future development plans.

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1. Introduction

Decision Maker is a prototype software tool that has been developed by the Defence Science and Technology Organisation (DSTO) for potential application in decision-making problems within the System Program Offices (SPOs) of the Defence Materiel Organisation (DMO), and in other areas of the Australian Defence Organisation (ADO).

Decision Maker is a tool that supports users throughout their decision-making activities. This includes problem formation, decision-analysis and result interpretation. Structuring a problem within *Decision Maker* allows users to evaluate their problem using qualitative and quantitative models. The process for developing these models in *Decision Maker*, as shown in Figure 1, inherently provides tractability and documentation of the problem structuring process that users have undertaken. This provides for an enhanced validation process when evaluating *Decision Maker*'s output.

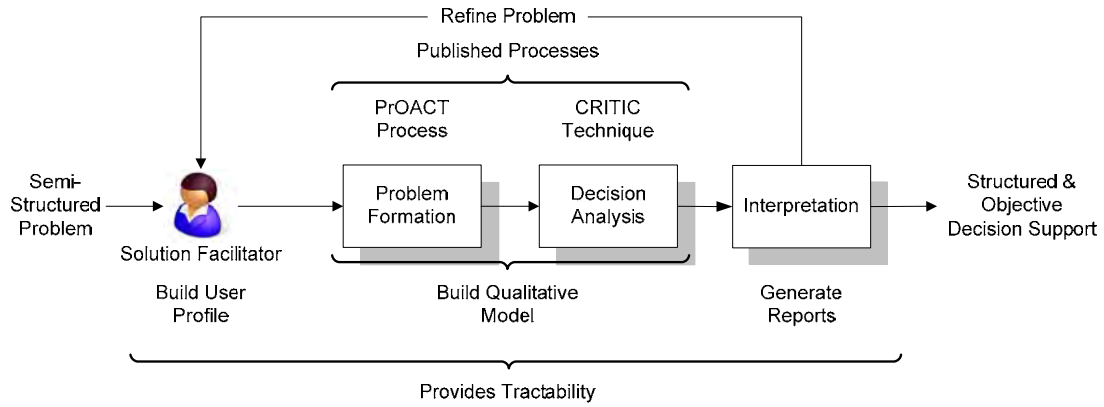


Figure 1. Overview of Decision Maker

Decision Maker is a software implementation of the Criteria Importance Through Intercriteria Correlation (CRITIC) objective decision-making technique [1]. This technique has a wide range of applications in all areas of the ADO, and other government and public organisations. It can be utilised in most multi-criteria decision-making problems that use a set of criteria/objectives to identify the most preferred alternative in a set of alternatives.

In most problems there are conflicting criteria/objectives and, therefore, complex trade-offs need to be made between the alternatives. *Decision Maker* can be used in these situations to support the selection process, for example in choosing a preferred product or service satisfying the requirements/criteria/objectives; or ranking the performance of systems/components/items using a combination of several performance measures.

The key features *Decision Maker* are:

1. the implementation of an objective decision-making technique;
2. the cardinal and ordinal ranking of alternatives;
3. the criteria/objectives do not have to be independent;
4. objective calculation of criteria/objectives weights;
5. the provision of a guide to structuring decision problems;

6. an easy to use Graphical User Interface (GUI);
7. a simulation module; and
8. advanced sensitivity analysis.

The *Decision Maker User Guide* will assist and inform users in the decision-making process. The *Decision Maker User Guide* will also assist users to structure their decision problems in the required format for *Decision Maker*. The outcome of using *Decision Maker* will enable users to make a 'better' decision. 'Better' in this context means a decision that has been thoroughly considered and explored. It does not mean that a better decision will necessarily be the right decision or a good decision. A right, or good, decision usually refers to the outcome of the decision and not the process that was used to make the decision.

This user guide is structured to help users install and run *Decision Maker* (Section 2); to help users structure their decision problem (Section 3); to give users a quick start in using *Decision Maker* (Section 4); and to enable users in structuring and analysing decision problems in *Decision Maker* (Sections 5 to 15). Known problems and faults with the software are presented in Appendix A.

2. Getting Started with Decision Maker

2.1 Installing Decision Maker

Decision Maker is installed from an installation Compact Disc (CD).

2.1.1 System Requirements

Mandatory requirement:

1. Microsoft *Windows XP* Operating System.

Minimum requirements:

1. Microsoft *Internet Explorer 5.01*;
2. Microsoft .NET Framework 2.0; and
3. Microsoft *SQL Server 2005 Express Edition*.

NOTE: Microsoft .NET Framework 2.0 is available as a free of charge update from Microsoft. If your system has an earlier version of the .NET framework, download the latest .NET framework from Mircosoft's website.

2.1.2 Installing Decision Maker from CD

1. Insert the *Decision Maker* installation CD into your computer.
2. Start the installation by double clicking ***setup.exe***.
3. Follow the on-screen instructions to install the *Decision Maker* software. If *SQL Server 2005 Express Edition* is not installed on the computer it will be installed first.
4. If you have a previous version of *Decision Maker* installed on your computer, the *Installation Wizard* will ask you whether to ***Repair*** or ***Remove*** your current version. If you want to install the current version from the CD, select ***Remove*** and continue following the *Installation Wizard*'s instructions.

2.2 Uninstalling Decision Maker

1. From the ***Start*** button on the Microsoft *Window*'s taskbar, open the ***Control Panel*** and select ***Add or Remove Programs***.
2. Within the ***Currently installed programs and updates*** list, find the *Decision Maker* application and select ***Remove***.
3. This process will uninstall the *Decision Maker* application from your computer but it will not remove any project files you have created.

2.3 Starting Decision Maker

1. Open the **DSTO** program folder from the **Programs | DSTO | Decision Maker II** menu within your taskbar **Start** button.
2. Alternatively, the *Decision Maker Installation Wizard* has placed an icon, as shown in Figure 2, on your desktop. Double-click the icon to start the application.

Figure 2. Decision Maker desktop icon

2.4 Exiting Decision Maker

1. Prior to exiting *Decision Maker*, ensure that you have saved your project by using the **File | Save** menu.
2. *Decision Maker* can be exited by using the **File | Exit** menu.

3. A Guide to Making Better Decisions

There are many processes and techniques that can be used to assist decision-makers [2, 3]. The PrOACT structured decision-making process, developed in [4], is recommended and used in this user guide to assist users in structuring their decision problems. The acronym, PrOACT, is named after the key elements within the structured decision-making process, i.e. **Pr**oblem, **O**bjectives, **A**lternatives, **C**onsequences, **T**rade-offs. In this context, *Decision Maker* is used throughout the PrOACT process to support problem structuring and is used in the Trade-offs step instead of the methods suggested in [4].

An overview of the PrOACT process is given in Figure 3. Other elements of the PrOACT process that may require consideration are: uncertainty; risk tolerance; and linked decisions. Tips and techniques to clarify the uncertainties; to consider the effect risk tolerance will have on the decision; and the implications of linked decisions are briefly considered as part of the Revise step in Figure 3. The choice of the acronym PrOACT is deliberate by the authors of [4] to remind us to be proactive and not wait until a decision is forced upon us (when we may not have time to consider all alternatives and consequences).

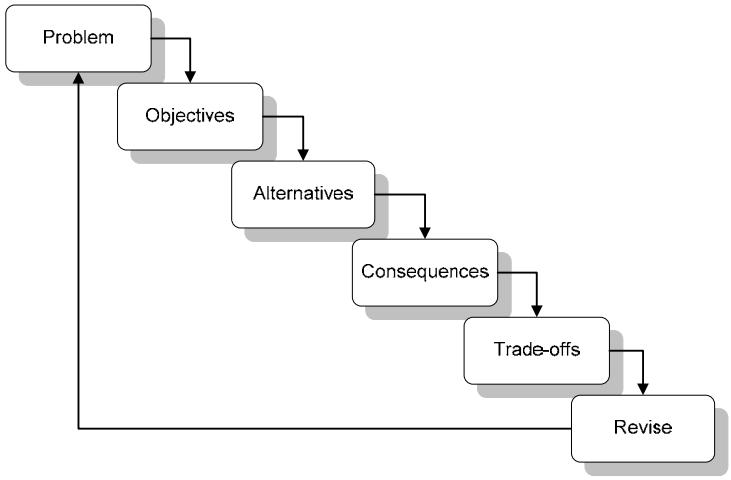


Figure 3. The PrOACT decision-making process

A structured approach, such as PrOACT, is recommended because it enables decision-makers to effectively communicate, clarify and consolidate/organise their decisions. However, a structured approach is not required for all decisions, especially those that are regarded as simple or present an obvious or clear choice. These types of decisions invariably do not involve complex trade-offs and, therefore, tools such as *Decision Maker* are not required.

Each step of the PrOACT process, in conjunction with a worked example, is described and discussed in the following subsections. These descriptions, with the exception of the worked example and the use of *Decision Maker*, are short summaries of the key points made in [1].

Decision Maker is a software implementation of the CRITIC decision-analysis technique [1]. CRITIC is an **objective** decision-analysis technique and, therefore, does not require the decision-maker's preferences. The underlying principle in objective decision-analysis techniques is that 'attributes can be viewed as information sources, and that weights of importance reflect the amount of information contained in each of them' [1].

Weights are derived using the CRITIC technique and incorporates both the contrast intensity within each criterion/objective and the conflict between the criteria/objectives. These weights are then used to combine the criteria/objectives into a single cardinal ranking of the alternatives [1]. An important feature of the CRITIC technique is that the criteria/objectives do not have to be independent.

Note the word 'criteria' used in the description of *Decision Maker* can be used interchangeably with the word 'objective'. Criteria is a more general term, including 'all those attributes, objectives and goals which have been judged relevant in a given decision situation by a particular decision-maker (individual or group)' [1]. *Decision Maker* uses criteria to measure the performance of each objective. Therefore, each objective must have at least one criterion to complete the decision-analysis and obtain a result.

3.1 Problem

It is important to start the decision-making process with the 'right' problem. Whilst it might be convenient and/or expedient to skip this step, it is unwise since this step forms the basis for all the other steps in the decision-making process. It is important to think creatively and look at how the problem could be turned into an opportunity. Do not constrain your problem definition by including possible alternatives at this stage, since this could prevent consideration of other alternatives that may not be as visible.

It may take time to define your problem, and it is advisable to re-examine your problem definition as you work through the remaining steps. Time spent here may prevent undesirable delays and consequences later.

The following example will be used to demonstrate each of the steps in the PrOACT decision-making process, as shown in Figure 3. You may choose to follow this example or substitute your own decision problem as you work through the steps.

EXAMPLE: Supply Manager's Dilemma
PrOACT STAGE: Problem Definition

The Supply Manager is in the process of reviewing the existing contracts that supply Type A and Type B spare parts to his firm. These contracts are about to expire and he needs to consider whether he should renew the existing contracts or not. Currently, Widget Inc. has the contract to supply Type A spare parts and Gadget Inc. has the contract to supply Type B spare parts to his firm.

Both companies have the ability to supply Type A and B spare parts, however they did not have this ability when the contracts (which are about to expire) were originally signed. The Supply Manager is considering his options and has defined his problem as 'Keep the current arrangement or amalgamate both contracts into a single contract to supply both Type A and B spare parts and offer it to Widget Inc. and Gadget Inc. and then choose the best proposal'.

The trigger for this decision problem is that the existing contracts are about to expire. However, the Supply Manager has already limited his problem by including possible suppliers in his problem definition. There may be other companies that could supply the spare parts.

A better problem definition (that would keep his options open) is: 'What is the best arrangement for the supply of Type A and B spare parts, and who can provide them?' The key word in this definition is 'best'. By considering our objectives in the next step, we will be able to define 'best' for this example.

3.2 Objectives

Let objectives be your guide [4]. They help to determine the information required and assist you to explain your choices to others. Objectives become the decision criteria and it is therefore important to spend time considering and defining your objectives. Some of the ways that may help to identify your objectives include [4]:

1. making a wish list;
2. deciding what you want to avoid; and
3. brain storming.

When you have a list of concerns and wishes, asking why they are on the list and whether they capture your interest will also help to further refine and add to your list. The list of concerns and wishes need to be converted into succinct objectives, such as a short phrase consisting of a verb and an object [4]. For example: 'minimise cost'; 'maximise profit'; and 'maximise safety'.

EXAMPLE CONTINUED: Supply Manager's Dilemma
PrOACT STAGE: Defining Objectives

It is time for the Supply Manager to consider what he means by 'best' in his problem definition.

His wishes are:

1. *low cost;*
2. *fast supply time for each part request;*
3. *minimum amount of administration and paperwork managing the contract; and*
4. *good quality of parts, note that these are non-repairable (consumable) spares.*

His concern is:

1. *slow supply time.*

These wishes and the concern are then converted into the following objectives:

1. *minimise the total cost; and*
2. *maximise the performance of the spares, defined by:*
    a. *maximise the Reliability; and*
    b. *minimise the Supply Time.*

The structure of the problem is shown in Figure 4.

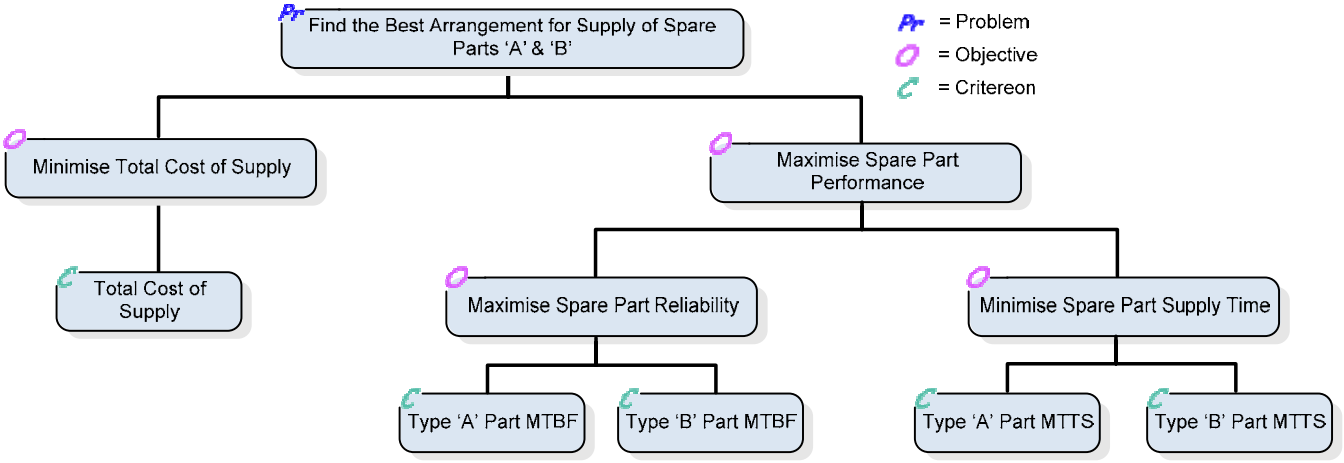


Figure 4. The structure of the Supply Manager's Dilemma, where MTTS is the Mean Time To Supply; and MTBF is the Mean Time Between Failure

3.3 Alternatives

The aim of this step is to generate many possible alternative solutions to the problem, while not limiting the range of alternatives that could be considered. Do not evaluate or eliminate any alternatives during this step. This will occur later. Some suggestions [4] for generating alternatives include:

1. using your objectives and asking how they might be achieved;
2. being creative and thinking outside the square;
3. challenging the constraints; and
4. setting high aspirations.

EXAMPLE CONTINUED: Supply Manager's Dilemma
PrOACT STAGE: Generating Alternatives

The Supply Manager is ready to generate some alternatives. He starts his list of possibilities with the types of contracts that are available:

1. *separate contracts for the supply of each type of spare part; or*
2. *a combined contract to supply both Type A and B spare parts.*

He has two companies in mind: Widget Inc. and Gadget Inc. However, after talking to some of his colleagues and telephoning a few different companies, he is able to add two more companies to his list: Gismo Inc. and Turtle Supplies Inc. All four companies can supply Type A and Type B spare parts.

The Supply Manager now has 16 possible alternatives: a combined contract for each company; or separate contracts with two companies either supplying Type A or Type B spare parts.

3.4 Consequences

In this step the benefits of each of the competing alternatives are considered by assessing how well they fulfil the objectives of your problem. To do this, appropriate attributes, scales or measures are needed for each objective. These may include:

1. costs (such as, operating costs and expected profit/loss);
2. measures of performance (such as failure rate and fuel efficiency); and
3. characteristics of the objectives.

The inclusion of accurate and appropriate data will enable you to make better choices. If the attributes, scales or measures you wish to use are descriptive in nature, such as those you might use to describe comfort or colour, then you will either need to convert them to numbers or use an alternative decision-making technique [2, 3, and 4] in the Trade-offs step (Section 3.5).

Note: *Decision Maker* uses a mathematical process to determine the ranking of alternatives, hence numerical measures are required.

When you have determined how you will measure each objective, it is then time to collect the data and organise it in a consequence table. Using a spreadsheet, build a table with the alternatives list on the left hand side and the objectives along the top. Note this differs from the consequence table described in [4], where the alternatives are along the top and the objectives down the left hand side. The consequence table presented in this user guide is to facilitate the use of *Decision Maker* in the Trade-offs step. An example of the consequence table is shown in Table 1.

Note: *Decision Maker* provides the tools to structure decision problems and provides the user with a consequence table for data entry.

EXAMPLE CONTINUED: Supply Manager's Dilemma
PrOACT STAGE: Evaluating Consequences

The Supply Manager's objectives were to:

1. *minimise the total cost; and*
2. *maximise the performance of the spares, defined by:*
    a. *maximise the Reliability;*
    b. *minimise the Supply Time.*

He now needs to determine how he might measure each of these objectives. He decides that the expected number of days per month spent on administration of the contracts and the total cost of the contract (or contracts) are appropriate measures for the first two objectives, respectively. For the remaining two objectives, he decides to utilise the 95% confidence intervals for the Mean Time Between Failures (MTBF) and the Mean Time To Supply (MTTS), respectively. The resulting measures for each of these objectives are the lower limit of the 95% confidence interval for the MTBF, and the upper limit of the 95% confidence interval for MTTS.

Both measures use the less desirable outcome as a way of determining how well each alternative performs against the objectives. The Supply Manager then asks each company to provide the relevant data and, subsequently, constructs the consequence table shown in Table 1.

Table 1. Consequence table for the Supply Manager's Dilemma

Problem Alternatives				**Problem Objectives & Criteria**				
Alternative ID	Contract Type	Potential Companies		Minimise Total Cost ($)	Maximise Reliability		Minimise Supply Time	
		Type 'A'	Type 'B'		Type 'A' MTBF[1] (Hrs)	Type 'B' MTBF[1] (Hrs)	Type 'A' MTTS[2] (Days)	Type 'B' MTTS[2] (Days)
Supplier 1	Combined	Widget	Widget	70,000	7,300	7,200	8	8
Supplier 2	Combined	Gadget	Gadget	60,000	6,600	9,100	7	7
Supplier 3	Combined	Gismo	Gismo	55,000	6,200	6,600	8	8
Supplier 4	Combined	Turtle	Turtle	75,000	6,100	6,800	9	9
Supplier 5	Separate	Widget	Gadget	71,500	7,300	9,100	8	7
Supplier 6	Separate	Widget	Gismo	68,750	7,300	6,600	8	8
Supplier 7	Separate	Widget	Turtle	79,750	7,300	6,800	8	9
Supplier 8	Separate	Gadget	Widget	71,500	6,600	7,200	7	8
Supplier 9	Separate	Gadget	Gismo	63,250	6,600	6,600	7	8
Supplier 10	Separate	Gadget	Turtle	74,250	6,600	6,800	7	9
Supplier 11	Separate	Gismo	Widget	68,750	6,200	7,200	8	8
Supplier 12	Separate	Gismo	Gadget	63,250	6,200	9,100	8	7
Supplier 13	Separate	Gismo	Turtle	71,500	6,200	6,800	8	9
Supplier 14	Separate	Turtle	Widget	79,750	6,100	7,200	9	8
Supplier 15	Separate	Turtle	Gadget	74,250	6,100	9,100	9	7
Supplier 16	Separate	Turtle	Gismo	71,500	6,100	6,600	9	8

3.5 Trade-offs

In this step, enter the contents of the *Alternative ID* column (or define unique descriptors of your choosing) and the objectives and criteria columns of the consequence table (Table 1)

[1] Here, MTBF is the lower limit of the 95% confidence interval of the MTBF.
[2] Here, MTTS is the upper limit of the 95% confidence interval of the MTTS.

into *Decision Maker*. When complete, click the ***Calculate*** button. *Decision Maker* will give a cardinal[3] and ordinal ranking to all the alternatives.

EXAMPLE CONTINUED: Supply Manager's Dilemma
PrOACT STAGE: Trading-off the Alternatives

The Supply Manager now enters the relevant parts of his consequence table into Decision Maker.

Open the file named ***Supply Mangers Dilemma.xml*** *to see the Supply Manager's table shown in Table 1. Now click the* ***Calculate*** *button and the result will appear as shown in Figure 5.*

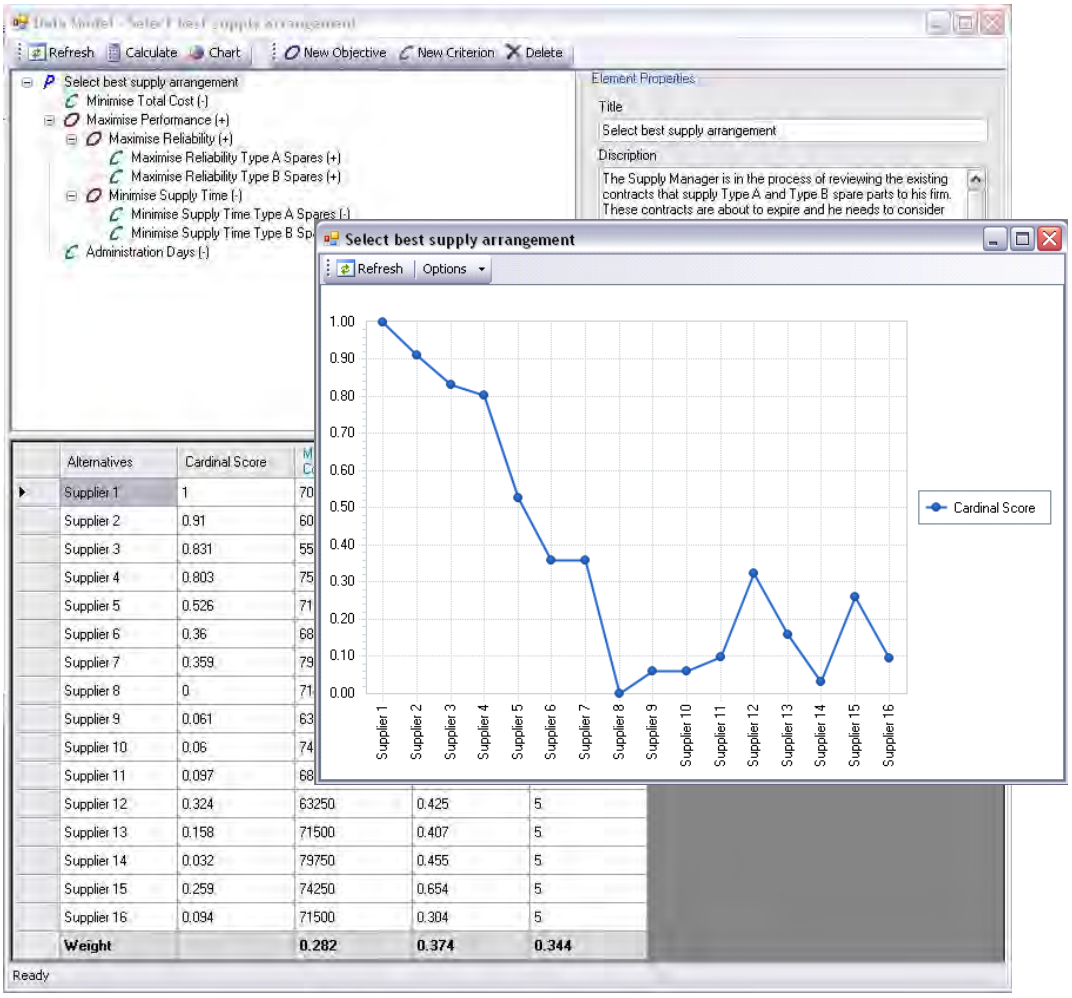


Figure 5. Decision Maker's data model for the Supply Manager's Dilemma

Note if the scales or measures you chose for your consequences are descriptive in nature, then you will need to convert them to numbers. Use the 'Even Swap' method given in [4] or use an alternative decision-making technique [2, 3].

[3] Note, outputs from multi-criteria decision-making techniques can be categorised as either cardinal or ordinal. An ordinal ranking only provides an order ranking of the alternatives. A cardinal ranking gives the order ranking and how much the alternatives differ (e.g. alternative A is preferred twice as much as alternative B).

3.6 Revise

The Revise step has been included as a separate step to remind users that at any stage of the decision-making process, as presented in this user guide (see Figure 3), you need to check, recap, and reconsider your problem definition, objectives, alternatives and consequences.

If you are not satisfied with the preferred choice and ranking as a result of using *Decision Maker*, then you need to reconsider whether you have captured your decision problem adequately. The omission of an important objective can lead to an unsatisfactory result. Other factors to include and consider are: uncertainties in the consequences; the level of risk you are willing to accept; and whether the decision is linked to others.

A full explanation of these factors and suggestions on how to include them in your decision problem are given in [4].

EXAMPLE CONTINUED: Supply Manager's Dilemma
PrOACT STAGE: Revise your decision problem.
The Supply Manager is reasonably satisfied with the ranking presented in Figure 5 but wonders whether he should have 'minimise administration/paperwork' as an objective, given that the monetary savings could more than compensate for the additional two days of administration/paperwork for the separate contracts.

He considers employing a temporary staff member to do the additional two days of administration for the separate contracts. The cost of a temporary staff member is $300 per day and, so, he adds $600 to the total cost of the separate contracts. He deletes the administration column in his consequence table and clicks the **Calculate** *button. Figure 6 shows the result.*

4. Quick Start using the Decision Maker Wizard

The example in this section makes use of the hypothetical *Supply Manager's Dilemma* that was introduced in Section 3. The following subsections present a step-by-step example on how to structure and analyse your decision problem in *Decision Maker*.

The scenario assumes the Supply Manager has not previously used *Decision Maker* but does have an understanding of the problem's structure from using the PrOACT process discussed in Section 3. This includes the identification of the problem's objectives and criteria. It is assumed the Supply Manager has identified the problem's objectives, criteria and alternatives and has access to relevant data for each criterion from the possible suppliers.

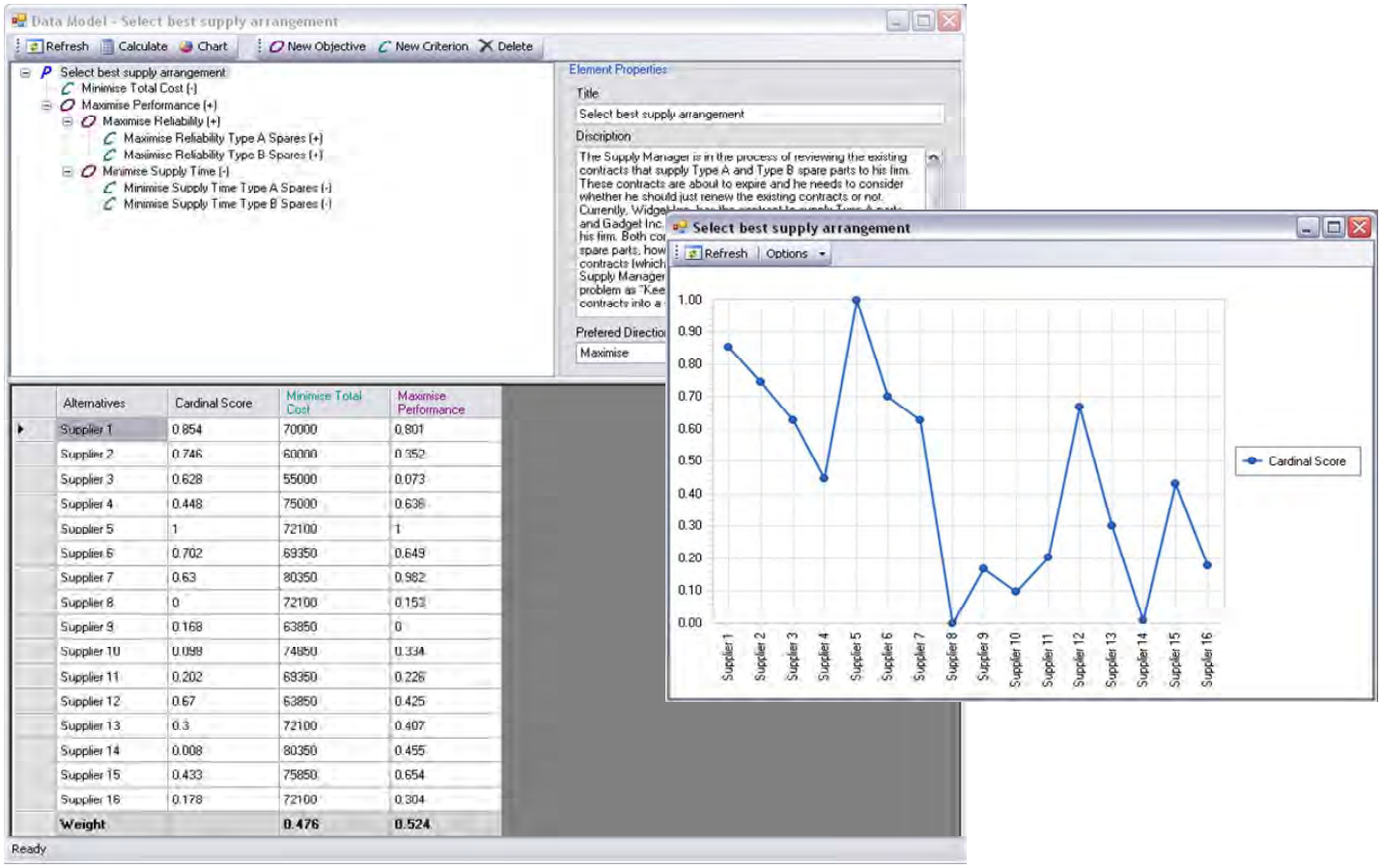


Figure 6. Decision Maker's revised data model for the Supply Manager's Dilemma

Figure 4 presented the structure and data that will be used in this example. Also, it is assumed that *Decision Maker* is installed and ready for operation.

4.1 Using Decision Maker and the Wizard

Now that the Supply Manager has an understanding of the PrOACT decision-making process, from reading Section 3, he has an initial (and possibly incomplete) list of objectives, alternatives and criteria. The Supply Manager is now ready to use *Decision Maker* to analyse the supplier selection problem.

The Supply Manager has chosen to use *Decision Maker*'s Wizard to expedite the initial problem structuring process. The steps the Supply Manager must perform to complete the decision-making activities using *Decision Maker* are:

1. create a new project using the Wizard;
2. create the problem's structural elements using the Wizard;
3. assign data to each of the problems criteria;
4. calculate the scores for each alternative in the problem;
5. chart the results of the decision-analysis process; and
6. revise and amend the problem's structure.

4.2 Using the Wizard

Decision Maker's Wizard is a tool that will guide you through the process of structuring your decision problem in *Decision Maker*, as shown in Figure 7. The Wizard is best used when you know the PrOACT elements to your problem and you want to quickly structure the problem in *Decision Maker* for further analysis.

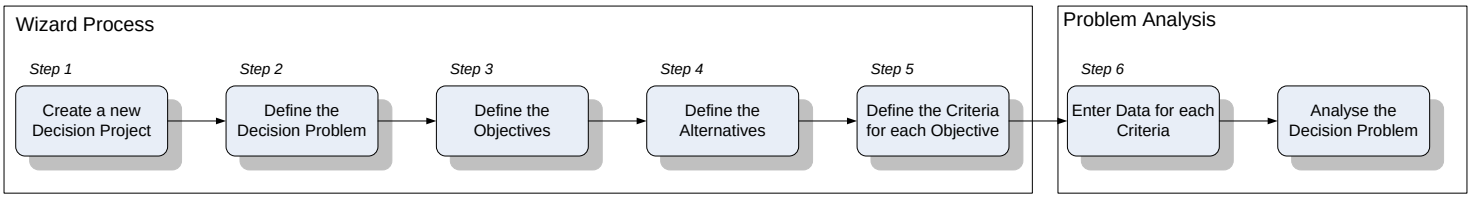


Figure 7. The Decision Maker Wizard problem structuring process

The Wizard is only accessible when all projects are closed. To begin using the Wizard, close any open project. To do this, select the **File | Close** menu option, as shown in Figure 8. A prompt will then appear on the screen asking if you wish to save the current project. At this point take the appropriate action to save the project or to close without saving. Then, run the Wizard by selecting the **File | New | Run Wizard** menu as shown in Figure 9.

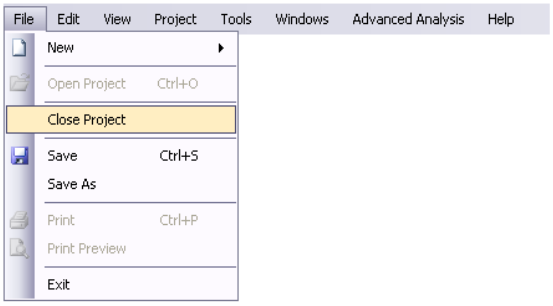


Figure 8. Closing a project

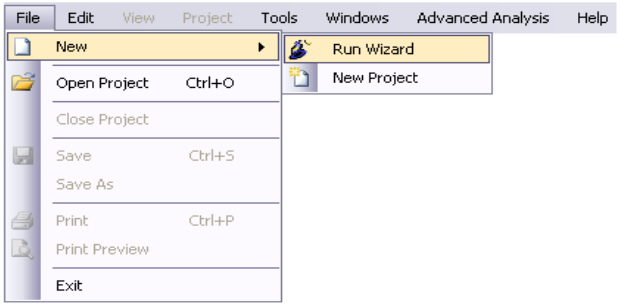


Figure 9. Running the Decision Maker Wizard

The Wizard's navigation dialog box, as shown in Figure 10, will guide you through the steps for structuring your decision problem. Each step creates a different set of structural element types (Section 5.3). Upon completion, your problem will be structured and ready for data and analysis.

The Wizard can only be run when all projects are closed.

4.2.1 Step 1: Create a new Decision Project

The first step in structuring your problem in *Decision Maker* is to create a Project to contain your decision problem. Therefore, in the first step, the Wizard requests you to enter a title and description for your project. You must save your project before continuing. Refer to Section 5.2.2 for an overview of the dialog box the Wizard presents for creating a new project.

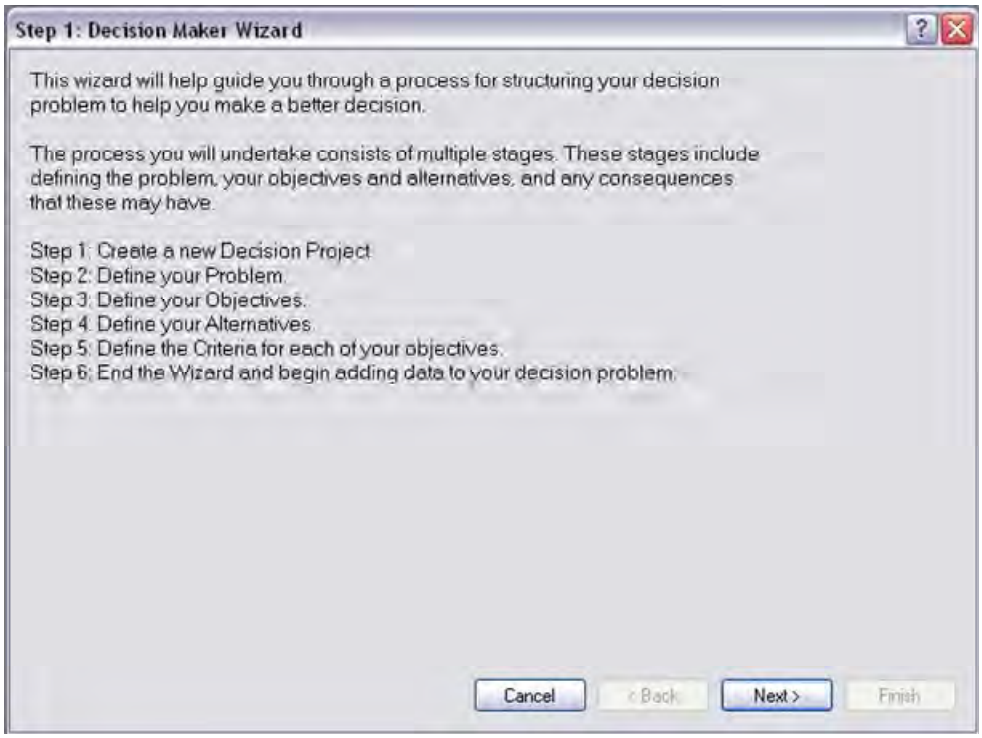


Figure 10. The Decision Maker Wizard navigation dialog box

4.2.2 Step 2: Define your Problem

The second step requires you to define your decision problem (see Section 3.1). This is achieved by creating a *Problem* element. You must create a *Problem* element before the Wizard will allow you to continue to the next step. Defining your problem is simple and only requires a short title for your problem, a description and a direction of preference.

Section 5.3.1 gives an overview of the dialog box the Wizard presents to you for creating a *Problem* element. Section 5.3.1 also provides an example to help understand and choose the direction of preference.

4.2.3 Step 3: Define your Objectives

The third step requires you to define your objectives (see Section 3.2). This is achieved by creating an *Objective* element for each objective you have in your decision problem. The Wizard will ask you to ***Please enter the number of Objectives you know of***. If you do not know your objectives at this stage, let the Wizard know by entering zero (0) in the appropriate field, otherwise enter the number of objectives.

When you have entered the number of objectives for your decision problem, the Wizard will request you to create an *Objective* element for each objective. This requires you to enter a short title, a description and a direction of preference for each objective.

Refer to Section 5.3.2 for an overview of the dialog box the Wizard presents to you to create each *Objective* element. Section 5.3.2 also presents an example to assist in choosing a direction of preference.

When creating each Objective element, you can specify if the objective is a sub-objective of another. Do this by setting the ***Sub-Objective Of*** *field in the element's creation dialog box. By default, each new Objective element is set as a sub-objective of your Problem element.*

4.2.4 Step 4: Define your Alternatives

The fourth step requires you to define all the possible alternative solutions to your decision problem (see Section 3.3). This is done by creating an *Alternative* element for each alternative in your problem.

You must have a minimum of two (2) alternatives in your problem. Do not limit the number of alternatives that could be considered. Also, let *Decision Maker* support you by ranking your alternatives based on your criteria, at which stage you can then select amongst the best alternatives for your decision problem.

Refer to Section 5.3.3 for an overview of the dialog box the Wizard presents to you to create each alternative element.

Each alternative element in your decision problem must be unique and you must have at least two alternatives in your decision problem.

4.2.5 Step 5: Define the Criteria for each of your objectives

The fifth step in the Wizard is the final step required before your problem is structured and ready for data entry and analysis. This step requires you to define the criteria that you will use to measure the performance of each objective in your decision problem (see Section 3.4). This is done by creating a *Criterion* element for each quantifiable attribute belonging to each objective in your decision problem.

Each objective in your problem (including the problem itself) can have as many *Criterion* elements as needed. The greater the number of *Criterion* elements, the greater the resolution of your decision-analysis and *Decision Maker*'s output. This is a difficult stage since it requires you to specify the quantifiable attributes that define each of your objectives. Refer to Section 3.4 for more support on this stage.

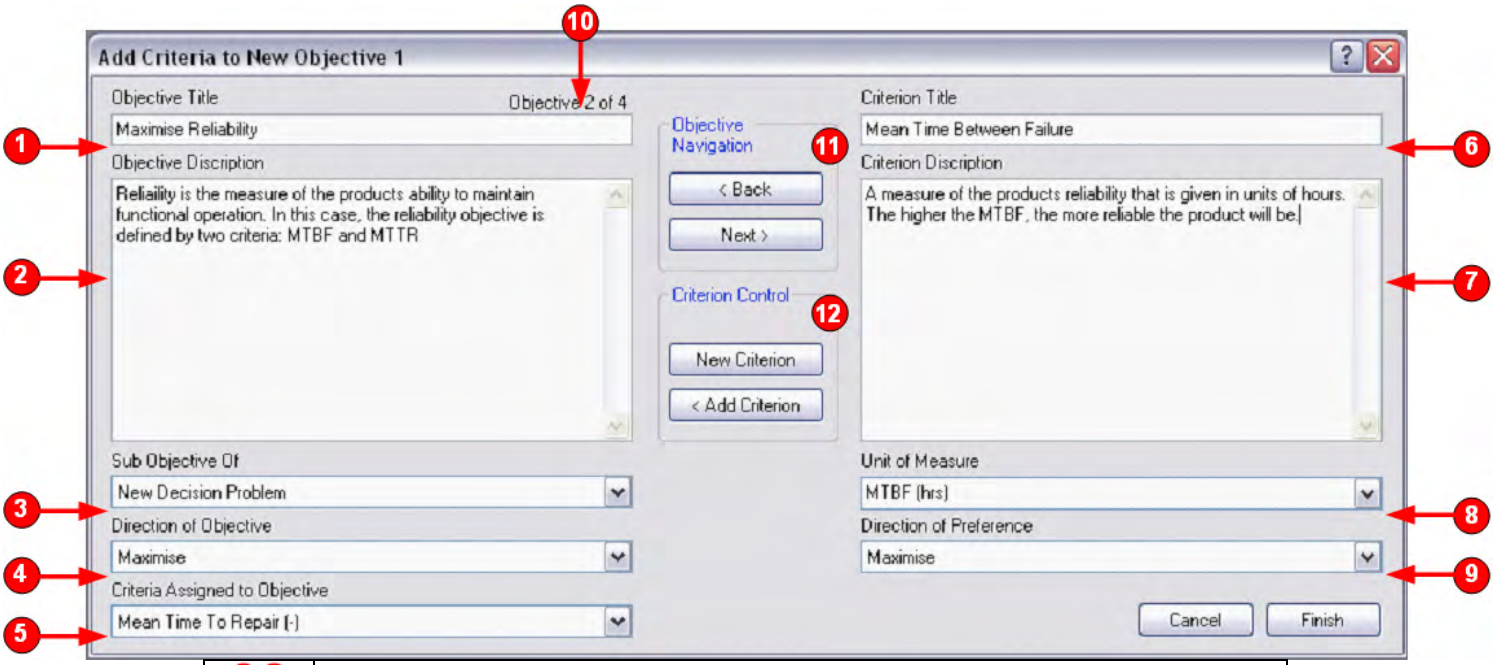
The dialog box used to create *Criterion* elements in the Wizard is shown in Figure 11. This dialog box incorporates the same fields as the *Objective* and *Criterion* element dialog boxes (as presented in Sections 5.3.2 for the *Objective* element). In addition, buttons are provided to navigate between the objectives created in Step 3 of the Wizard, and also for the creation of the *Criterion* elements.

You can have as many Criterion elements as you desire in your decision problem. The greater the number of criteria, the greater the resolution of Decision Maker's output.

You may edit the properties of the currently selected objective at any time in the dialog box, and the changes will be added to your project automatically.

4.2.6 Step 6: Adding data to your decision problem

When the problem has been defined, by following Steps 1 through 5, it is then possible to add data to each of the criteria. This is described in Section 4.3.



1 2 3 4	Refer to the *Problem* and *Objective* elements in Sections 5.3.1 and 5.3.2.
5	***Criteria Assigned to Objective*:** This field lists the Criteria that have been assigned to the currently selected objective. You can use this field to verify that the criterion you have just created has been added to the objective.
6 7 8 9	Refer to the *Criterion* element in Section 5.3.4.
10	Displays the numerical index of the currently selected *Objective* element.
11	***Objective Navigation*:** The **Back** and **Next** buttons enable you to navigate to your desired objective so that you may then add its criteria.
12	***Criterion Control*:** The **New Criterion** button creates a new *Criterion* element so you can edit and add to the *Objective* element (as indicated by 1) by using the **Add Criterion** button.

Figure 11. Adding criteria to your decision problem using the Wizard

4.2.7 Create a New Project Using the Wizard

Run the *Decision Maker* Wizard as shown in Figure 9. Running the Wizard from the **File** menu will open the Wizard's navigation dialog box shown in Figure 10. In the first step, you are required to create a project for your problem. When you click the **Next** button on the Wizard, you will be presented with a **New Project** dialog box (Section 5.2.2). Enter the

information presented in Table 2 into the ***New Project*** dialog box. The completed ***New Project*** dialog box should appear like that shown in Figure 12.

Table 2. Wizard example - project information

Field	Text
Project Title	`Acquisition Contract Renewal Project`
Project Description	`This project has been created to demonstrate that an organisation or department can use Decision Maker to support multiple decision-making activities for any one project or task.`

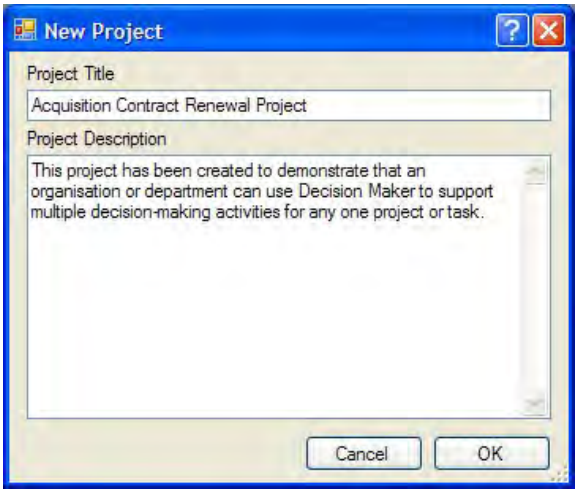


Figure 12. Wizard example – Defining a new project

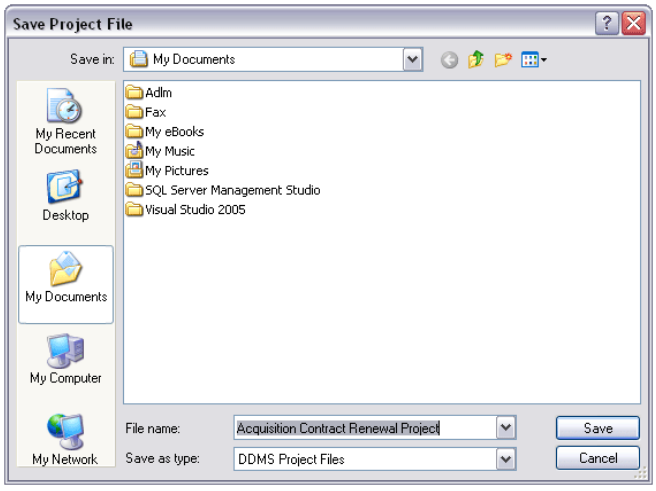


Figure 13. Wizard example – Saving a project

When you have defined your project, click ***OK*** in the ***New Project*** dialog box and the Wizard will then ask to save your project, as shown in Figure 13. Give the project a name and click on ***Save***.

The *Decision Maker* Wizard will now guide you through defining the problem elements using the PrOACT process discussed in Section 3. This process requires you to define your problem; define your objectives and alternatives; and finally the consequences (defined using decision criteria). The Trade-offs occur when the Wizard has structured your problem and you have assigned data to the criteria.

Navigate through the Wizard using the ***Next*** and ***Back*** buttons. The following subsections will guide you through providing the information required at each step. Images of the completed dialog boxes are also presented. The example used is the *Supply Manager's Dilemma*.

4.2.8 Problem Definition

After creating and saving the new project, the dialog box shown in Figure 14 will appear. Click ***Next*** and the dialog box will then present advice for defining the problem, as shown in Figure 15. Clicking the ***Next*** button again will open the ***New Decision Problem*** dialog box, shown in Figure 16.

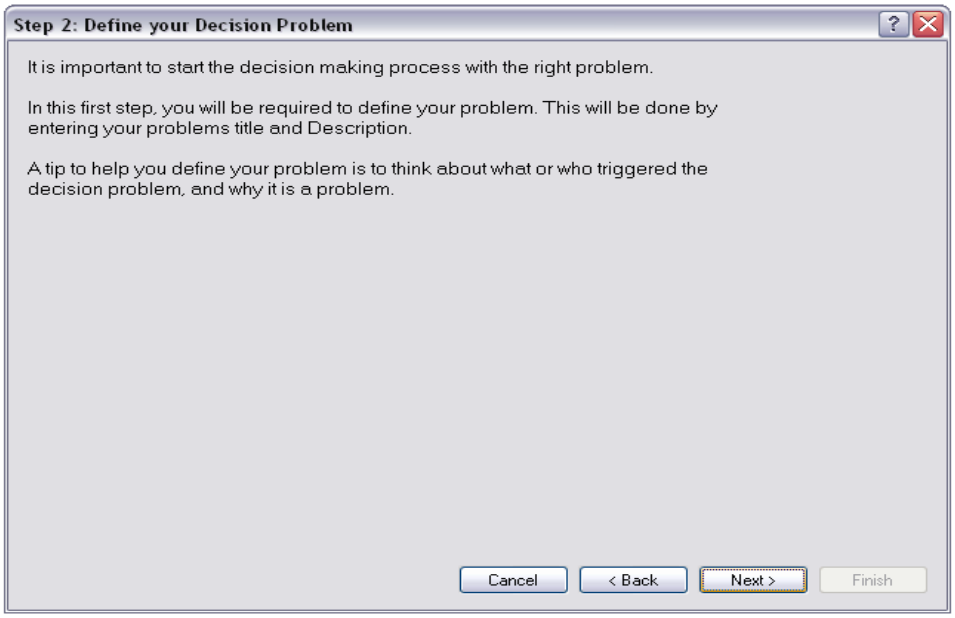


Figure 14. Wizard example – Step 2: Define your Decision Problem

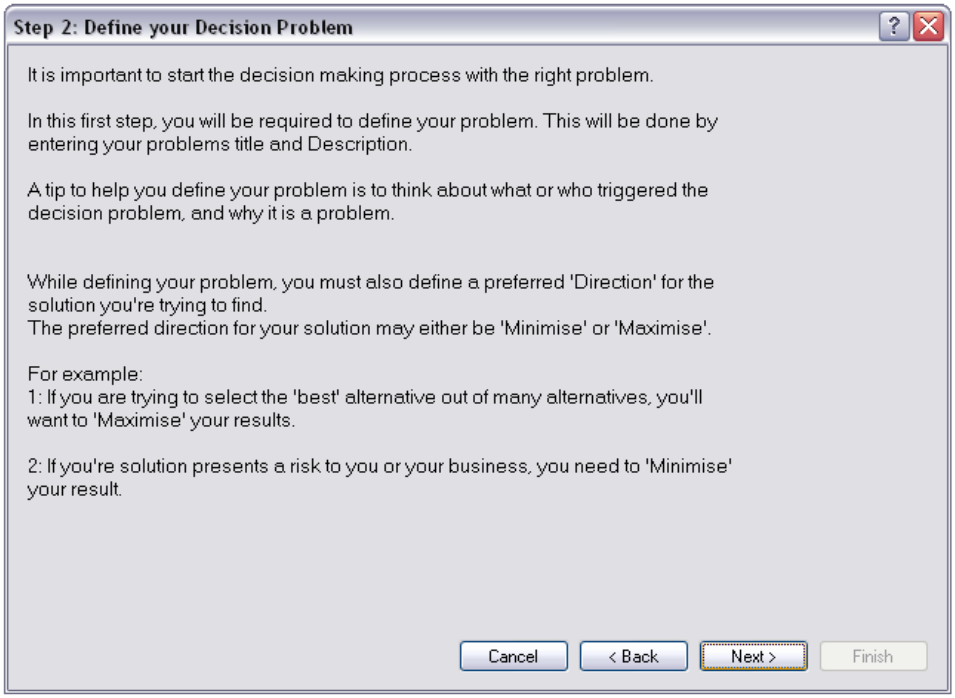


Figure 15. Wizard example – Step 2: Define your Decision Problem (continued)

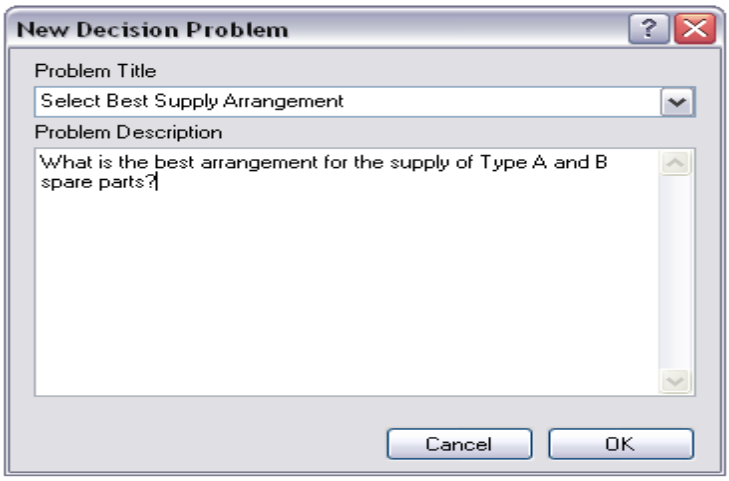


Figure 16. Wizard example – New Decision Problem

Using the information presented in Table 3, complete the fields in the ***New Decision Problem*** dialog box so that it appears as shown in Figure 16.

Table 3. Wizard example - problem information

Field	Text
Problem Title	`Select Best Supply Arrangement`
Problem Description	`What is the best arrangement for the supply of Type A and B spare parts?`

When your problem has been defined, click the ***OK*** button in the ***New Decision Problem*** dialog box. The Wizard then requests that you define the objectives, as shown in Figure 17.

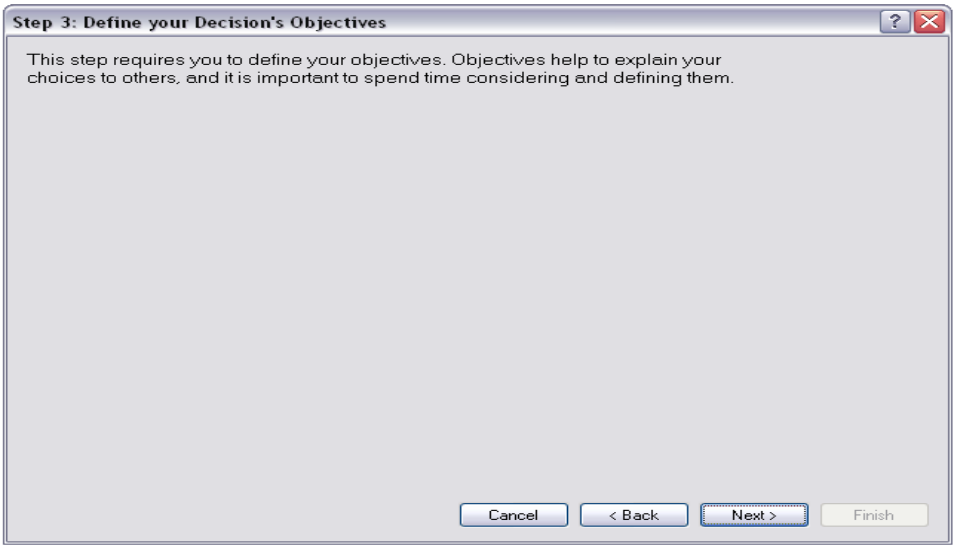


Figure 17. Wizard example – Step 3: Define your Decision's Objectives

4.2.9 Objective Definition

The Wizard will request you to enter the number of objectives for your decision problem. The Supply Manager defined an initial list of three objectives to be used in support of selecting the best arrangement for the Type 'A' and 'B' spare parts (Section 3.2). The objectives were to:

1. minimise the total cost (this will be treated as a criteria); and
2. maximise the performance of the spare parts, defined by:
   a. maximise the reliability of the spare parts; and
   b. minimise the supply time of the spare parts.

Note that the second objective is decomposed into two sub-objectives. The two sub-objectives are used to evaluate the overall performance objective for the spare parts.

Click the ***Next*** button until the dialog box shown in Figure 18 is displayed. Change the ***Number of Objectives*** to ***3***. When the number of objectives has been changed, click ***Next*** until the dialog box shown in Figure 19 is displayed. Tables 4, 5 and 6 present the information required for the three objectives. Enter the information presented in Table 4 into the ***Define Objective Number 1*** dialog box. The completed dialog box should appear as shown in Figure 19. When the information is entered, click the ***OK*** button.

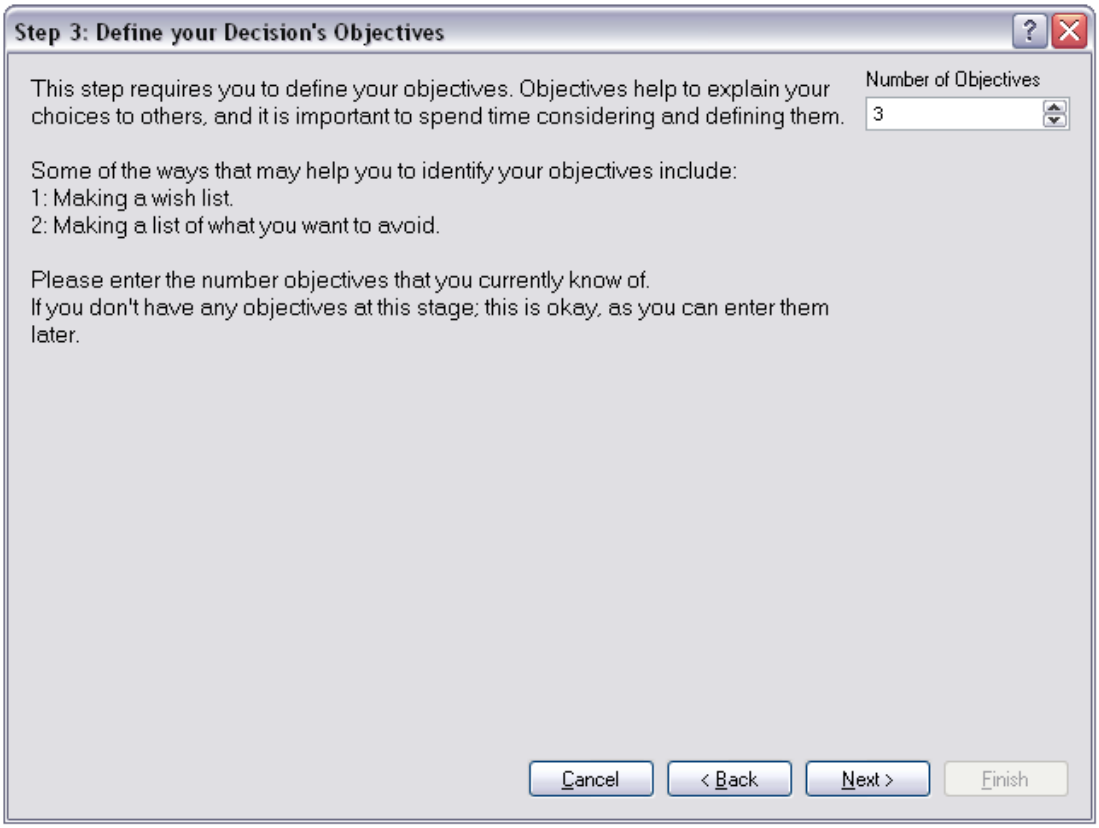


Figure 18. Wizard example - Step 3: Define your Decision's Objectives (continued)

Table 4. Wizard Example - Objective 1 information

Field	Text
Objective Title	`Maximise Performance`
Objective Description	`The best spare part supply arrangement shall be able to supply the parts with the highest performance in reliability and supply time.`
Sub Objective Of	`Select Best Supply Arrangement`

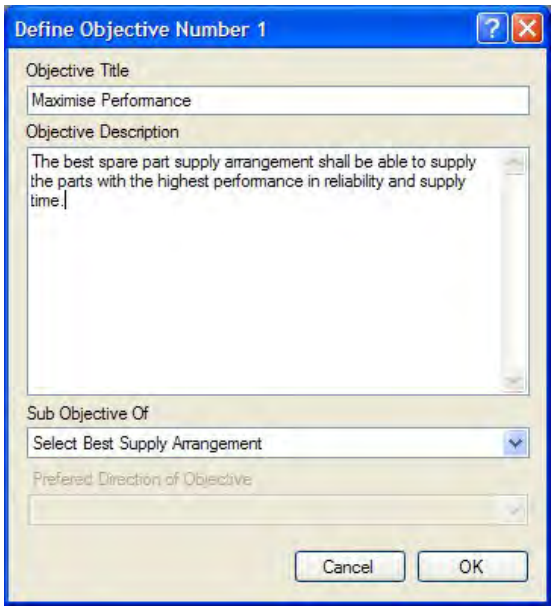


Figure 19. Wizard example - Define Objective Number 1

Next, for Objective 2, enter the information presented in Table 5 into the ***Define Objective Number 2*** dialog box. The completed dialog box should appear as shown in Figure 20. When the information is entered, click the ***OK*** button.

Finally, for Objective 3, enter the information presented in Table 6 into the ***Define Objective Number 3*** dialog box. The completed dialog box should appear as shown in Figure 21. When the information is entered, click the ***OK*** button.

Table 5. Wizard example - Objective 2 information

Field	Text
Objective Title	`Maximise Reliability`
Objective Description	`The best spare part supply arrangement shall be able to supply the parts with the highest reliability.`
Sub Objective Of	`0.1 Maximise Performance`

Table 6. Wizard Example - Objective 3 information

Field	Text
Objective Title	`Minimise Supply Time`
Objective Description	`The best spare part supply arrangement shall have a short supply time.`
Sub Objective Of	`0.1 Maximise Performance`

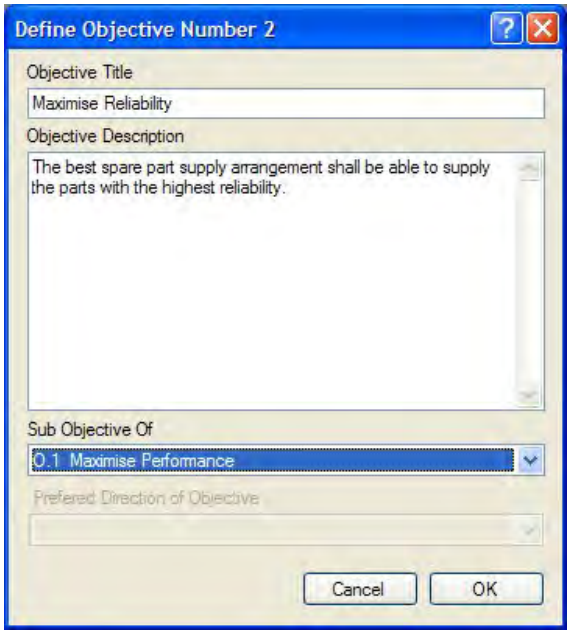


Figure 20. Wizard Example - Define Objective Number 2

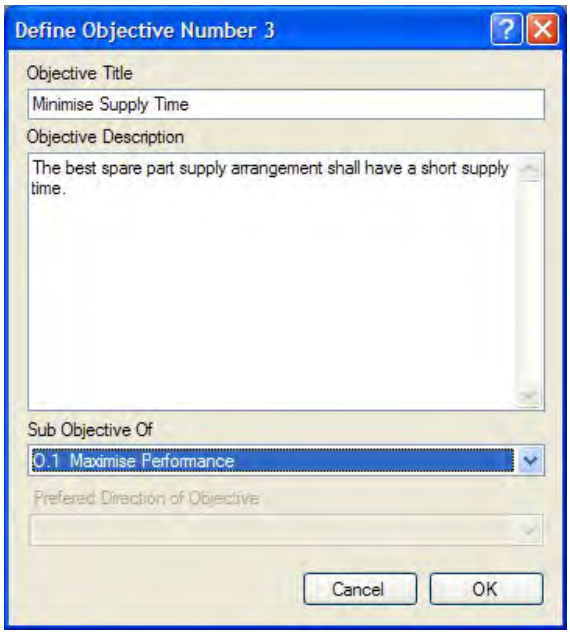


Figure 21. Wizard example - Define Objective Number 3

4.2.10 Alternative Definition

In the alternative definition stage, you are required to enter the number of alternatives you currently have for your decision problem. The Supply Manager had defined an initial list of 16 possible alternative arrangements for the supply of *Type A* and *Type B* spare parts (Section 3.3). For this example, use the data given in Table 1.

Note that the Wizard is not the best method for entering a large number of alternatives for a problem. If you do wish to enter a large number of alternatives, set the number of

alternatives to zero (0) and when the decision structure is complete (using the Wizard), the alternatives can be added using the ***Import Alternatives from File*** facility (Section 15). For this example, each alternative will be manually created.

Click ***Next*** until the dialog box shown in Figure 22 is visible. Enter the number of alternatives (i.e. 16) in the ***Number of Alternatives*** field. Click ***Next*** twice, reading the *Decision Maker* Wizard dialog boxes as you proceed. The ***Define Alternative Number 1*** dialog box should now be open, as shown in Figure 23. Change the ***Alternative Title*** to ***Supplier 1***, as shown in Figure 24. For this example, a description will not be used; however it is worth noting that one can be added at this stage. When the alternative title has been entered, click the ***Ok*** button.

Now, repeat the process for the 16 alternatives, entering ***Supplier 2*** through to ***Supplier 16*** in the ***Alternative Title*** field for each of the 16 alternatives.

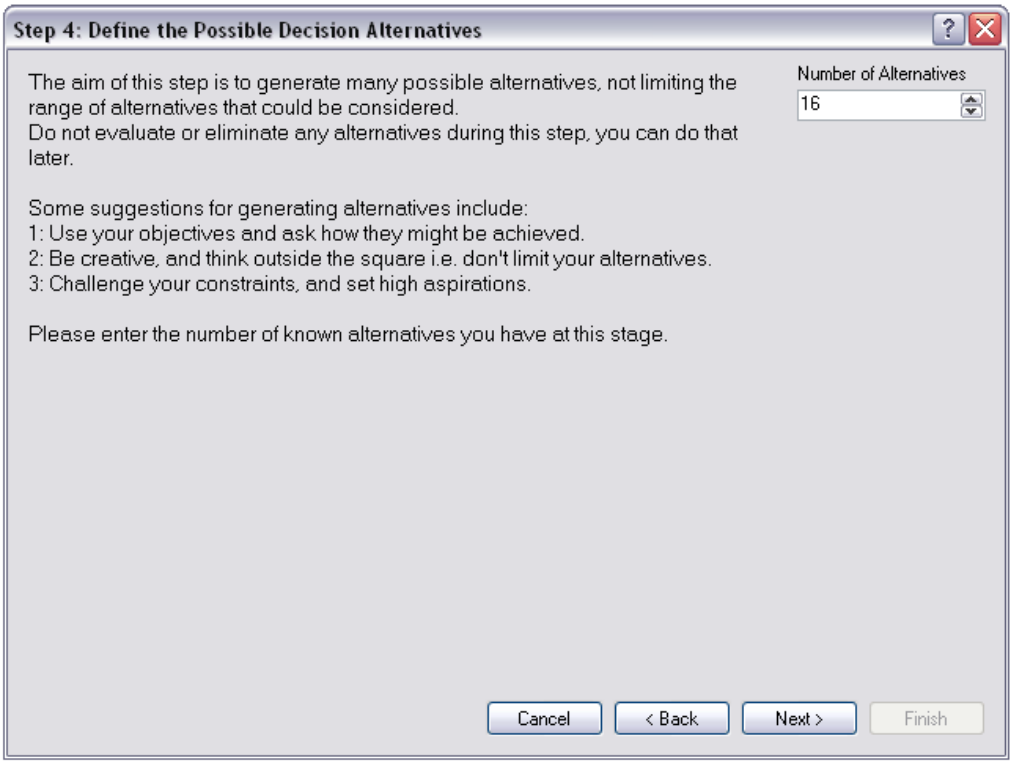


Figure 22. Wizard example - Step 4: Define the Possible Decision Alternatives

4.2.11 Consequence Definition

In this final stage of using the Wizard, you will be required to define and assign the appropriate attributes, scales or measures needed to evaluate each of the objectives. This is done in *Decision Maker* using criterion elements (Section 5.3.4). Each of the objectives you defined earlier must have at least one criterion element for the problem to be complete.

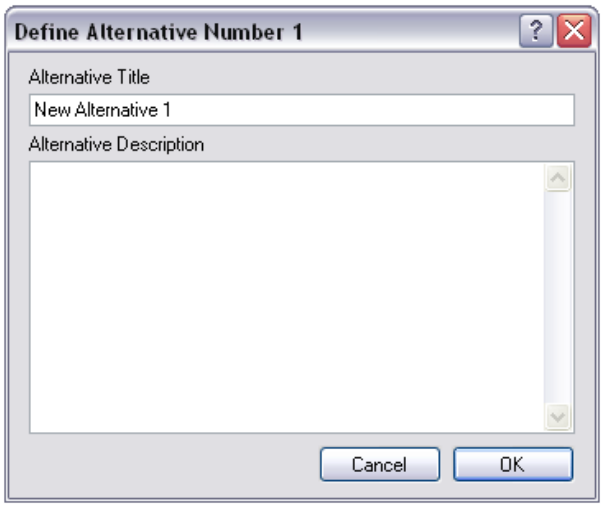


Figure 23. Wizard example - Define Alternative Number 1

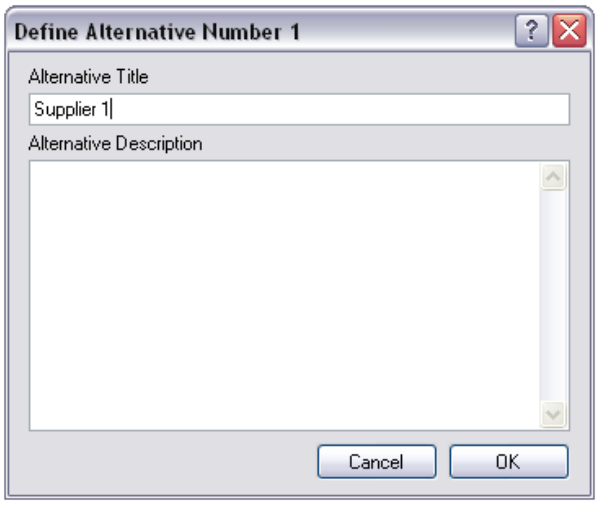


Figure 24. Wizard example - Define Alternative Number 1

For detailed information on using the dialog box presented in this stage, refer to Figure 11 and Section 4.2.5. Use the ***Objective Navigation*** buttons to navigate to each of the objectives you defined earlier. For each objective, define the appropriate criteria and create each criterion using the information presented in Tables 7, 8, 9, 10 and 11. To commence the definition stage, click the ***Next*** button until the dialog box shown in Figure 25 is visible.

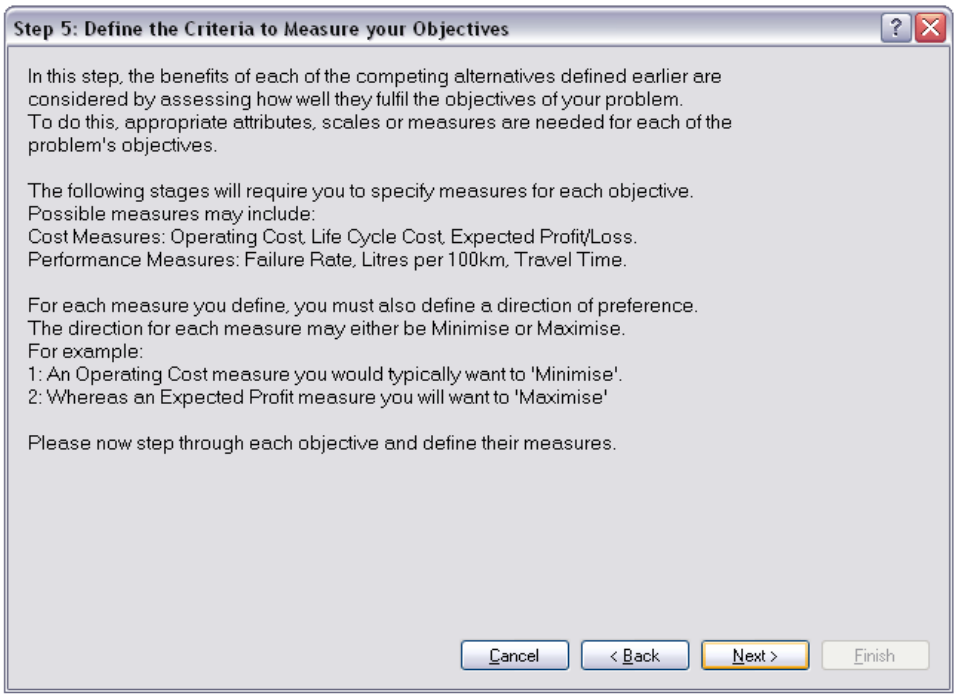
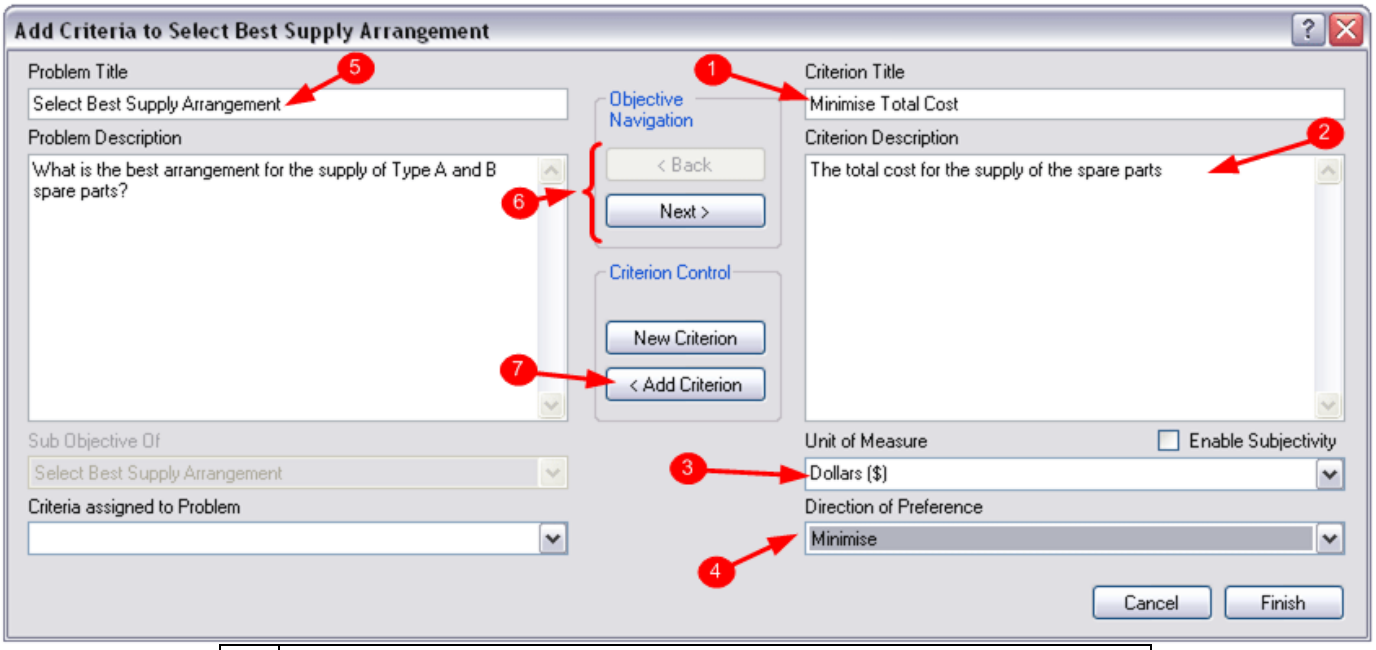


Figure 25. Wizard example – Step 5: Define the Criteria to Measure your Objectives

Clicking the ***Next*** button, again, will display the ***Add Criteria*** dialog box, as shown in Figure 26. Figure 26 steps you through entering the criterion information using the information presented in Table 7. When all the information is entered, click the ***Add Criterion*** button.



1	Enter the criterion title.
2	Enter the description.
3	Select the unit of measure, for example dollars.
4	Select the direction of preference, for example ***minimise***.
5	Ensure ***Select Best Supply Arrangement*** is selected.
6	If the problem or objective parent of the criterion needs changing, use the ***Objective Navigation Next*** and ***Back*** buttons.
7	When all the settings are correct, click ***Add Criterion*** to add ***Minimise Total Cost*** to ***Select Best Supply Arrangement***.

Figure 26. Wizard Example - add criterion 1 to Select Best Supply Arrangement

Table 7. Wizard example - criterion 1 information. Objective: Minimise Total Cost of Supply

Field	Text
Criterion Title	`Minimise Total Cost`
Criterion Description	`The total cost for the supply of the spare parts.`
Unit of Measure	`Dollars`
Preferred Direction	`Minimise`

When step 7 of Figure 26 is complete, the Wizard will appear as shown in Figure 27. Now, click the ***New Criterion*** button and the remaining criteria can be entered by following the same steps as used for Criterion 1. Ensure that the correct ***Problem Title*** is selected for each criterion. Remember, this is done using the ***Objective Navigation Back*** and ***Next*** buttons. For more help using this interface, refer to Section 4.2.5. Next, enter the information presented in Table 8 into the Wizard. It should appear as in Figure 28.

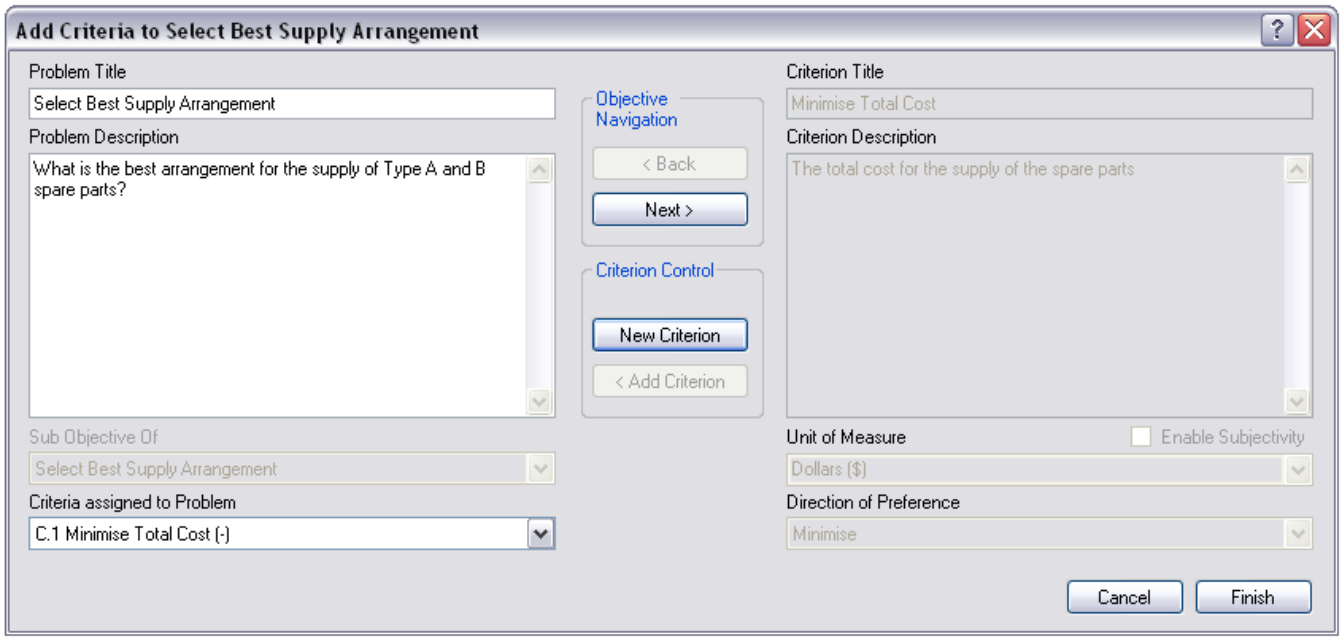


Figure 27. Wizard example - add criterion 1 to Select Best Supply Arrangement (continued)

Table 8. Wizard example - criterion 2 information. Objective: Maximise Performance

Field	Text
Criterion Title	`Maximise Reliability Type A Spares`
Criterion Description	`The lower limit of the 95% confidence interval of the Mean Time Between Failures (MTBF) of Type A spares in hours (hrs).`
Unit of Measure	`MTBF`
Preferred Direction	`Maximise`

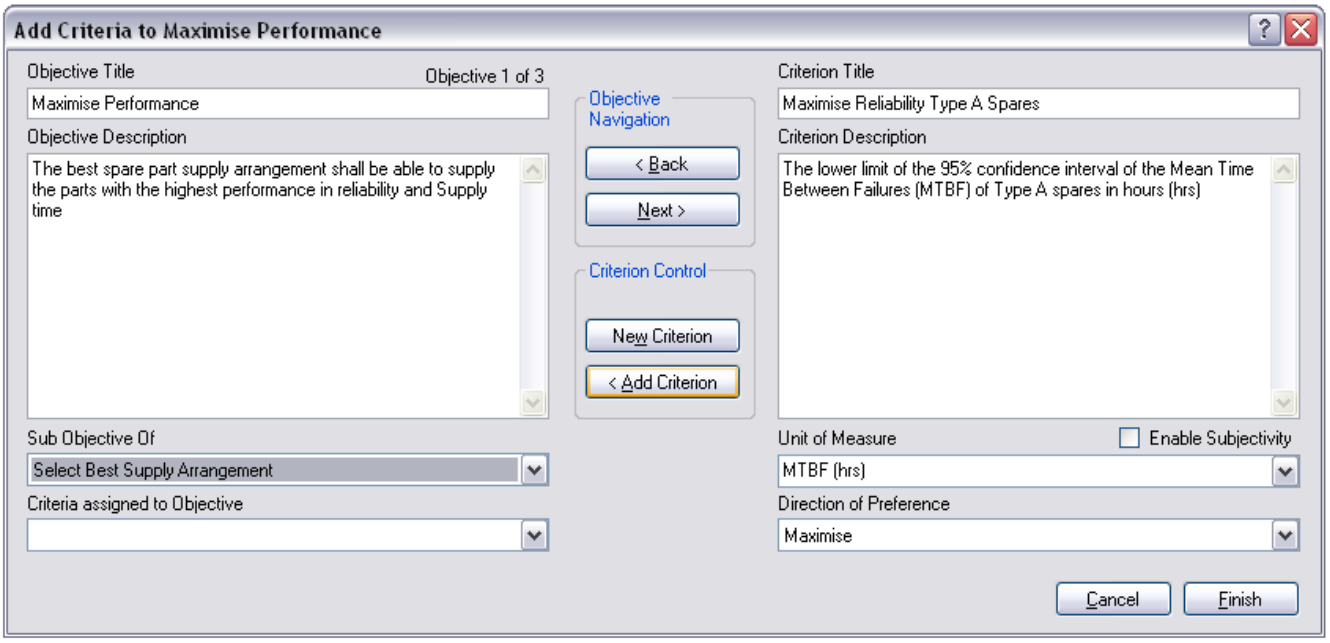


Figure 28. Wizard example - add criterion 2 to Maximise Performance

When the information has been entered, click the ***Add Criterion*** button. Next, click the ***New Criterion*** button. Enter the information presented in Table 9 into the Wizard. It should appear as shown in Figure 29.

Table 9. Wizard example - Criterion 3 information. Objective: Maximise Reliability

Field	Text
Criterion Title	`Maximise Reliability Type B Spares`
Criterion Description	`The lower limit of the 95% confidence interval of the Mean Time Between Failures (MTBF) of Type B spares in hours (hrs).`
Unit of Measure	`MTBF`
Preferred Direction	`Maximise`

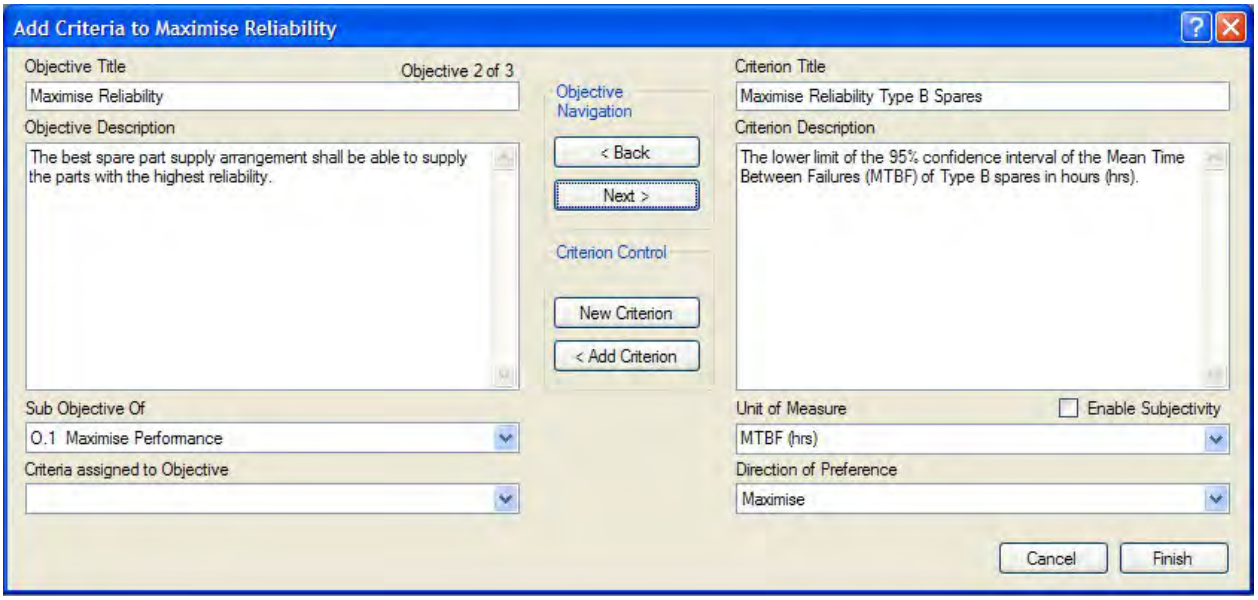


Figure 29. Wizard example - add criterion 3 to Maximise Reliability

When the information has been entered, click the ***Add Criterion*** button. Next, click the ***New Criterion*** button. Enter the information from Table 10 into the Wizard. It should appear as shown in Figure 30.

Table 10. Wizard example - Criterion 4 information. Objective: Minimise Supply Time

Field	Text
Criterion Title	`Minimise Supply Time Type A Spares`
Criterion Description	`The upper limit of the 95% confidence interval of the Mean Time To Supply (MTTS) of Type A spares in hours (hrs).`
Unit of Measure	`MTTS`
Preferred Direction	`Minimise`

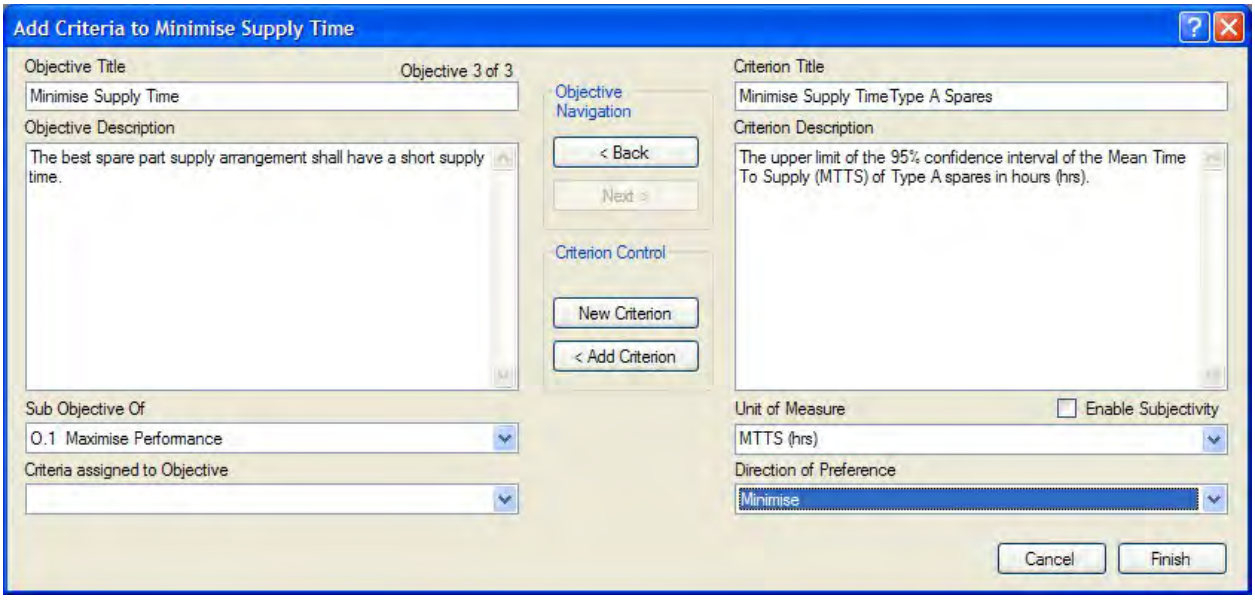


Figure 30. Wizard example - add criterion 4 to Minimise Supply Time

When the information has been entered, click the ***Add Criterion*** button. Next, click the ***New Criterion*** button. Enter the information from Table 11 into the Wizard. It should appear as shown in Figure 31.

Table 11. Wizard example - Criterion 5 Information. Objective: Minimise Supply Time

Field	Text
Criterion Title	`Minimise Supply Time Type B Spares`
Criterion Description	`The upper limit of the 95% confidence interval of the Mean Time To Supply (MTTS) of Type B spares in hours (hrs).`
Unit of Measure	`MTTS`
Preferred Direction	`Minimise`

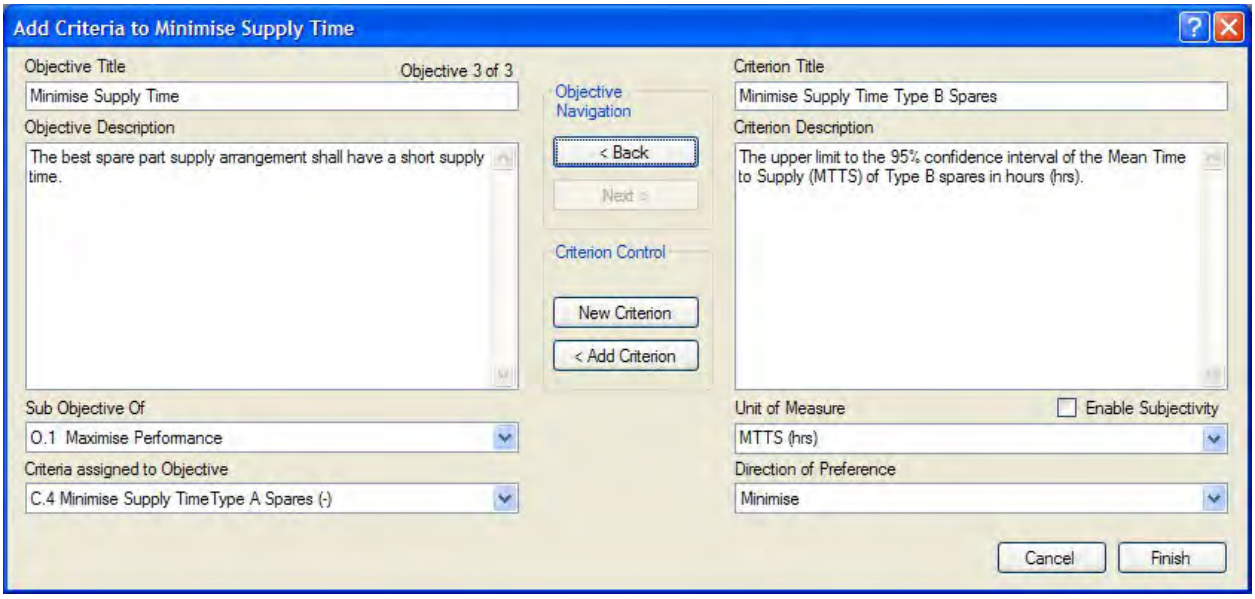


Figure 31. Wizard example - add criterion 5 to Minimise Supply Time

All the criteria have now been assigned to the objectives. Click the ***Finish*** button on the Wizard's dialog box. The Wizard will now display a dialog box indicating that the process is complete. This is shown in Figure 32. Click on ***Finish*** and the ***Data Model*** view will then appear, as shown in Figure 33.

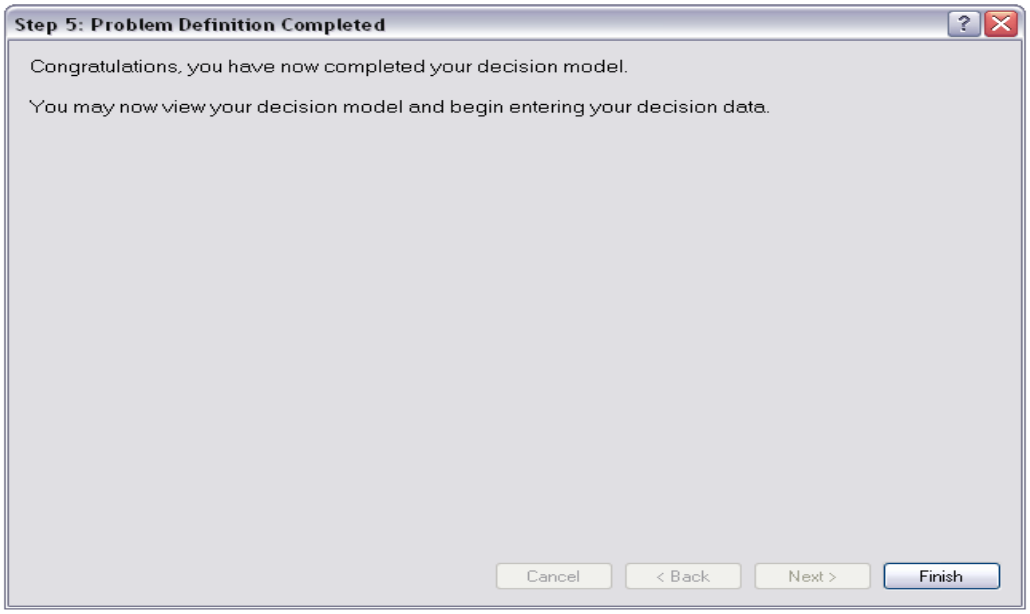


Figure 32. Wizard example - Problem Definition Completed

4.3 Assign Data to Each of the Problem's Criteria

Once the Wizard has concluded, the assignment of data to the criteria has to be entered. This is done using the ***Data Model*** view. At this stage the ***Data Model*** view will look like the example in Figure 33. For detailed information on the ***Data Model*** view, refer to Section 6.3. To open the ***Data Model*** view, select from the **View | Data Model** menu.

To assign data to the problem's criteria, select an objective or criterion element in the Element Tree. The Data Grid window below the Element Tree will display the data fields for the selected element. Use the data presented for the *Supply Manager's Dilemma* in the consequence table shown in Table 1. This data is also available from the installation CD in a Microsoft *Excel* spreadsheet, which can then be copied and pasted into *Decision Maker*. Do this for each criterion in the problem's structure. When completed, and upon selection of an objective, the Data Grid will show the ranking of each supplier. The ranking is calculated automatically and does not require the user to initiate the calculation. Figure 34 shows the rankings for each supplier for the object *Maximise Performance.*

4.4 Calculate the Scores for Each Alternative in the Problem

When the data for each of the *Supply Manager's Dilemma* criteria has been entered, a score can be calculated to evaluate the performance of each alternative. To calculate the scores, select the **Project | Calculate** menu, or click the ***Calculate*** quick access button on the form.

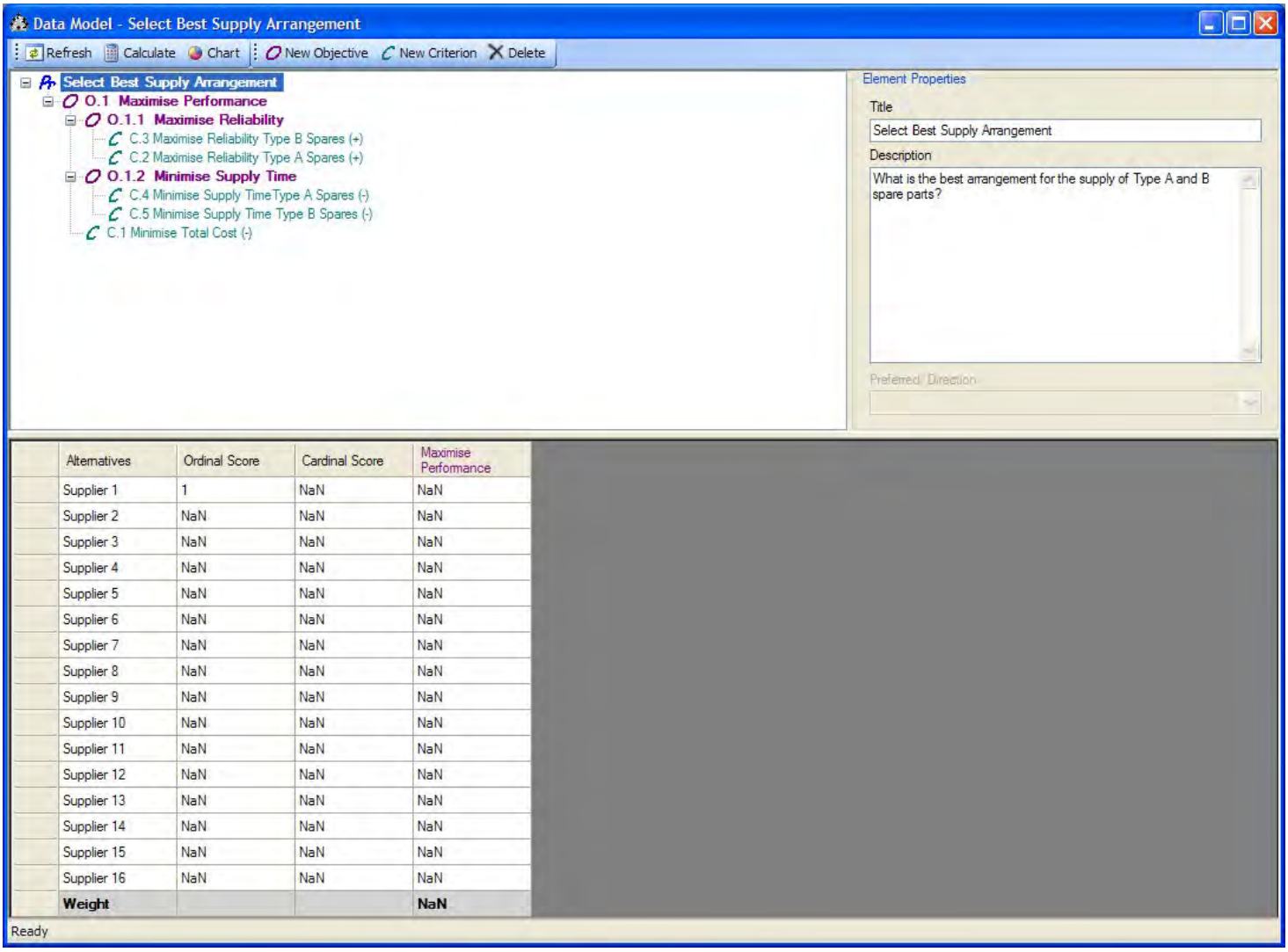


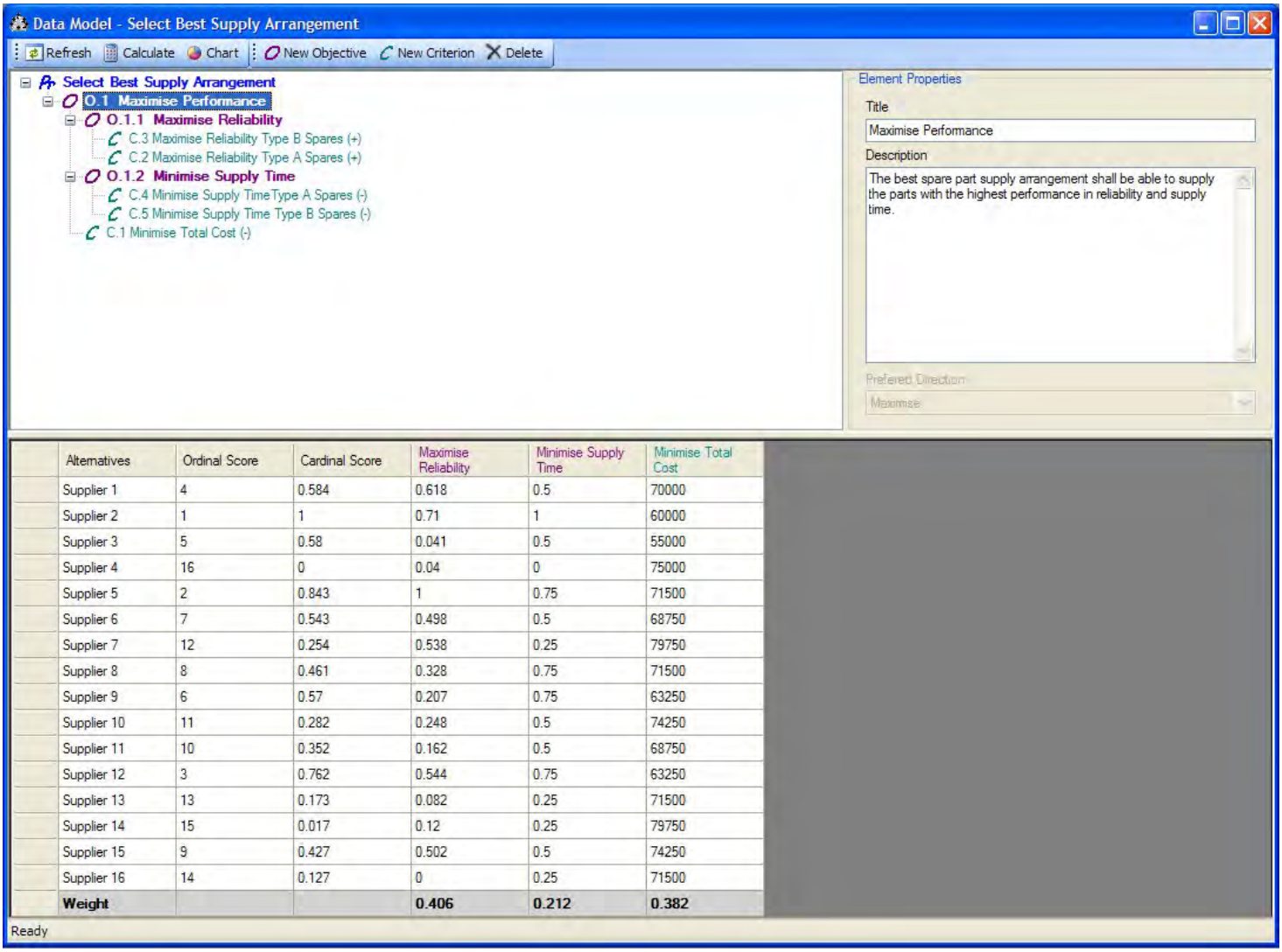
Figure 33. Wizard example – the data model upon Wizard completion

Note that when selecting between elements in the Element Tree, *Decision Maker* will automatically re-calculate and update your decision problem scores. To disable the automatic calculation feature, un-check **Background Calculating** in the **Project** menu (located in *Decision Maker*'s main menu bar).

4.5 Chart the Results of the Decision-Analysis Process

Charting the results calculated in the previous section provides a visual representation of *Decision Maker*'s output as a graph of the cardinal and ordinal scores for each alternative.

To chart the results, select an element in the Element Tree and select the **View | Chart** menu (located in *Decision Maker*'s main menu bar). If you select a criterion element, *Decision Maker* will chart the results for that element.



Alternatives	Ordinal Score	Cardinal Score	Maximise Reliability	Minimise Supply Time	Minimise Total Cost
Supplier 1	4	0.584	0.618	0.5	70000
Supplier 2	1	1	0.71	1	60000
Supplier 3	5	0.58	0.041	0.5	55000
Supplier 4	16	0	0.04	0	75000
Supplier 5	2	0.843	1	0.75	71500
Supplier 6	7	0.543	0.498	0.5	68750
Supplier 7	12	0.254	0.538	0.25	79750
Supplier 8	8	0.461	0.328	0.75	71500
Supplier 9	6	0.57	0.207	0.75	63250
Supplier 10	11	0.282	0.248	0.5	74250
Supplier 11	10	0.352	0.162	0.5	68750
Supplier 12	3	0.762	0.544	0.75	63250
Supplier 13	13	0.173	0.082	0.25	71500
Supplier 14	15	0.017	0.12	0.25	79750
Supplier 15	9	0.427	0.502	0.5	74250
Supplier 16	14	0.127	0	0.25	71500
Weight			**0.406**	**0.212**	**0.382**

Figure 34. Wizard example – the data model without data

4.6 Revise and Amend the Problem's Structure

Now that you have structured your decision problem and have entered the problem's data for the criteria and/or uncertainties, you can calculate some scores. You can also revise your problem. This can be achieved by:

1. adding more objectives;
2. adding more alternatives;
3. adding uncertainties;
4. running a simulation and analysing the results;
5. defining more criterion elements for your objectives; and/or
6. moving elements throughout the problem structure.

When you have gained understanding of your problem, you may identify additional objectives that you want to include in your project. Both the ***Structure Model*** and ***Data Model*** views provide the tools to add and delete the elements for your problem's structure.

4.7 Remarks

Do not forget to save your work regularly. *Decision Maker* saves your project using Simple Object Access Protocol (SOAP), which is an eXtended Mark-up Language (XML) file format. This file format is readable using most text reader applications.

5. Structuring Your Problem in Decision Maker

Before you begin entering your decision problem, it is important to understand the decision-making process that you will undertake while using *Decision Maker*.

5.1 PrOACT Process

To begin solving your decision problem in *Decision Maker*, it is recommended that you first think about your problem in terms of the PrOACT process (Section 3). This process begins with steps where you are required to clearly define for your ***Problem*** and specify your ***Objectives***. The next activities undertaken in the PrOACT process include the construction of lists of any possible alternative***s*** and their ***Consequences***. *Decision Maker* provides the tools so that you can follow this process to structure your decision problem. Once you have structured your problem, you can then begin adding data and performing ***Trade-off*** analysis studies using the decision-analysis tools provided by *Decision Maker*.

It is important to note that, during the initial stage of defining your problem in *Decision Maker*, you do not need to be overly thorough. It is more important that you begin structuring your problem with the information you have and then refining your problem later through an iterative structuring and reviewing process. Furthermore, prior to commencing any decision-making, it is also important to understand what your problem *really* is. Objectives, alternatives and the consequences (i.e. the decision criteria) can be added or removed at any stage using the tools provided by *Decision Maker*.

5.2 Structuring Your Decision Problem

Decision Maker provides two methods for structuring your decision problem. The first method uses the Wizard, and the second method is a manual structuring process. The manual method is more flexible, since you can add/remove elements to/from your decision problem in your own time when you have the information available. If you choose the Wizard, it is best that you have available some elementary objectives, alternatives and criteria before you begin so that this information can be entered into the Wizard. The Wizard will then structure your problem in *Decision Maker* using the information provided.

5.3 The First Step

The first step is to decide whether you will use the Wizard to structure your problem, or whether you will structure your problem manually. If you know the basic structure of your decision problem, you can use the Wizard to guide you through the steps that will

structure your problem in *Decision Maker*. These steps include the creation of the project that will contain your decision problem.

If you choose the manual method for structuring your decision problem, you must first create an empty project to store the decision problem. Then you can begin defining your problem and its structure. The following subsections provide an introduction to the various elements that you will need to use to structure your decision problem in *Decision Maker*, including:

1. Decision Maker Project;
2. Decision Maker Structural Elements:
   a. Problem Element;
   b. Objective Element;
   c. Alternative Element; and
   d. Criterion Element.

Figure 35 presents the basic structure of a project in *Decision Maker* using these elements. The figure shows that any one project may contain more than one Problem, and that each Problem has its own structure consisting of Alternatives, Objectives and Criteria.

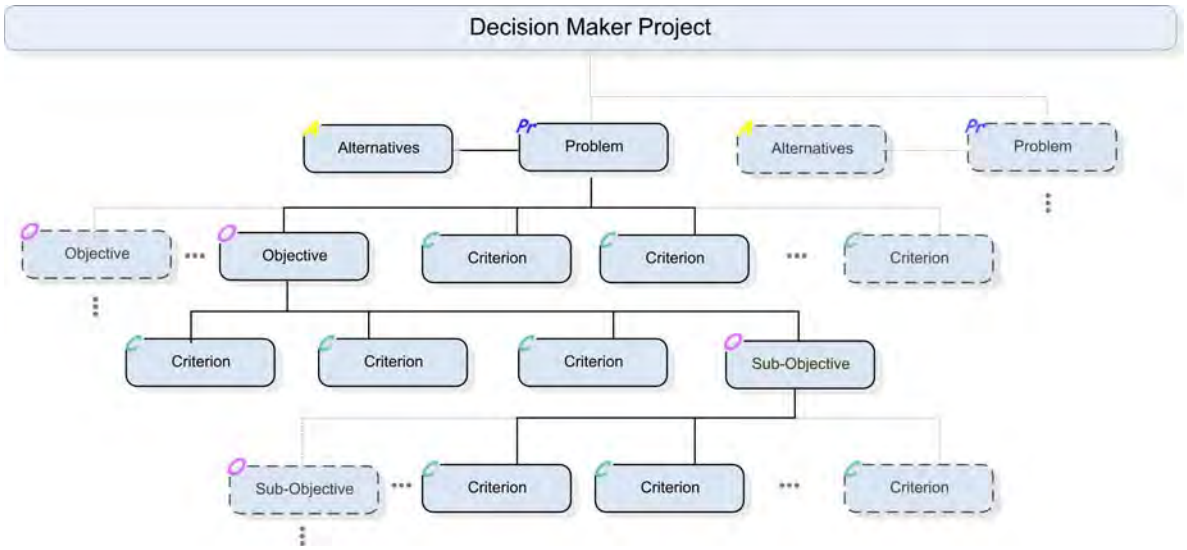


Figure 35. Structure of a Decision Maker project

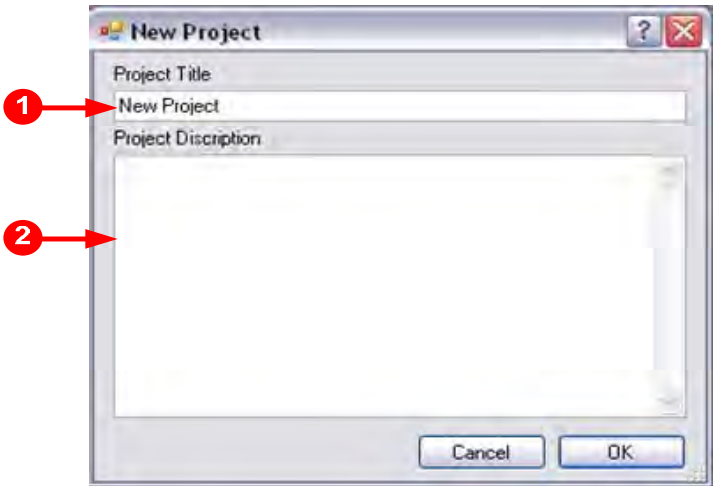
5.3.1 Creating a Project

Every decision problem must belong to a project and a project may contain more than one decision problem. Before you can begin structuring your problem in *Decision Maker*, you must create a project to store your decision problems.

Creating a project is achieved by using either the Wizard (Section 4) or by creating a new empty project manually from the **File** menu (Section 5.4). Figure 36 presents an example of the dialog box presented to you when creating a new project.

5.4 Decision Maker Structural Elements

Decision Maker uses structural objects generically referred to as *elements*. It is a combination of these elements that you will use to structure your problem in *Decision Maker*. The elements represent various attributes within the structure of your decision problem. These elements can either be a *Problem*, *Objective, Alternative* or a *Criterion*, and you may have multiples of each of these elements in your problem's structure (see Figure 35).



1	***Project Title*:** Use this field to enter a short title for your project. For example, this may be your department's name or the name of the task that has a decision problem you would like to resolve.
2	***Project Description*:** Enter a detailed description of your project in this field, the more detail the better.

Figure 36. The New Project dialog box

The following subsections introduce the structural elements used within *Decision Maker* with the associated dialog boxes that you will use to create the elements for your problem's structure.

5.4.1 Problem Element

A *Problem* element is used to represent your decision problem in *Decision Maker*. Before you can begin structuring or analysing any decision, you must identify your problem and clearly define it using a *Problem* element. This step is important, since it will ensure that you are starting your decision-making process with the correct problem (see Section 3.1 for more information on defining your problem). The *Problem* element has three fields that are used to define your decision problem, as shown in Figure 37.

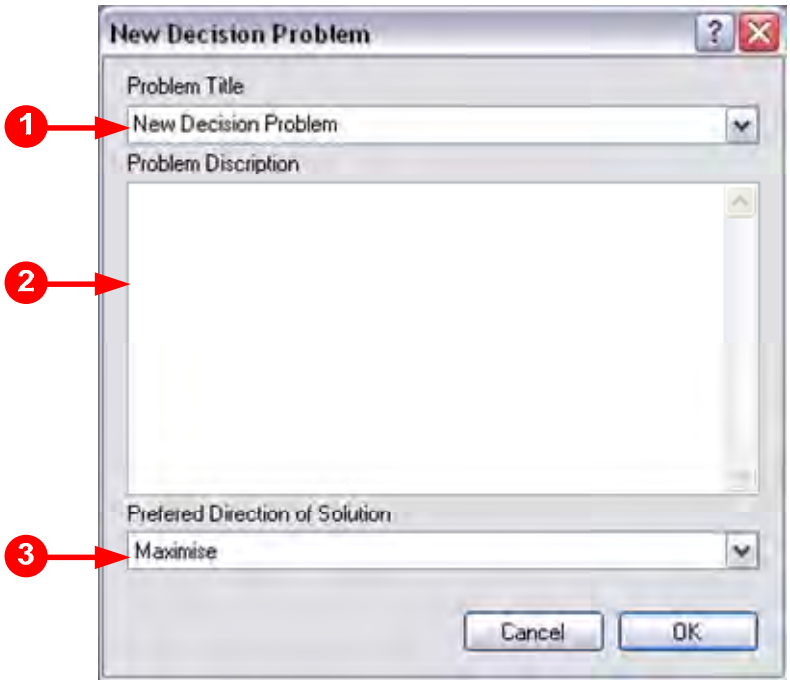
5.4.2 Objective Element

An *Objective* element is used to represent each of your objectives and sub-objectives within your decision problem (see Section 3.2 for more information on objectives). You can have many *Objective* elements within your problem. The *Objective* element has four fields that are used to define the objective it represents, or sub-objective if required, as shown in Figure 38.

5.4.3 Alternative Element

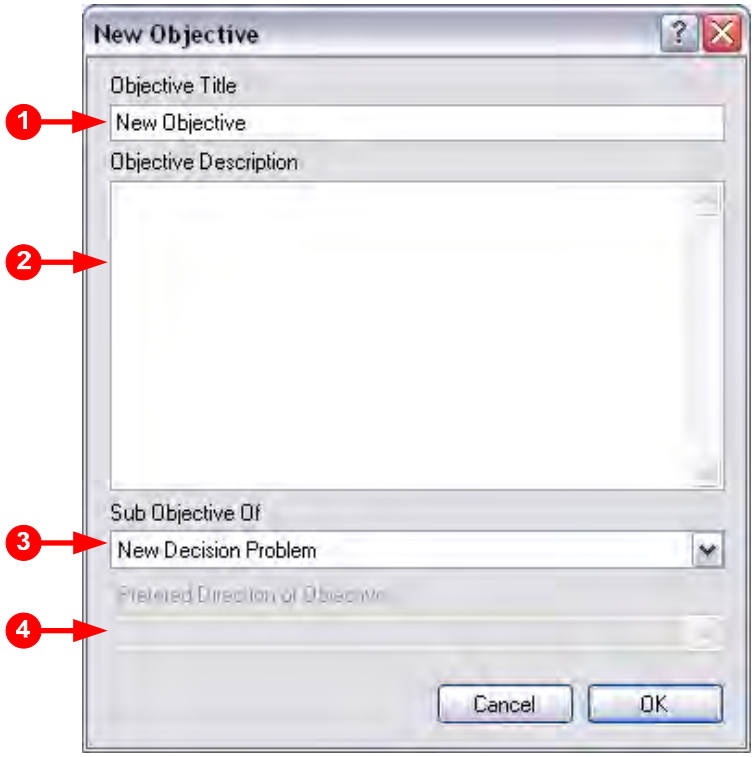
An *Alternative* element is used to represent each of the possible alternatives to your decision problem (see Section 3.3 for more information on alternatives). Each *Alternative* element in your decision problem must be unique and you must have at least two alternatives in your decision problem for *Decision Maker* to analyse your problem. The *Alternative* element has two fields, as shown in Figure 39.

> ⚠ *Each alternative element in your decision problem must be unique, and you must have at least two alternatives in your decision problem for Decision Maker to analyse your problem.*



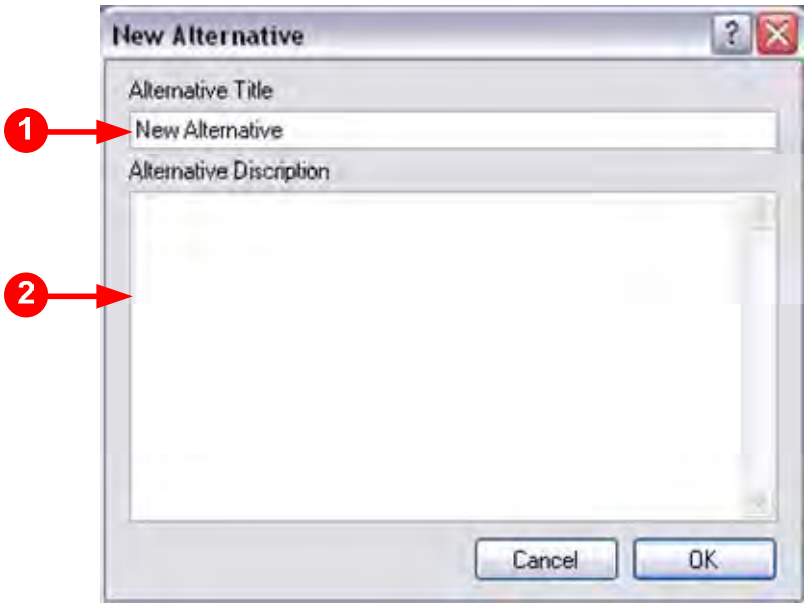
1	***Problem Title*:** Use this field to enter a short title for your decision problem.
2	***Problem Description*:** Enter a detailed description of your problem, the more detail the better.
3	***Preferred Direction of Solution*:** Select the direction of preference for the solution of your decision problem. The preferred direction field provides a simple method that will be used by *Decision Maker* to calculate and sort the priority of your decision problem's analysis output. For example, if your problem requires you to find the *best* alternative, the preferred direction for your decision problem will be ***maximise***. Otherwise, if you are making a risk-based decision and you are searching for the alternative that has the least impact in your problem, the direction of preference will be ***minimise***.

Figure 37. The New Decision Problem dialog box



1	***Objective Title*:** Use this field to enter a short title for your objective.
2	***Objective Description*:** Enter a detailed description of your objective in this field, the more detail the better.
3	***Sub-Objective Of*:** This field allows you to select any other *Objective* element, including your *Problem* element, which your objective decomposes. Setting this field will establish a hierarchical tree of objectives in your decision problem. By default, each new *Objective* element is set as a sub-objective of your *Problem* element.
4	***Preferred Direction of Objective*:** This has been disabled. It is recommended that the preferred direction for objectives is described in the ***Objective Title*** or ***Objective Description***. For example, one objective may be to maximise profit. This objective may be decomposed into two other sub-objectives such as minimise expenditure and maximise reliability. These sub-objectives will have their own set of criteria (as discussed in Section 5.3.4) to evaluate their performance in your decision problem.

Figure 38. The New Objective dialog box



1	***Alternative Title*:** Use this field to enter a short title for your alternative. The title of each alternative must be unique.
2	***Alternative Description*:** Enter a detailed description of your alternative in this field, the more detail the better.

Figure 39. The New Alternative dialog box

5.4.4 Criterion Element

A *Criterion* element is used to represent each quantifiable consequential attribute, scale or measure in your decision problem (see Section 3.4 for more information on consequences). *Criterion* elements represent each quantifiable attribute in your decision problem and they include attributes such as operating costs, expected profit/loss, performance measures and

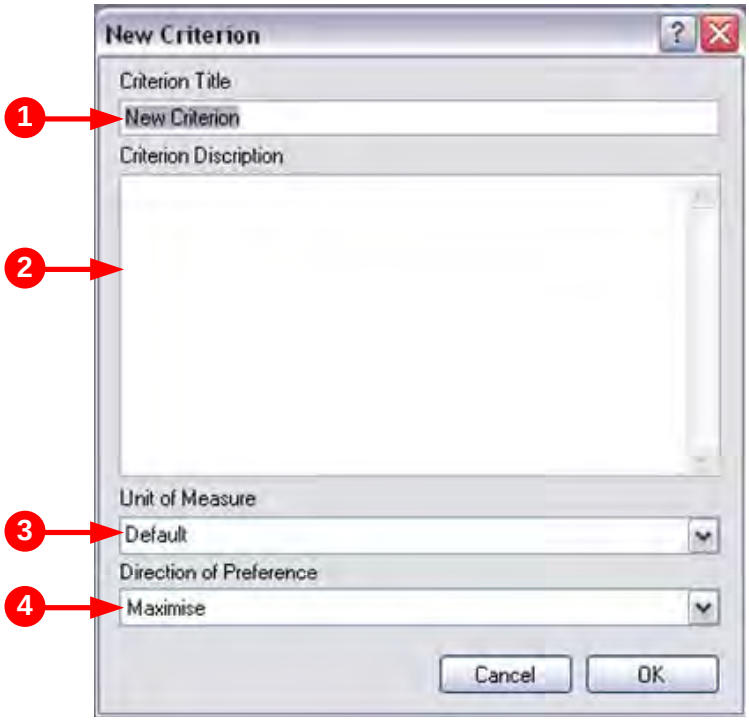
other characteristics of the objective they define. The *Criterion* element has four fields, as shown in Figure 40.

5.4.5 Uncertainty Element

The *Uncertainty* element represents the variation and/or tolerance in a *Criteria* element. This value may be known from documentation, such as the tolerances of machinery parts, or may be uncertain and the expected value may vary by a certain percentage. All uncertainties in *Decision Maker* are represented as a percentage of the criterion value.

It is not a requirement to have any *Uncertainty* elements in the decision problem. However, to take advantage of the simulation components of *Decision Maker*, one or more criteria require some level of uncertainty to be set.

When an uncertainty has been added to a criterion it cannot be removed. If it is no longer required, setting all the values for each element to zero (0) will have the same effect as having no uncertainty. Each criterion can only have one uncertainty. However the values for each alternative can be different.



1	***Criterion Title*:** Use this field to enter a short title for your criterion. The title of each criterion must be unique.
2	***Criterion Description*:** Enter a detailed description of the criterion in this field, the more detail the better.
3	***Unit of Measure*:** This field allows you to select or enter a unit of measure for your criterion. For example, the minimise expenditure objective might have a criterion "Labour Cost". The unit of measure for "Labour Cost" may be the dollars measure, which has the $ symbol. Alternatively, you can type in your own unit of measure and define your own symbol.
4	***Direction of Preference*:** Select the preferred direction of preference for your criterion. Like the *Problem* and *Objective* elements, the criterion's direction of preference field provides a simple method used to inform *Decision Maker* whether the criterion will have a positive or negative influence on its parent objective. For example, the sub-objective maximise reliability can be evaluated by assigning *Criterion* elements representing Mean Time To Repair (MTTR) and MTBF. In this example, the MTTR criterion will have a ***Direction of Preference*** set to ***minimise***, and the alternative with the lowest MTTR will be the preferred alternative. Conversely, the MTBF criterion will have a ***Direction of Preference*** set to ***maximise*** and the alternative with the greatest MTBF will be the preferred alternative. *Decision Maker* will analyse your decision problem based on the MTTR and MTBF data and their preferred direction.

Figure 40. The New Criterion dialog box

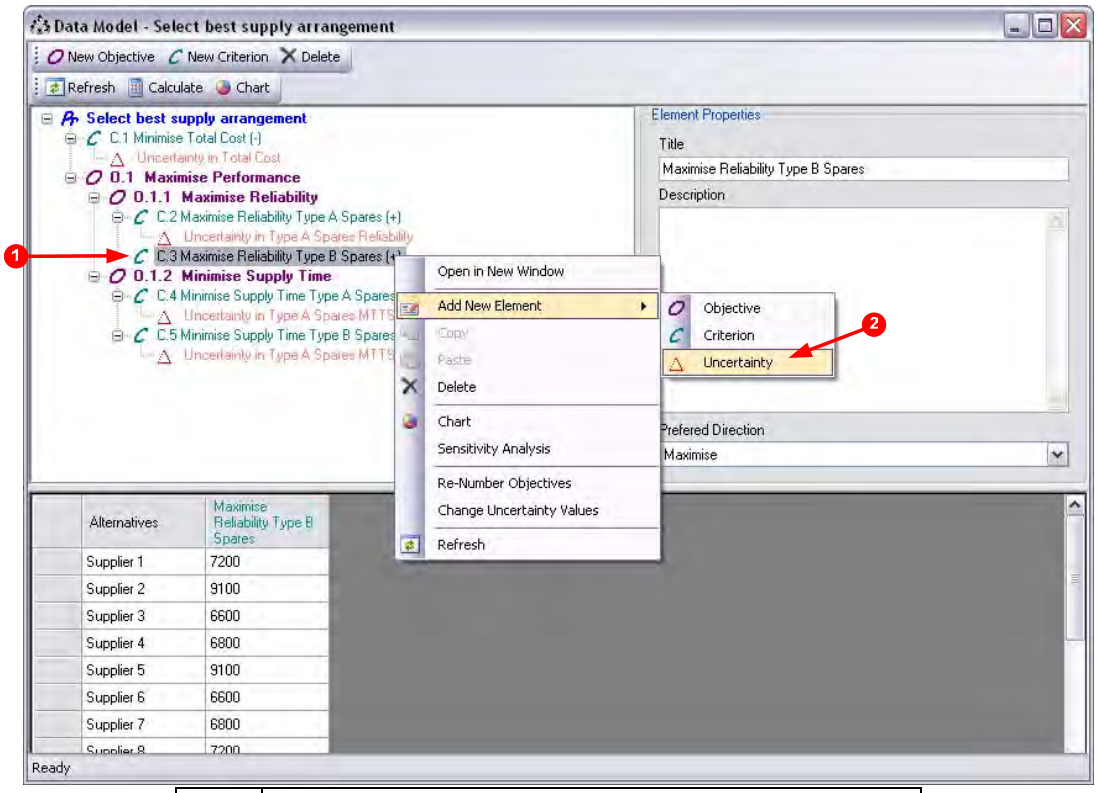
5.4.5.1 *Adding Uncertainties*

To add uncertainties to your criterion, follow the steps shown in Figure 41.

After completing the steps in Figure 41, the confirmation prompt shown in Figure 42 will appear. Selecting ***No*** will set all uncertainties to a default value of zero. This is useful if each alternative has a different value to set or if the values will be copied from a Microsoft *Excel* spreadsheet. If every alternative is to have the same value, click ***Yes.*** If ***Yes*** is selected, a dialog box will appear on the screen asking for the value to set, as shown in Figure 43. In the ***Value*** field, enter a number between 0 and 1. For example, enter 0.05 for a 5% uncertainty, as shown in Figure 44. Click ***OK*** to confirm and the Data Model will be updated as shown in Figure 45.

5.4.5.2 *Changing Uncertainties*

Uncertainties can also be changed for all alternatives simultaneously, as shown in Figure 46. Then, when the dialog box shown in Figure 47 appears, enter a value between 0 and 1. Here 0.1 has been used, indicating 10% uncertainty. When you have entered a meaningful value, click ***OK.*** The Data Model will be updated to reflect the changes made, as shown in Figure 48. Uncertainties for individual alternatives can be set manually by editing the appropriate cell in the data view. This is discussed in Section 6.3.1.



1	Select the Criteria to which uncertainty is to be added and then click the right mouse button to open the menu.
2	Select **Add New Element | Uncertainty.**

Figure 41. Adding uncertainties

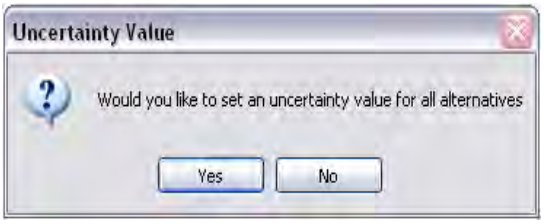


Figure 42. Uncertainty confirmation prompt

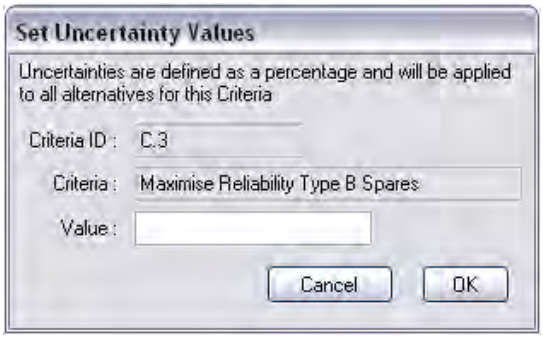


Figure 43. Set Uncertainty Values (blank)

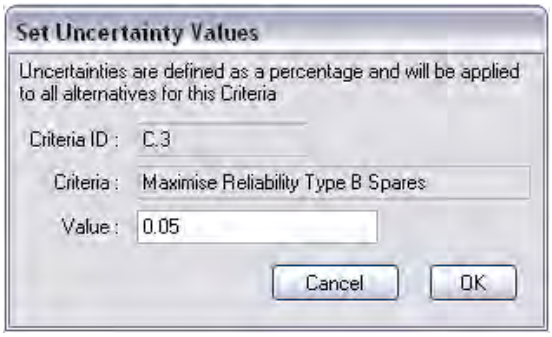


Figure 44. Set Uncertainty Values (example)

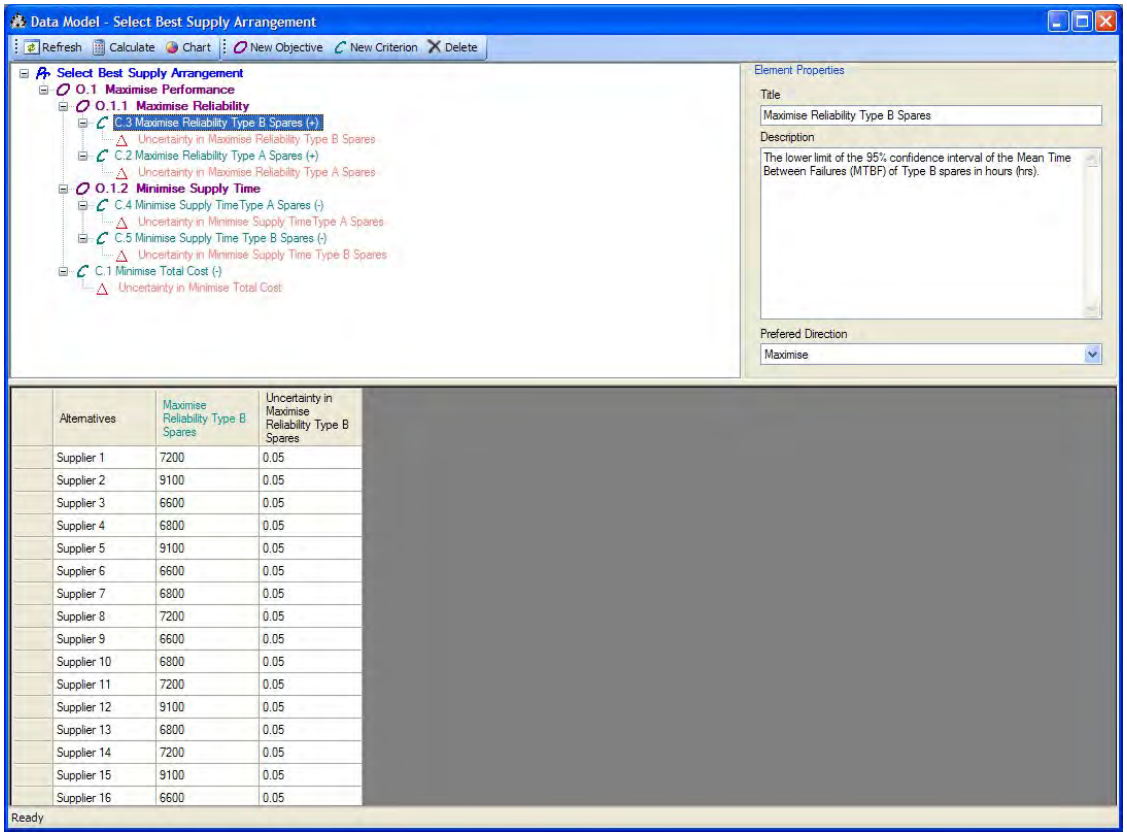
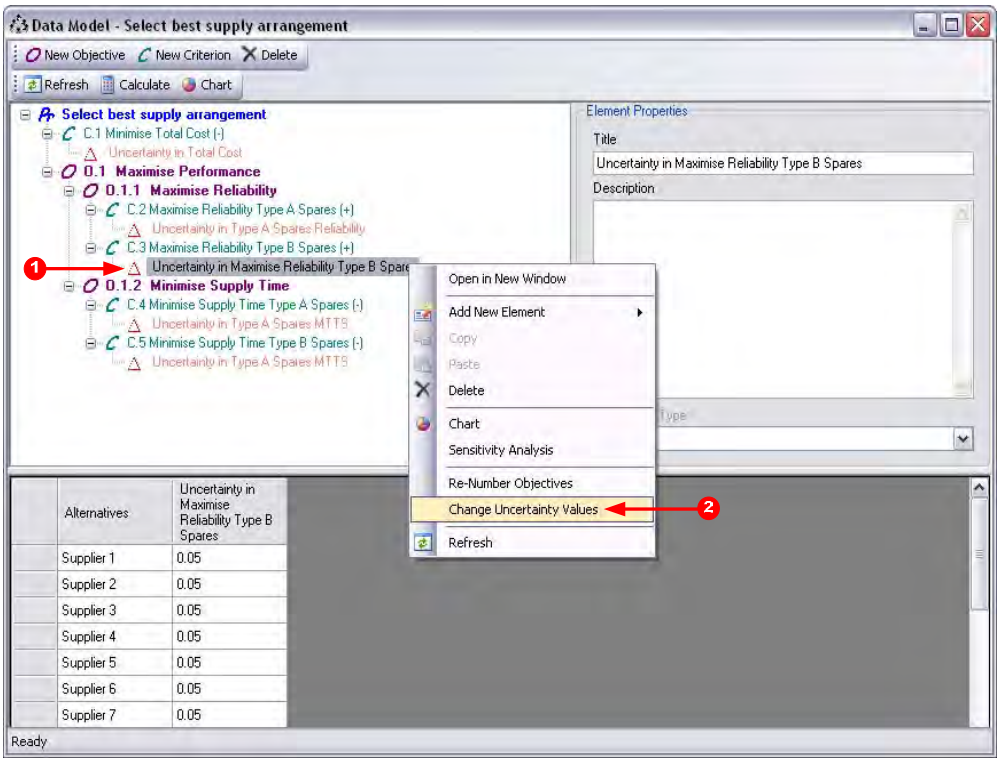


Figure 45. Uncertainties added



1	Select the uncertainty element for the criteria in question and click the right mouse button.
2	Select ***Change Uncertainty Value.***

Figure 46. Changing uncertainty values for all alternatives

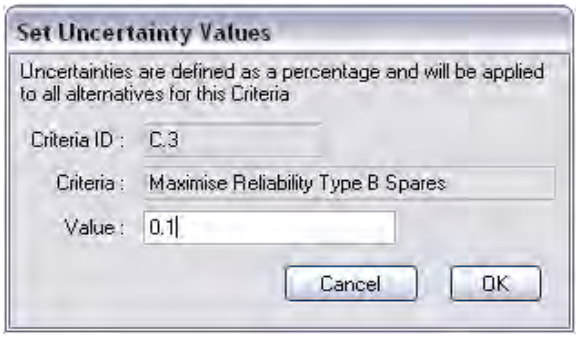


Figure 47. Set Uncertainty Values dialog box (changing uncertainty)

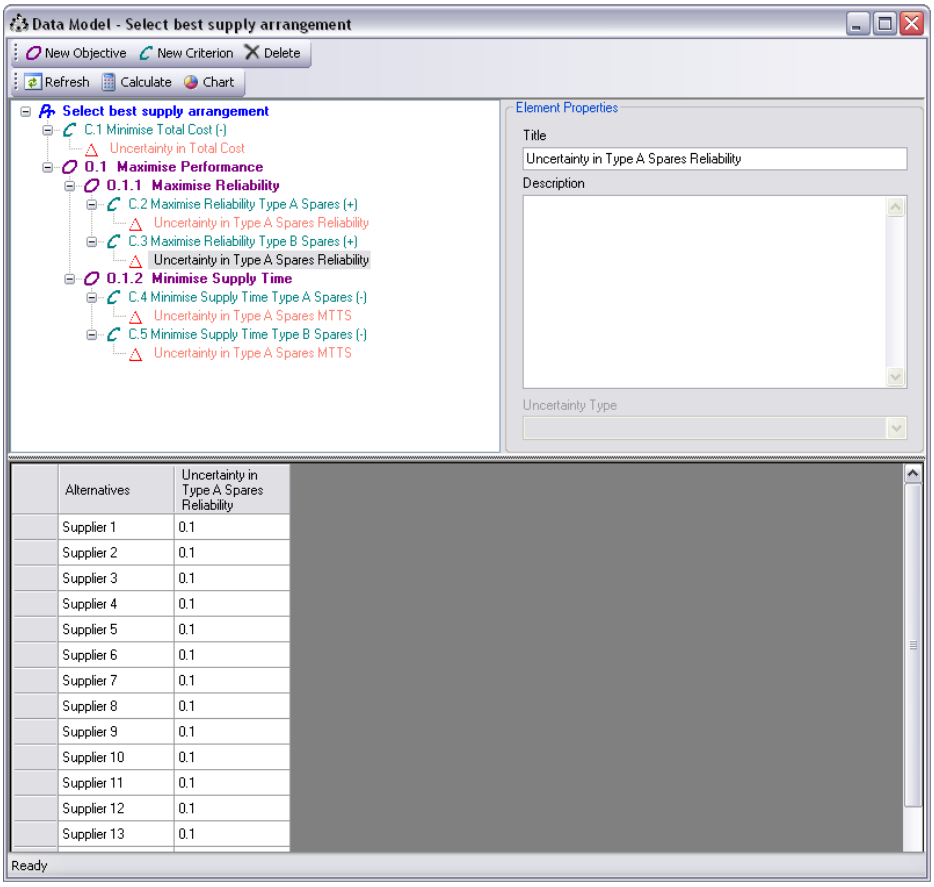


Figure 48. Changing uncertainty values for all alternatives

5.5 Manually Structuring your Problem

Manually structuring your decision problem in *Decision Maker* provides flexibility, since this method allows you to build your problem's structure element by element. This method is also a good option if you are lacking information about your problem, or the intended structure is unknown. This method begins by creating a new blank project, followed by the creation of all the structural elements for your problem as they are needed.

To begin structuring your problem manually, follow these steps:

1. Create a new project by selecting the **File | New | New Project** menu;
2. After creating the new project, open either the ***Structure Model*** (Section 6.2) or ***Data Model*** (Section 6.3) window, depending on your modelling needs. Do this by selecting **View | Structure Model** or **View | Data Model**; and
3. Create a *Problem* element by selecting the **Project | Set Current Problem** menu and then define your decision problem using the dialog box presented (Section 5.3.1).

When these steps are complete, you can begin structuring your problem in *Decision Maker*. It is highly recommended that the PrOACT process be followed (Section 3) while structuring your problem. However, *Decision Maker* does not require you to follow this process. The PrOACT recommended process includes the following sequence for structuring your decision problem:

1. define your **Problem;**

2. specify your **O*bjectives;***
3. create many **A*lternatives;***
4. define the **C*riteria*** for each Objective; and
5. calculate results and **T*rade-off*** the alternatives.

Refer to Section 5.3 for more information on creating the structural elements for your decision problem.

6. Analysing Your Problem in Decision Maker

Decision Maker provides for both quantitative and qualitative modelling of your decision problem. Both models are equally important for analysis of your decision problem, although they have different roles in the decision-analysis process.

Section 5 presented *Decision Maker*'s tools for developing a structural model of your decision problem. The structural model is a qualitative problem model constructed using various descriptive elements including *Objective*, *Alternative* and *Criterion* elements that, when combined, form the structure of your decision problem. The structural model is a powerful tool that enables traceability throughout your decision-making process. The structural model also provides a method to manage the complexity of hierarchical decision problems and their numerous 'problem' components.

Despite its usefulness, the structural model discussed so far does not provide any method to support quantitative analysis of your decision problem. For quantitative analysis, real data must be collected for the criteria defined in your problem's structure. *Decision Maker* provides a method for you to enter the data collected, analyse your problem and chart the output. *Decision Maker* uses a d*ata model* to do this, as shown in Figure 49.

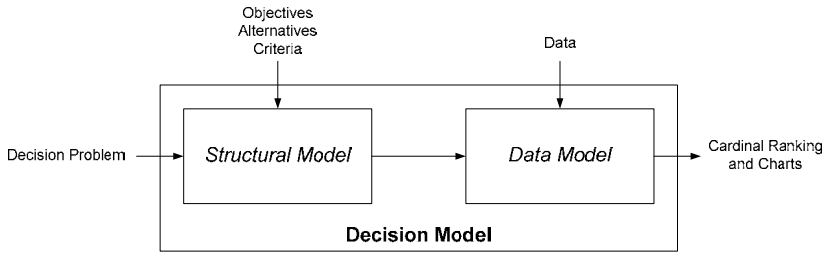


Figure 49. Decision Maker's Structural Model and Data Model input/output

The following sections will introduce you to *Decision Maker*'s Structure Model and Data Model forms. Within these forms, *Decision Maker* uses a common colour code for the four different types of problem elements. These colour codes enable you to quickly identify the type of the element, therefore making the analysis process visually easier to comprehend. The colour codes are presented in Figure 50.

Figure 50. Decision Maker element colour codes

6.1 The Structure Model – Modifying your Problem's Structure

The ***Structure Model*** window provides the tools that will enable you to build and modify your problem's structure. This includes adding and deleting your problem's structural elements and editing their properties. The ***Structure Model*** window is only accessible when a project is open. To open or create a project, refer to Section 5.2.2. To open the ***Structure Model*** window when a project is open, select the **View | Structure Model** menu option as shown in Figure 51. Use the data model discussed in Section 6.3 to add data to the problem and begin analysis

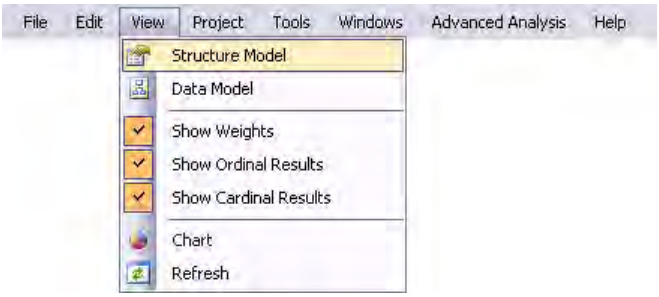


Figure 51. Opening the Structure Model

The ***Structure Model*** window, shown in Figure 52, consists of three panes, each presenting a different level of information from within your decision problem. The three panes from left to right are: the ***Folder List***; the ***Element List***; and the ***Properties/Hierarchy*** tabs.

Decision Maker organises your problem's structural elements into folders, with each folder containing all the elements of that particular type. Therefore, all objectives within your problem's structure can be found in the ***Objectives*** folder; similarly for your problem's *Alternative* and *Criterion* elements.

6.2 The Data Model – Adding Data and Analysing your Problem

The ***Data Model*** window in *Decision Maker* provides the tools that enable you to add data to your decision problem and undertake analysis. The ***Data Model*** window also provides the tools to create new *Objective* and *Criterion* elements so that you may further improve your problem's structure. Furthermore, an overview of properties for the currently selected element is provided.

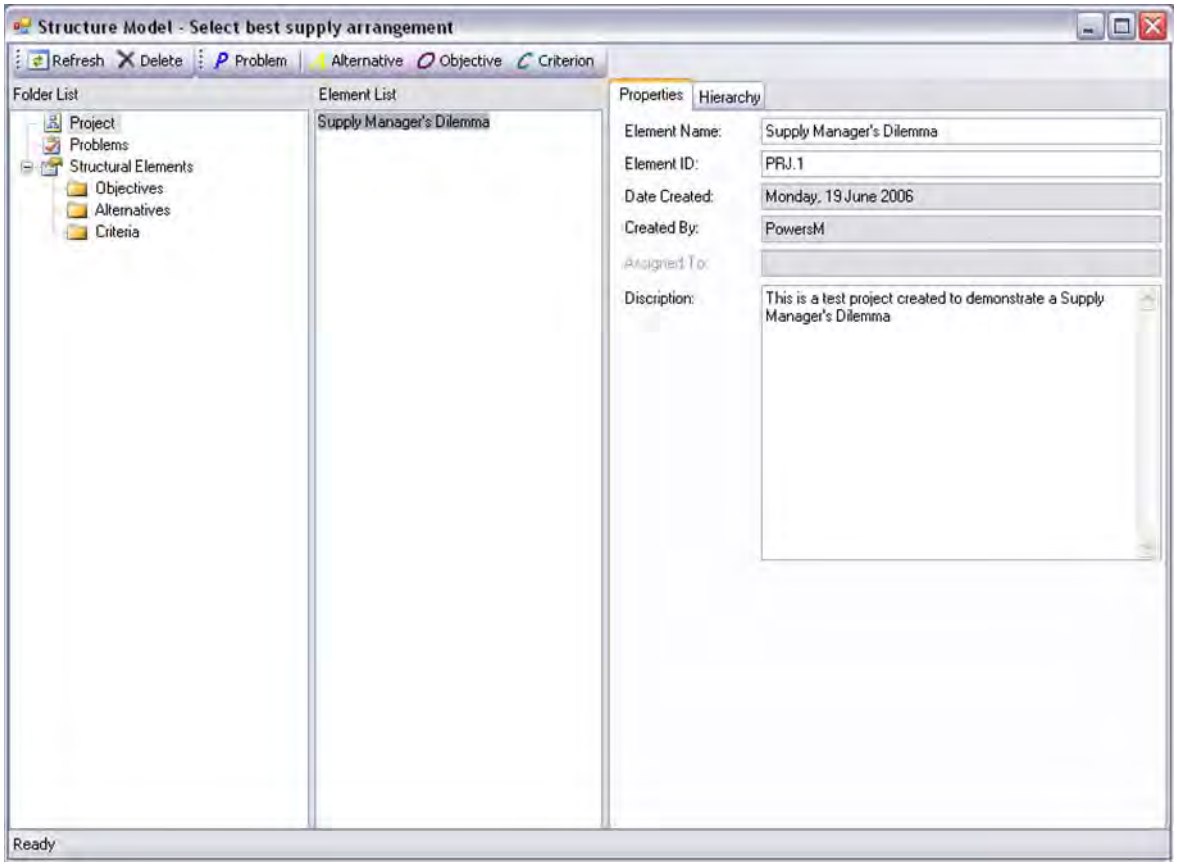


Figure 52. The Structure Model used to modify your problem's structure

To open the ***Data Model*** window, select the **View | Data Model** menu option as shown in Figure 53. Figure 54 describes each element of the ***Data Model*** window.

Items in the Element Tree can be dragged and dropped onto other elements to change the structure of the problem. This allows for quick and easy manipulation during trade-off analysis.

Editing data in the Data Grid can only be performed on criterion data. All other data in the Data Grid, other than the alternative's titles, is generated by Decision Maker. The titles for the alternatives may be changed in the Structure Model (Section 6.2).

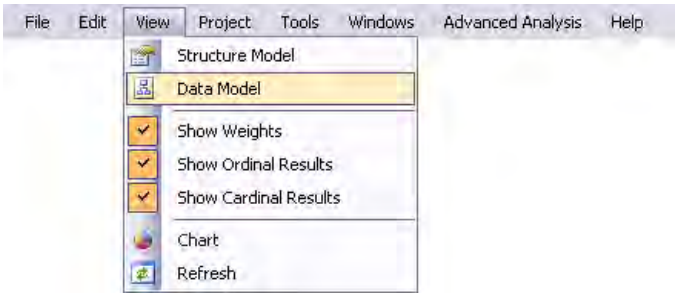
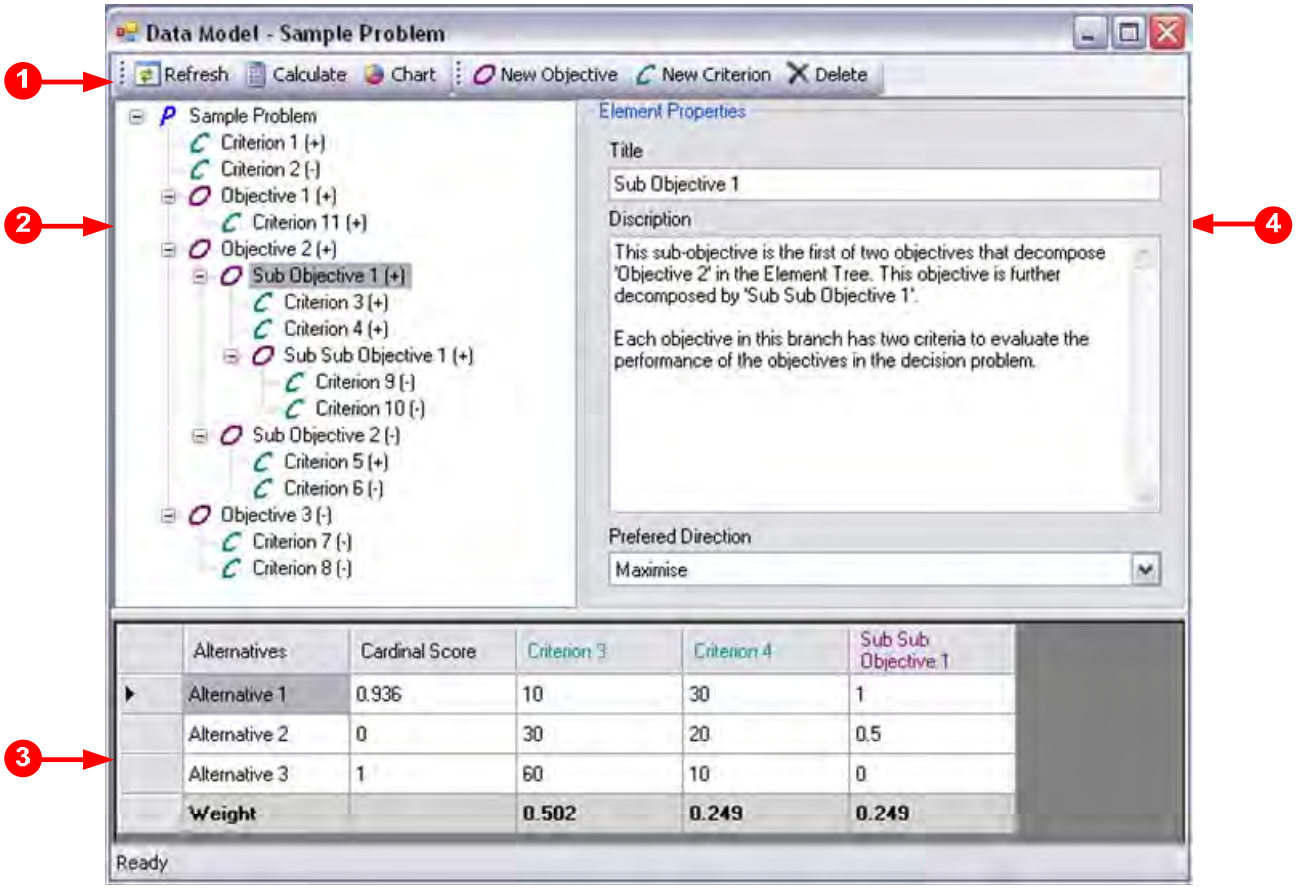


Figure 53. Opening the Data Model



1	Quick access menu buttons.
2	Element Tree**:** A hierarchical view of your problem's objectives and criteria.
3	Data Grid**:** The data grid is used to add data to the problem's criteria and to view the results of analysis. Refer to Section 6.3.1 for more information on using the data grid.
4	***Element Properties*****:** This window provides quick access to the key properties of the element selected in the Element Tree. You can edit the properties in this window.

Figure 54. Data Model – to add data and analyse your decision problem

6.2.1 Adding Data using the Data Grid

The Data Grid in the Data Model can be used to add data to your decision problem. This grid functions like a table in a database and data may be copied or pasted between applications such as Microsoft *Excel* or *Access*.

The data in the Data Grid can only be changed for your problem's *Criterion* elements. All data other than the titles for the alternatives is generated by *Decision Maker*. To help you identify your criterion data, the Data Grid column header text is coloured using the same colour code used throughout *Decision Maker* (Figure 50).

To copy or paste data between the Data Grid and any other application, using your mouse, select the data you want to copy, or replace, then right-click on the selected area and choose the appropriate command.

When pasting data into the Data Grid, ensure that the number of cells being pasted matches the number of cells in the Data Grid. An error will occur if there is no match.

Data can only be added to Criterion type elements. The data in all other elements is generated by Decision Maker, excluding Alternative elements.

6.2.2 Calculating Results in the Data Model

Calculating results in *Decision Maker* may be performed at any time within the Data Model. Do this by selecting the **Project | Calculate** menu option as shown in Figure 55.

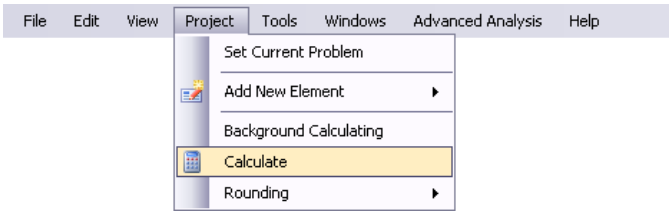


Figure 55. Calculating results

When the calculate function has been selected, *Decision Maker* calculates the result for the entire problem. If you have a large problem structured in *Decision Maker*, the process may take a few seconds to complete. The results from the calculation are presented in the Data Grid under the column heading ***Cardinal Score***. The information in this column is the normalised result of the CRITIC [1] decision-analysis process. The calculated results are displayed against each of the problem's alternatives. This enables you to quickly assess the performance of each alternative.

6.2.3 Calculation Errors

Decision Maker requires data for at least one alternative within each criterion. If you create a new *Criterion* element, the data values will be set at the default value of zero (0). If all data are of the same value, *Decision Maker* cannot calculate a result and ***NaN***[4] will be displayed for the objective, as shown in Figure 56. If the criterion is far down the hierarchy, the error will propagate up the hierarchical tree to the top most *Problem* element. To remove this error, you are required to add data to your decision problem. This requires you to ensure all *Criterion* elements have data for each alternative, which will then ensure that *Decision Maker*'s output is valid (based on the data you have provided).

[4] Not a Number.

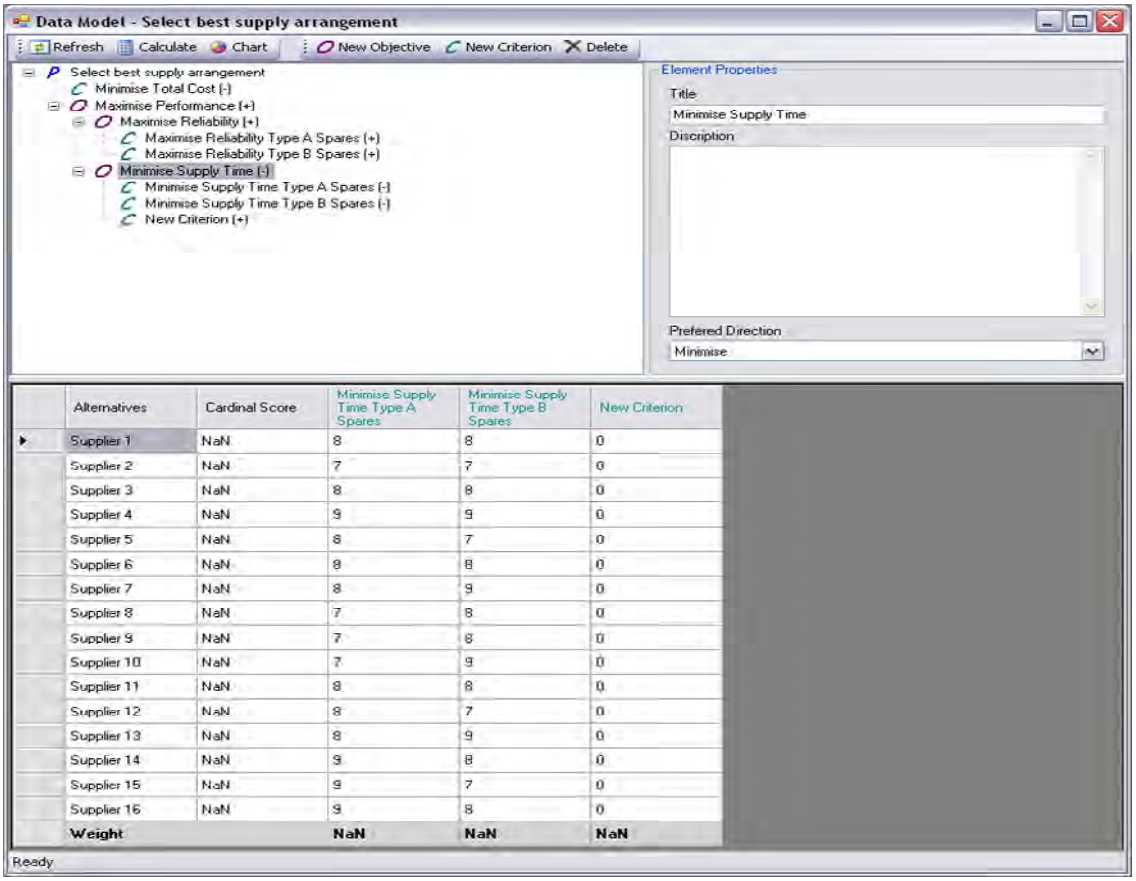


Figure 56. An incomplete calculation produces a 'NaN' result

6.2.4 Charting Results in the Data Model

Within the Data Model, *Decision Maker* provides a tool to chart the output of the decision-analysis process. This is achieved by first selecting the *Problem* element, or any *Objective* element in your problem's structure, and opening the chart window. To chart the data for any of the problem's elements, follow these steps:

1. in the Element Tree, select the element to be charted; and
2. select the **View | Chart** menu option as shown in Figure 57, or click on the chart button in the ***Data Model*** window.

The scaling of the chart will be automatically adjusted by *Decision Maker*. If you are charting your problem, or an objective, the chart will be scaled between 0.00 and 1.00 on the vertical axis. The problem's alternatives will be listed on the horizontal axis. If you are charting a *Criterion* element, the vertical axis will be scaled between the minimum and maximum values of the criterion's data.

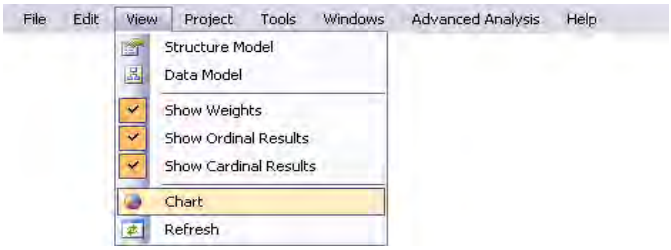


Figure 57. Charting scores

7. Simulations

Decision Maker uses simulations to calculate the decision a number of times while allowing some or all of the criteria values to vary. This provides a method for analysing a range of the likely outcomes that may be encountered for each alternative.

To use the simulation component in *Decision Maker*, it is important to understand some basic concepts:

- **Simulation Run**: This is a unique number that identifies an individual simulation run. For example, if the Decision Problem is simulated 50 times, each run will be identified by a number from 1 to 50.
- **Simulation Set:** This is a collection of Simulation Runs.
- **SimulationID**: This is a unique identifier generated when a Simulation Set is run and, therefore, identifies a group of Simulation Runs.

The remainder of this section describes how to run a simulation. Later sections in the user guide will describe simulation reporting.

7.1 Running a Simulation

Running a simulation is simple. However, it does require that uncertainties have been entered for some, or all, of the criteria for the various alternatives in the ***Data Model*** view. To run a simulation, select the **Tools | Run Simulation** menu option as shown in Figure 58. The ***Simulation Settings*** dialog box shown in Figure 59 will then appear.

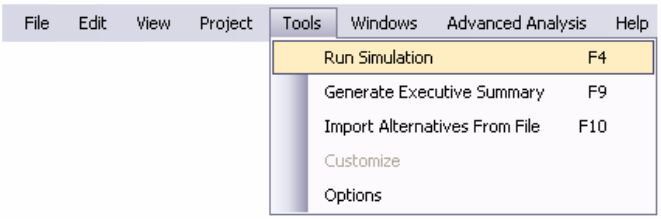


Figure 58. Running a simulation

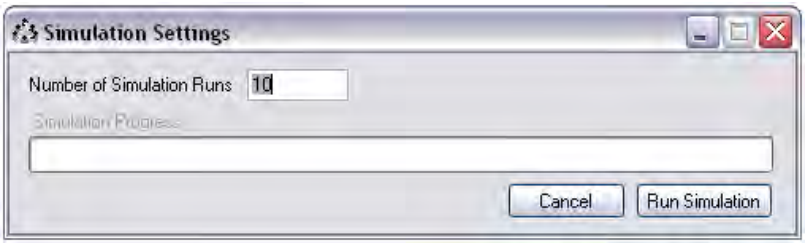


Figure 59. The Simulation Settings dialog box

Number of Simulation Runs is the number of times the simulation will calculate the problem. It is recommended that at least 50 runs are selected, since this provides better reporting data and data sampling. When set, click on the ***Run Simulation*** button to proceed. The confirmation prompt shown in Figure 60 will then appear.

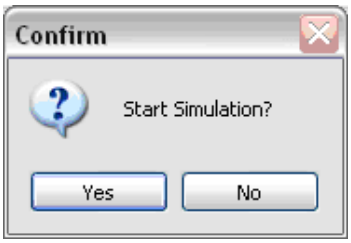


Figure 60. Run simulation confirmation prompt

Click the ***Yes*** button to start the simulation. Clicking ***No*** will return to the ***Simulation Settings*** dialog box (Figure 59). When the simulation process has begun, the progress will be visible as shown in Figure 61.

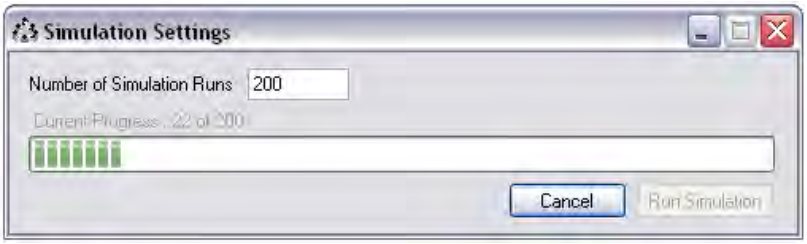


Figure 61. Simulation progress dialog box

When the simulation is complete, the dialog box shown in Figure 62 will appear. Click on the ***OK*** button to close the dialog box. *Decision Maker* will then return to the main user interface. Simulation results can now be viewed using any of the following tools:

- Simulation Reporting (Section 8);
- Scoring Matrix (Section 9);
- Domination Scoring Matrix (Section 10);
- Cobweb Plot Viewer (CWViewer) (Section 11);
- Weights Sensitivity Analysis (Section 12); or
- Criteria Sensitivity Analysis (Section 13).

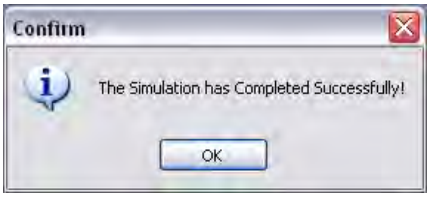


Figure 62. The simulation completed successfully dialog box

8. Simulation Reporting

The simulation reporting interface provides the summary for a simulation run and is the first analysis that should be viewed to provide a summary of the performance for each alternative. It presents summary information that can be used as a starting point for further elimination of poor performing alternatives and as a means of sorting the top performing alternatives before a more thorough analysis is performed.

The simulation reporting interface can be started from the *Decision Maker* main user interface and does not require a project to be open. Do this by selecting the **Advanced Analysis | Simulation Reporting** menu option as shown in Figure 63. The window shown in Figure 64 will then appear.

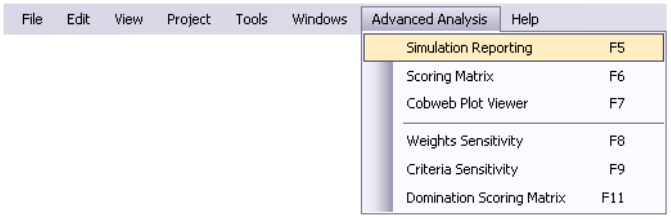


Figure 63. Starting simulation reporting

If an alternative has the lowest, average and best scores all being the same value then it will not appear in the graph. A work around for this is outlined in Section 8.2.3.

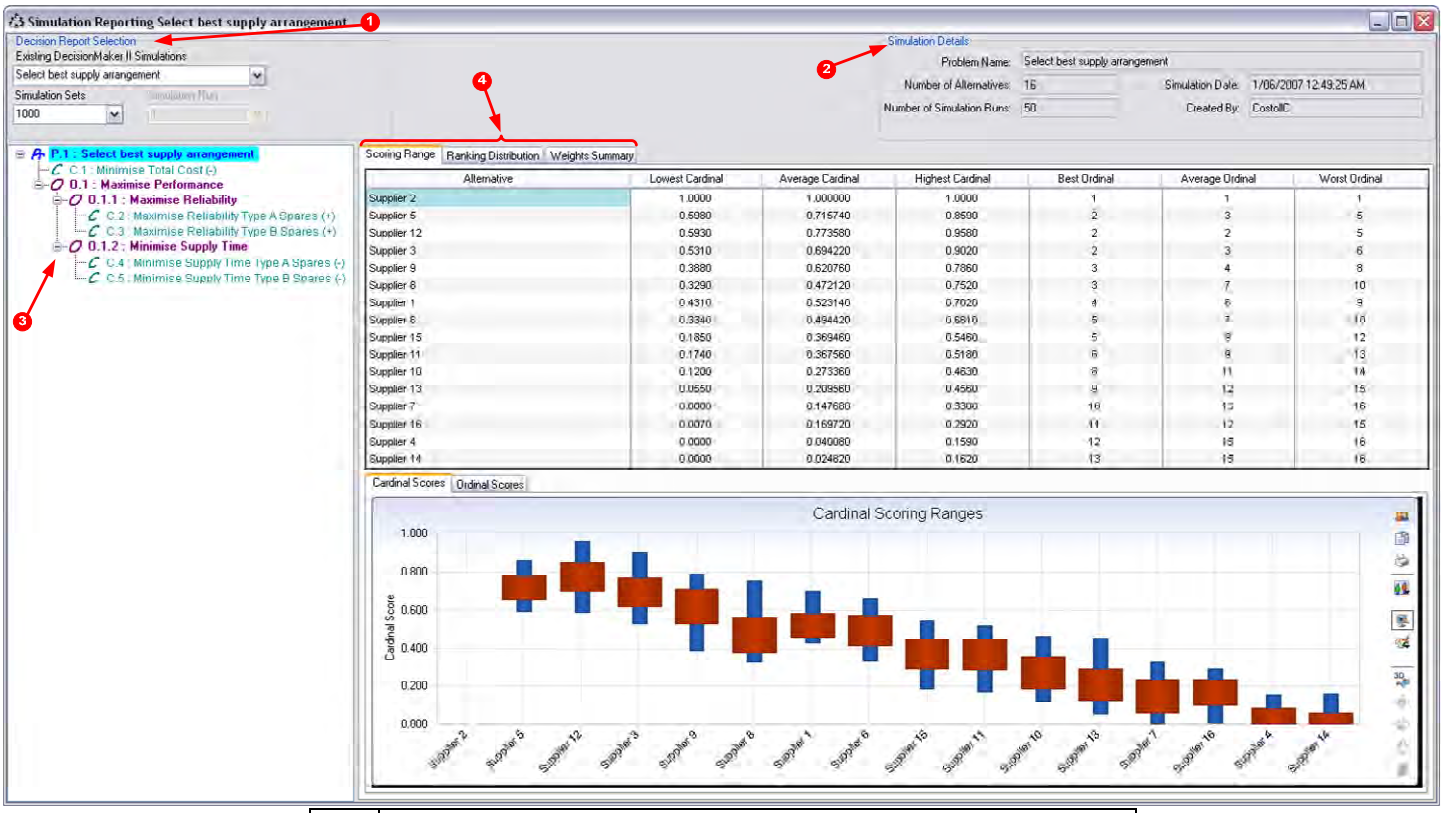
8.1 The Simulation Reporting Interface

The following subsections describe the four elements shown in Figure 64.

8.1.1 Decision Report Selection

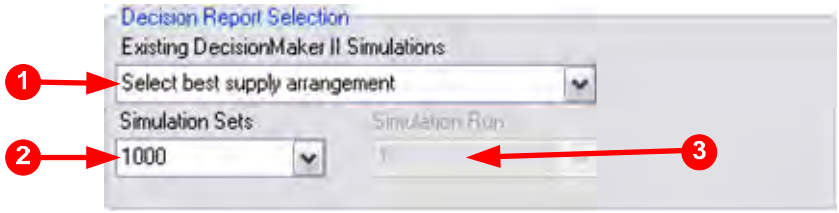
Figure 65 shows an enlarged view of the ***Decision Report Selection*** area of Figure 64.

When Simulation Reporting is selected, option 3 *(Figure 64) will always be disabled.*



1	***Decision Report Selection*** (Section 8.1.1).
2	***Simulation Details*** (Section 8.1.2).
3	Simulation Reporting Decision Tree (Section 8.1.3).
4	Simulation Report Tabs: • ***Scoring Range*** (Section 8.2); • ***Ranking Distribution*** (Sections 8.3 and 8.4); and • ***Weights Summary*** (Section 8.5).

Figure 64. Simulation Reporting interface (overview)

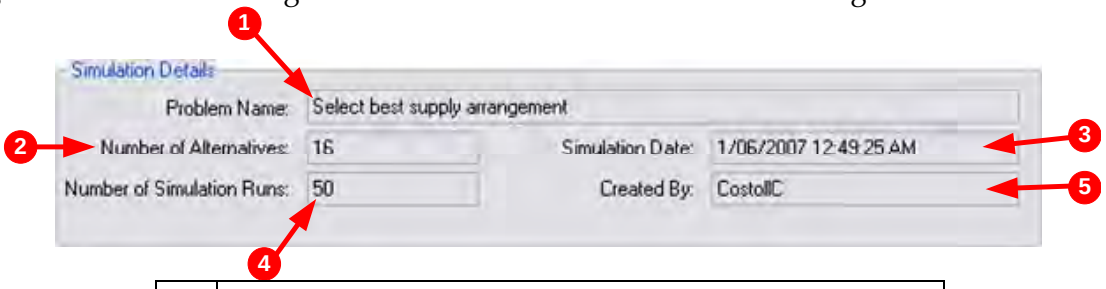


1	This drop down box contains all the available decision problem simulations by problem name.
2	For each decision problem there may be one or more simulation sets. This drop down box contains the list of their unique identifying numbers.
3	Each simulation set contains one or more simulation runs. In this example it is disabled, however, at other times, it is enabled to allow selection of a single simulation from a set.

Figure 65. Decision Report Selection

8.1.2 Simulation Details

Figure 66 shows an enlarged view of the ***Simulation Details*** area of Figure 64.



1	The name of the *Decision Maker* problem.
2	The number of alternatives that have been created for comparison in the problem.
3	The date and time the simulation was run.
4	The number of simulation runs for the selected simulation set.
5	The name of the person who ran the simulation (the *Decision Maker* user login).

Figure 66. Simulation Details

8.1.3 Simulation Reporting Decision Tree

Figure 67 shows an enlarged view of the Simulation Reporting Decision Tree area of Figure 64.

1	A cyan coloured highlight indicates that this is the selected node for viewing.
2	Criteria are visible however they do not provide any information when selected.
3	*Problem* and *Objective* elements are used to provide information in the Simulation Reporting Decision Tree.

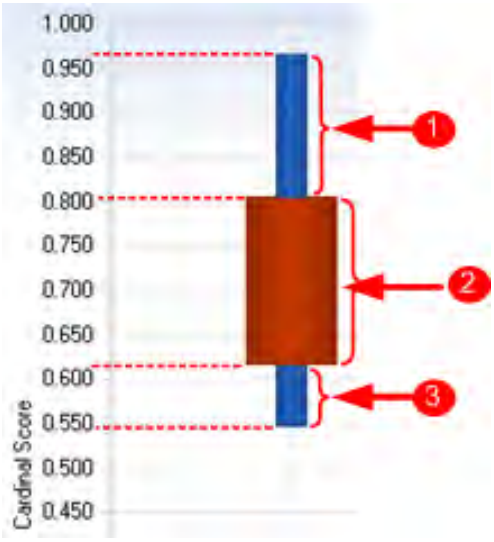
Figure 67. Simulation Reporting Decision Tree

8.1.4 Hi-Lo Range Bars

The Hi-Lo range bars in Figure 64 show the maximum, minimum and the ranges of the top 25%, middle 50% and lower 25% scoring ranges. Figure 68 describes elements of the Hi-Lo range bars. An interpretation of the example in Figure 68 is that, in relation to all the simulation runs:

- the cardinal scores range from 0.550 to 0.965;
- 25% of the time the alternative scored between 0.550 and 0.615;
- 50% of the time the alternative scored between 0.615 and 0.810;
- 25% of the time the alternative scored between 0.810 and 0.965;

- 75% of the time the alternative scored between 0.550 and 0.810; and
- 75% of the time the alternative scored between 0.615 and 0.965.



1	The upper narrow blue bar shows the range for the top 25% of scores.
2	The thicker red bar shows the range for the middle 50% of scores.
3	The bottom narrow blue bar shows the range for the bottom 25% of scores.

Figure 68. Hi-Lo range bars

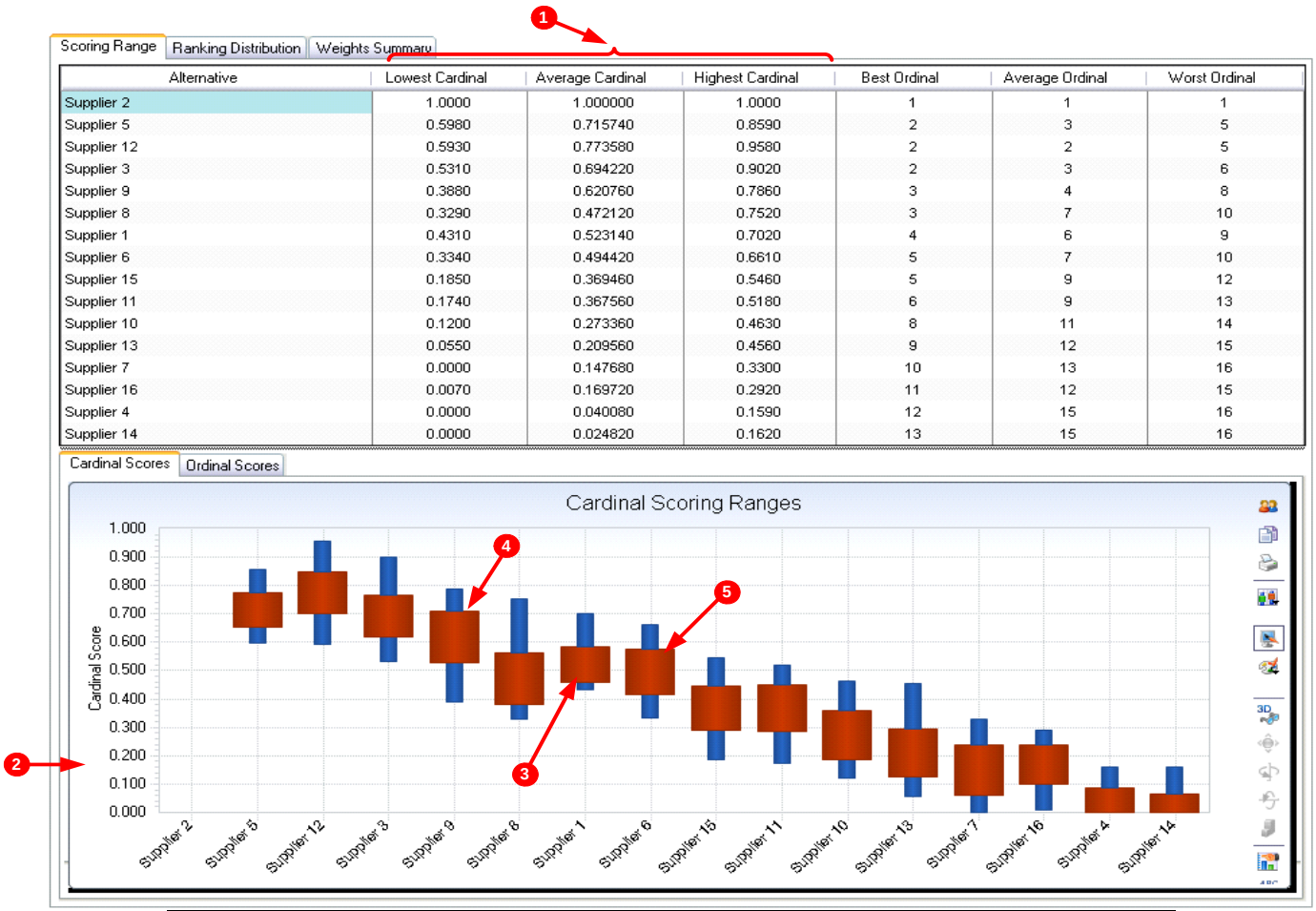
The location of the red bar can also be used to identify the region within the range of scores that an alternative was most likely to score if further simulations were run. In Figure 68, the red bar is located closer to the bottom of the scoring range. This indicates that the alternative scored more often somewhere in the lower range of scores in the simulation runs.

8.2 Scoring Range

The ***Scoring Range*** tab provides immediate information about how each alternative performed across all the simulation runs in a simulation set. The graphical window provides for cardinal scoring and ordinal scoring analysis. Figure 69 presents the elements of the ***Scoring Range*** tab.

8.2.1 Cardinal Scoring Ranges

The top half of Figure 69 shows some basic information collected from a simulation set, namely the range of cardinal scores that each alternative was assigned and the average cardinal score. Here the cardinal scores are indicated by the red bracket. In the case of cardinal scoring, the higher score is the better option.

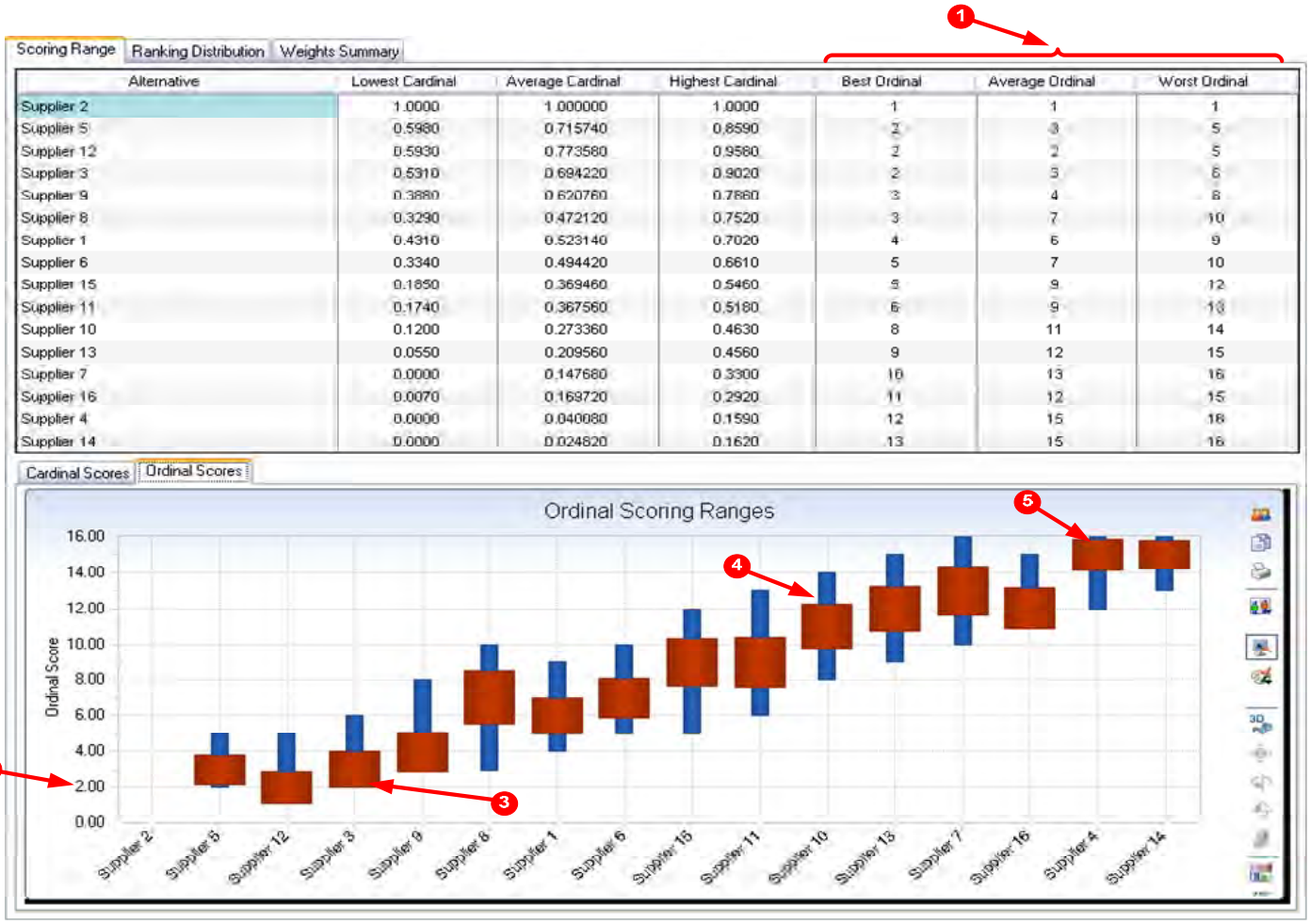


1	The table view contains the lowest, average and highest cardinal scores for each alternative for a set of simulation runs.
2	The ***Cardinal Score*** axis is used to determine the range of scores for each alternative.
3	This range bar indicates that most scores were in the lower part of the range.
4	This range bar indicates that most scores were in the upper part of the range.
5	This range bar indicates the scores were more-or-less evenly spread across the range.

Figure 69. Cardinal scoring ranges

8.2.2 Ordinal Scoring Ranges

The top half of Figure 70 shows some basic information collected from a simulation set, namely the range of ordinal scores that each alternative was assigned and the average ordinal score. Here the ordinal scores are indicated by the red bracket. In ordinal scoring, the lower the score is the better option.



1	The table view contains the best, worst, and average ordinal scores for each alternative for a set of simulation runs.
2	The range or ordinal scores obtained by an alternative can be read from the ***Ordinal Score*** axis.
3	This range bar indicates that most scores were in the lower part of the range, i.e. a better ordinal score.
4	This range bar indicates the scores were more-or-less evenly spread across the range.
5	This range bar indicates that most scores were in the upper part of the range, i.e. a worse ordinal score.

Figure 70. Ordinal scoring ranges

8.2.3 Hi-Lo Range Bars Not Appearing

At times, the Hi-Lo range bars for an alternative will not appear in the graphical display. This is due to the best, worst and average scores all being equal, as in highlighted by 1 in Figure 71.

Figure 71. Missing Hi-Lo range bars

To overcome this and display the missing data, the plot gallery needs to be changed to the bar or line plot. The line plot is simple to understand and is accessed as indicated by the call out 2 in Figure 72. To open scoring plot gallery, right click the mouse in the plot area and the menu shown in Figure 72 will appear. The plot will then change to a line plot of the same data and the missing alternatives will now be visible, as indicated by the call out 3 in Figure 73.

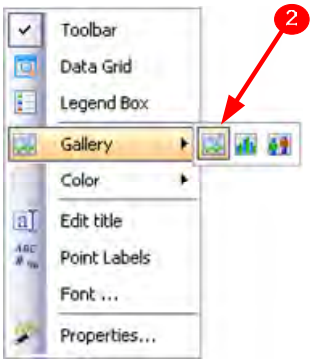
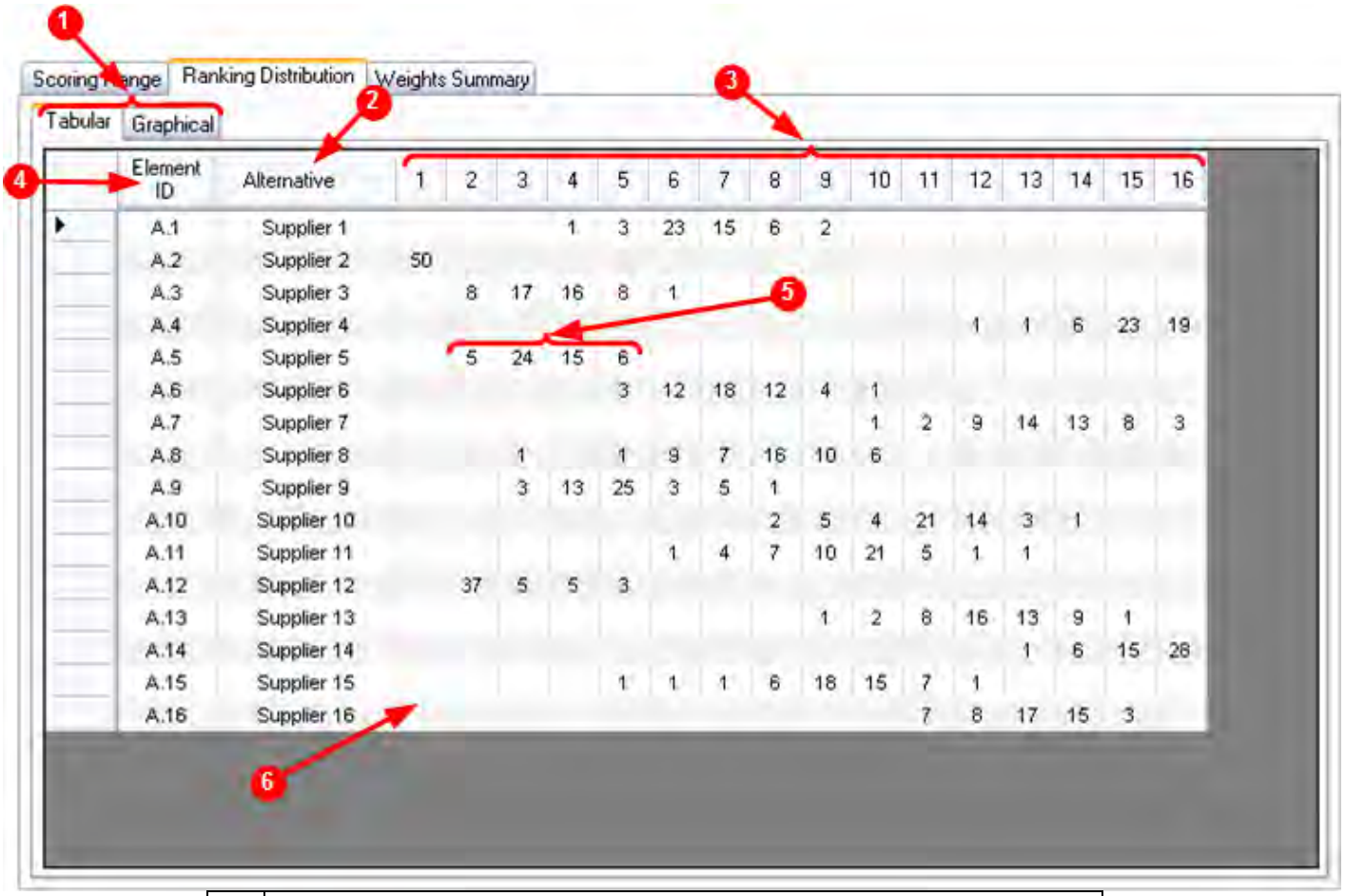


Figure 72. Scoring plot gallery

Figure 73. Line plot showing missing alternatives

8.3 Ranking Distribution (Tabular)

The ***Ranking Distribution*** tab, indicated by ❹ in Figure 64, is shown in Figure 74. Within the ***Ranking Distribution*** tab are two sub-tabs: ***Tabular***; and ***Graphical***. Figure 74 presents the ranking distribution in tabular format. Section 8.4 presents the ranking distribution in graphical format.

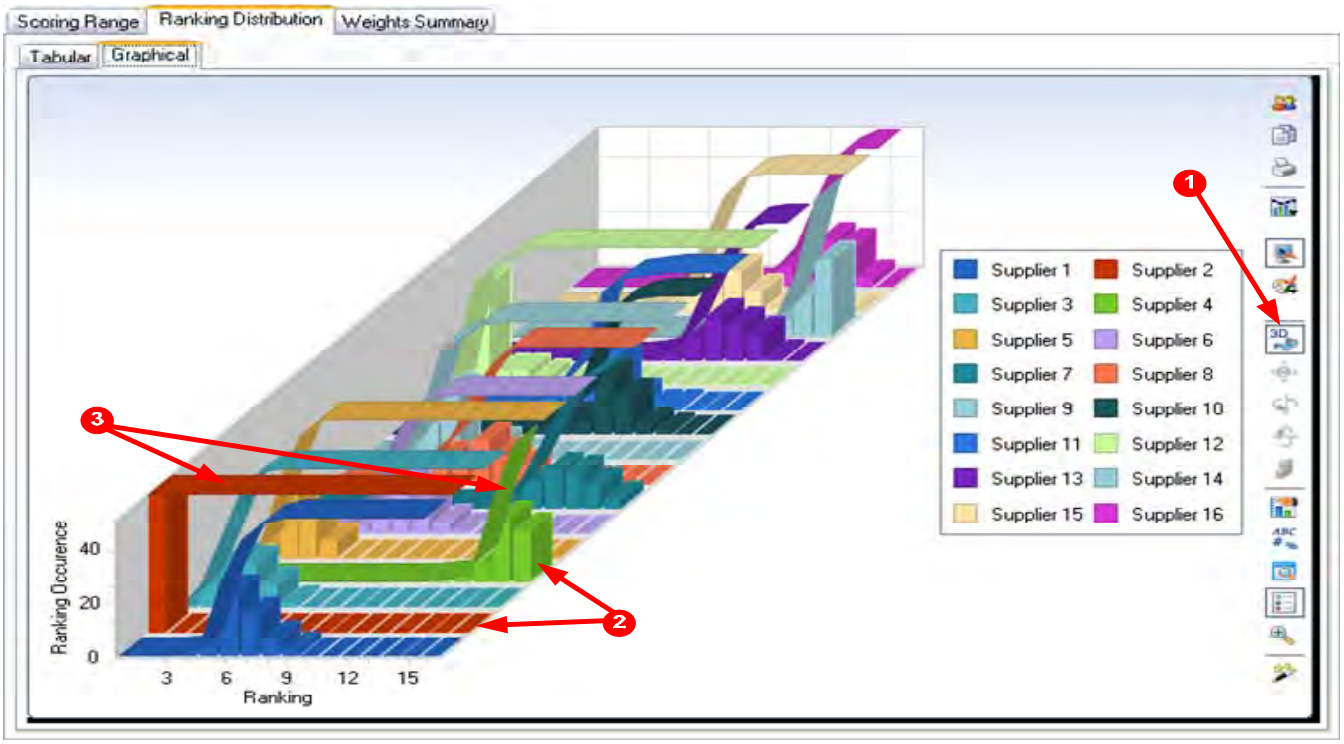


❶	Two views are available: ***Tabular*** and ***Graphical***.
❷	The ***Alternative*** column contains the names of all the available alternatives.
❸	The column headers contain numbers that correspond to the ordinal ranking.
❹	This is the uniquely generated identifier created when a *Decision Maker* element is added to a project.
❺	As a working example, ***Supplier 5*** scored the following rankings: • 5 times it ranked 2nd; • 24 times it ranked 3rd; • 15 times it ranked 4th; and • 6 times it ranked 5th.
❻	This table area shows the ranking distributions for each alternative for all the simulation runs (in this example, 50 simulation runs were conducted).

Figure 74. Ranking Distribution tabular format

8.4 Ranking Distribution (Graphical)

The ***Graphical*** tab in the ***Ranking Distribution*** window contains a graphical representation of the ranking distribution table, as shown in Figure 75. The two different views shown in Figures 75 and Figure 76 are examples of when to take advantage of the two and three dimensional plots. If there are only a small number of alternatives being viewed then the two dimensional plot may be more preferable and easier to read. If there are a large number of alternatives in the view simultaneously then the three dimensional view may be more preferable. The button visible in the plot area toolbar, indicated by 1 in Figures 75 and 76, is used to toggle between the views.

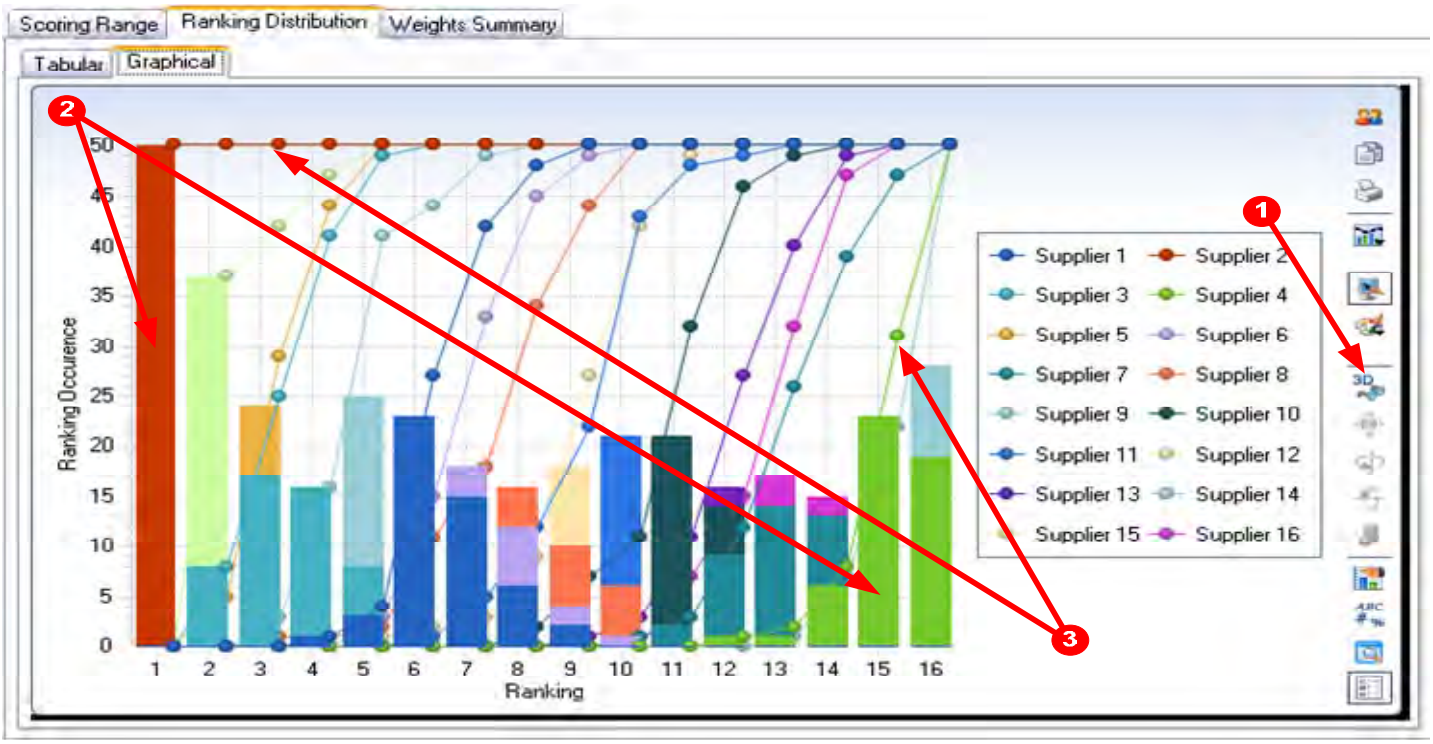


1	Toggle 2-Dimensional/3-Dimensional View.
2	Ranking Count.
3	Cumulative Total.

Figure 75. Overview of ranking distribution 3D graphical analysis

Each graph has two components: a bar section; and a line section. The bar indicates the number of times an alternative was ranked in the corresponding ordinal rank. This is indicated by 2 along the bottom axis of the graph in Figures 75 and 76.

The line component indicated by 3 in Figures 75 and 76 is a cumulative indicator for the alternative in percentage terms. When all of the ranking occurrences have been displayed in the bars, the line will plateau to indicate 100% of the values for that alternative have been displayed.

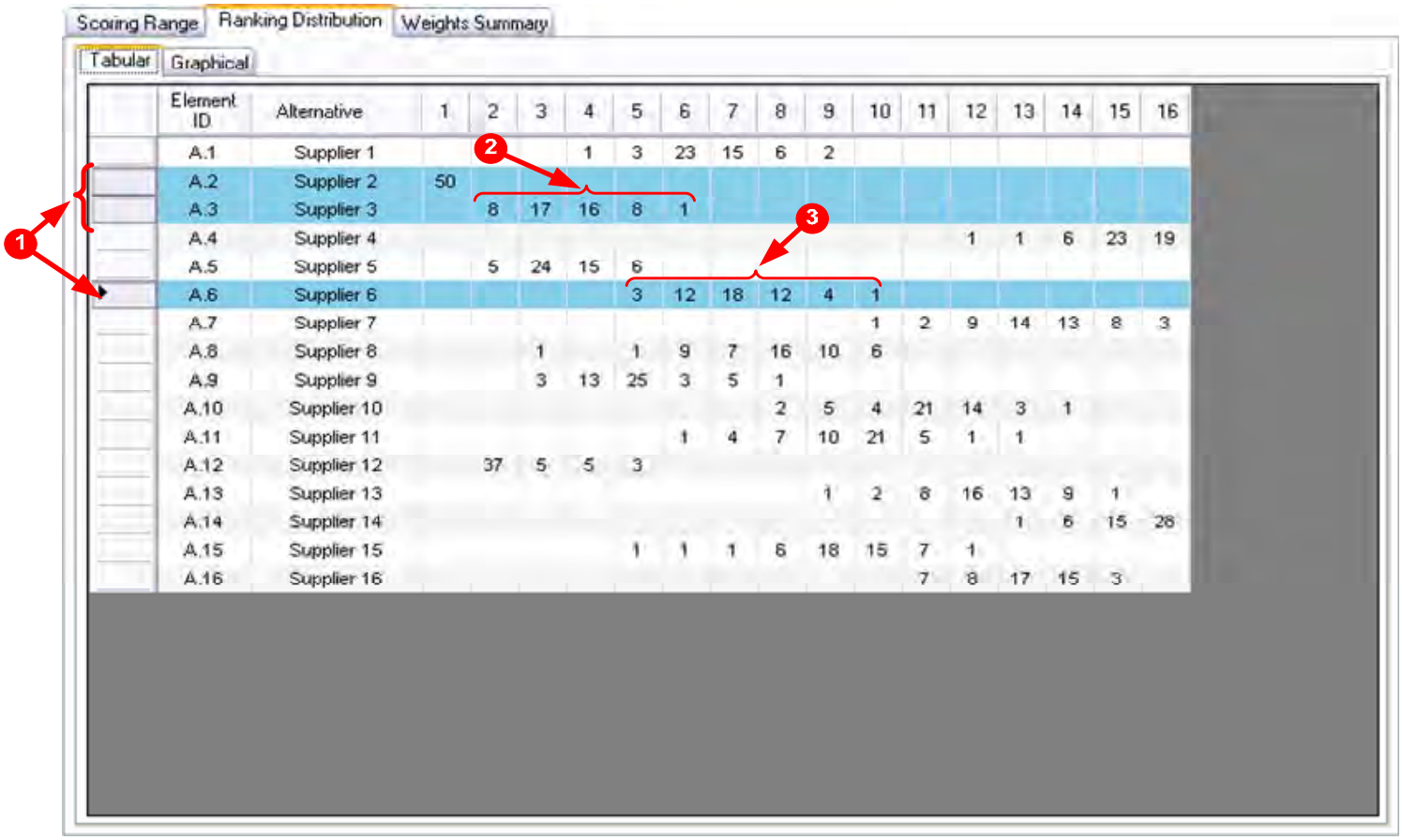


1	Toggle 2-Dimensional / 3-Dimensional View.
2	Ranking Count.
3	Cumulative Total.

Figure 76. Overview of ranking distribution 2D graphical analysis

8.4.1 Filtering Alternatives

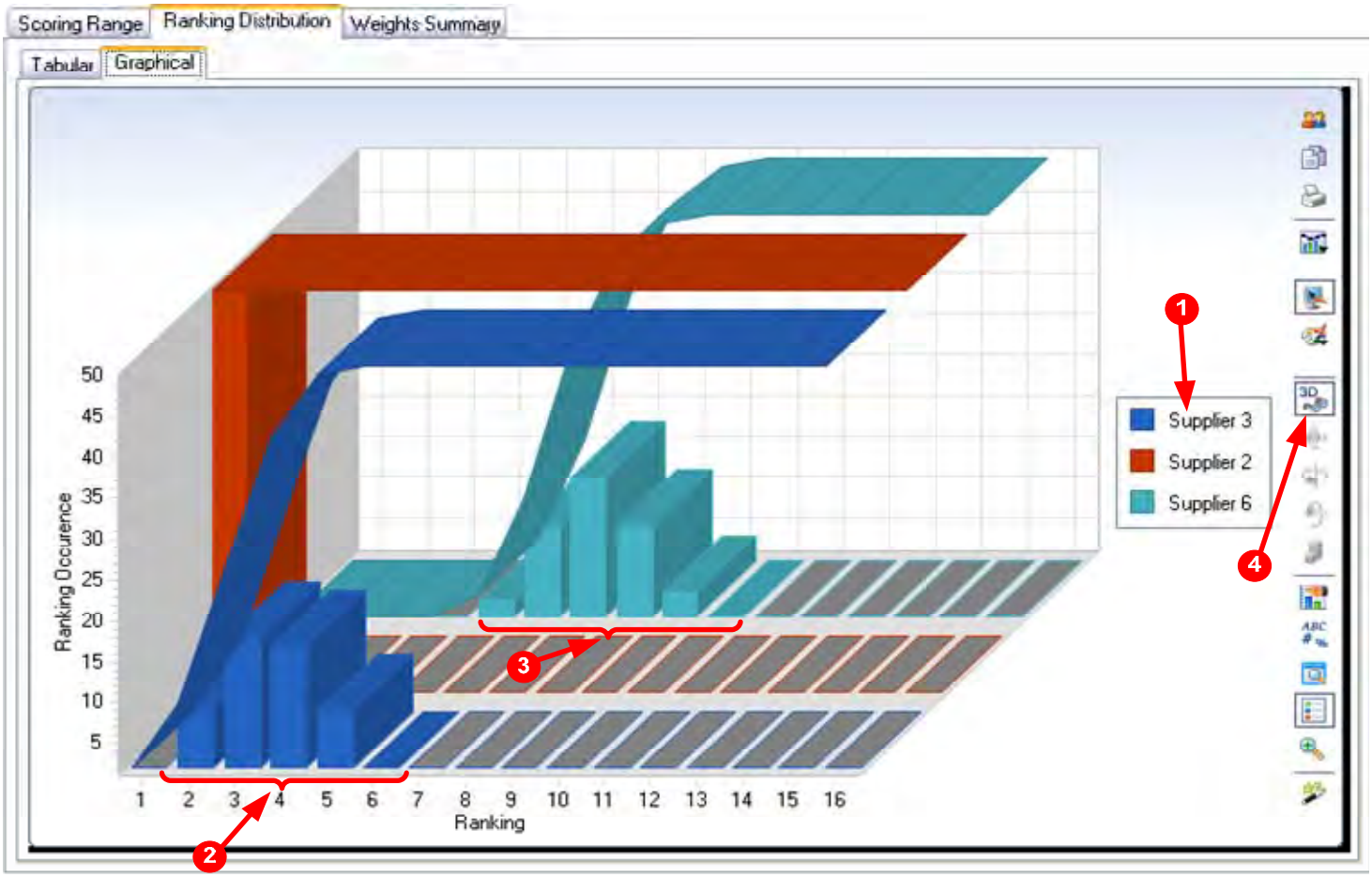
To select one or more alternatives to display in the graph area, click the left mouse button in the row header area of the table shown in Figure 77. To remove the alternative from the graphical display, click the right mouse button in the row header area of the alternative that is to be removed. Figures 77, 78 and 79 show the filtering of alternatives in tabular, three-dimensional graphical form and two-dimensional graphical form, respectively.



Element ID	Alternative	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A.1	Supplier 1				1	3	23	15	6	2							
A.2	Supplier 2	50															
A.3	Supplier 3		8	17	16	8	1										
A.4	Supplier 4												1	1	6	23	19
A.5	Supplier 5		5	24	15	6											
A.6	Supplier 6					3	12	18	12	4	1						
A.7	Supplier 7										1	2	9	14	13	8	3
A.8	Supplier 8			1		1	9	7	16	10	6						
A.9	Supplier 9			3	13	25	3	5	1								
A.10	Supplier 10								2	5	4	21	14	3	1		
A.11	Supplier 11						1	4	7	10	21	5	1	1			
A.12	Supplier 12		37	5	5	3											
A.13	Supplier 13									1	2	8	16	13	9	1	
A.14	Supplier 14													1	6	15	26
A.15	Supplier 15					1	1	1	6	18	15	7	1				
A.16	Supplier 16											7	8	17	15	3	

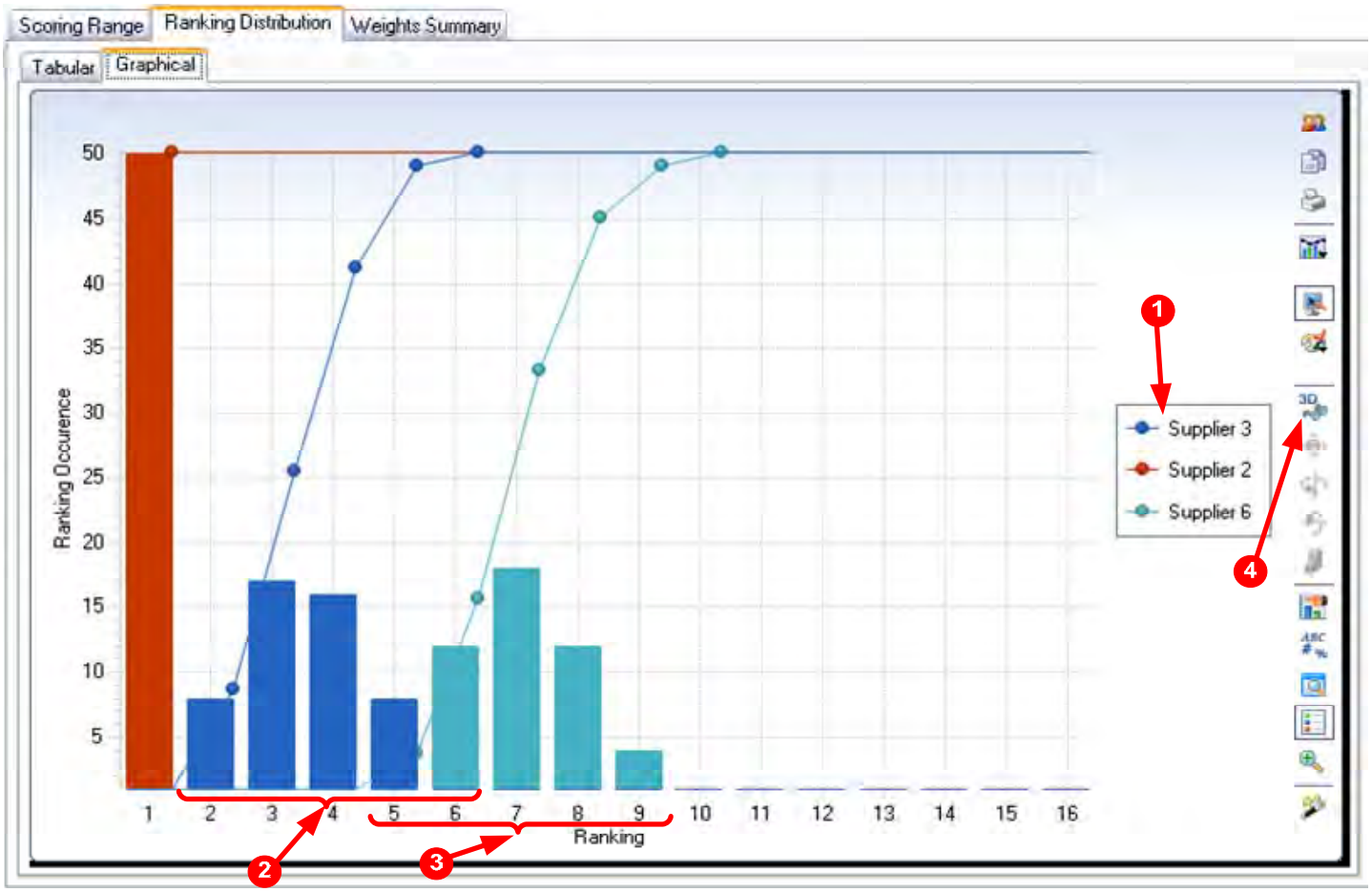
1	Row header: used to select/deselect alternatives displayed in the graphical view. In this example ***Supplier 2***, ***Supplier 3*** and ***Supplier 6*** have been selected.
2	***Supplier 3*** ranking in tabular form.
3	***Supplier 6*** ranking in tabular form.

Figure 77. Filtering alternatives (Ranking Distribution - Tabular)



1	Legend: used to show the alternatives being displayed in the graphical view. In this example ***Supplier 2***, ***Supplier 3*** and ***Supplier 6*** have been selected.
2	***Supplier 3*** ranking in graphical form.
3	***Supplier 6*** ranking in graphical form.
4	Use the 2D/3D switching option if it becomes difficult to interpret the graph, or to select fewer alternatives.

Figure 78. Filtering alternatives (Ranking Distribution - Graphical 3D)



1	Legend: used to show the alternatives being displayed in the graphical view. In this example, ***Supplier 2***, ***Supplier 3*** and ***Supplier 6*** have been selected.
2	***Supplier 3*** ranking in graphical form.
3	***Supplier 6*** ranking in graphical form.
4	Use the 2D/3D switching option if it becomes difficult to interpret the graph, or to select fewer alternatives.

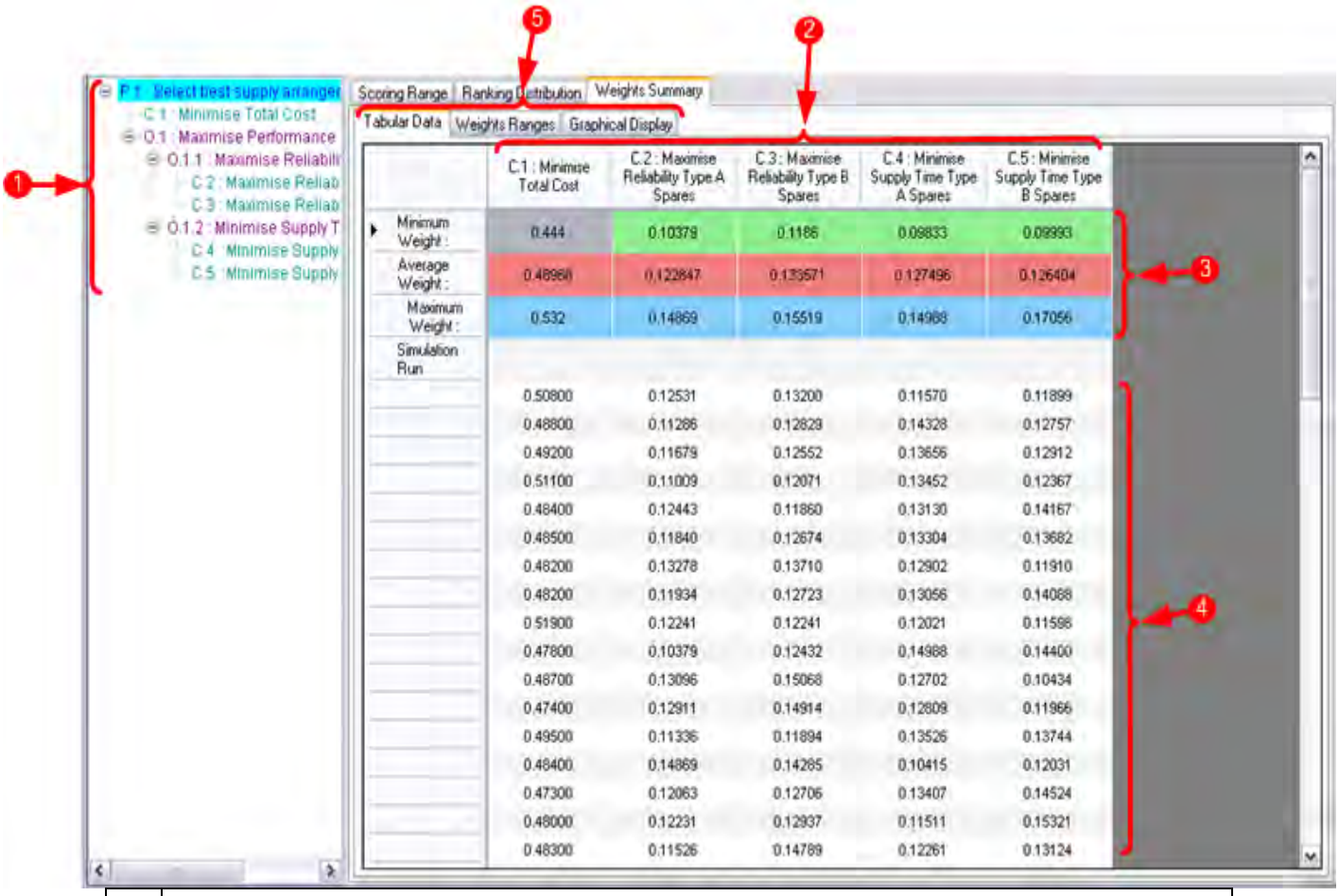
Figure 79. Filtering alternatives (Ranking Distribution - Graphical 2D)

8.5 Weights Summary

Weights Summary can be used to view the weights distribution calculated for all the criteria and objectives in the decision problem. There are three sub-tabs in the ***Weights Summary*** tab: ***Tabular Data***; ***Weights Ranges***; and ***Graphical Display***. Each is described in the following subsections.

8.5.1 Tabular Data

Selecting an objective or problem node in the decision tree will update the weights summary to show the weightings used for the child criteria and objectives. Figure 80 shows an example of the ***Tabular Data*** tab within the ***Weights Summary*** tab.



1	The tree view is used to select the level for analysis. Here the top-level is shown so all criteria weights will be displayed.
2	All the weights for the problem ***P.1 Select Best Supply Arrangement*** are shown, However, if ***0.1.2 Minimise Supply Time*** was selected, only the weights for ***C.4*** and ***C.5*** would be displayed.
3	The top three rows summarise the data with the minimum, average and maximum weights for each criterion.
4	The weights calculated for each simulation run is displayed in the table.
5	There are three tabs available for viewing the weights data in various ways: tabular, as shown in the figure; as a weight a range, which graphically displays the data presented in the first three rows (Section 8.5.2); and graphically, which is a graphic representation of the weight data (Section 8.5.3).

Figure 80. Overview of Weights Summary

8.5.2 Weights Ranges

Figure 81 shows an example of the ***Weights Ranges*** display for the top-level element in the Simulation Reporting Decision Tree. If some criteria weights have a small range, and it is desirable to examine them more closely, this can be done by selecting an element further down the tree. For example, to compare all the weights excluding ***C.1 Minimise Total Cost***, select ***O.1 Maximise Performance*** in the Simulation Reporting Decision Tree. The display will change as shown in Figure 82.

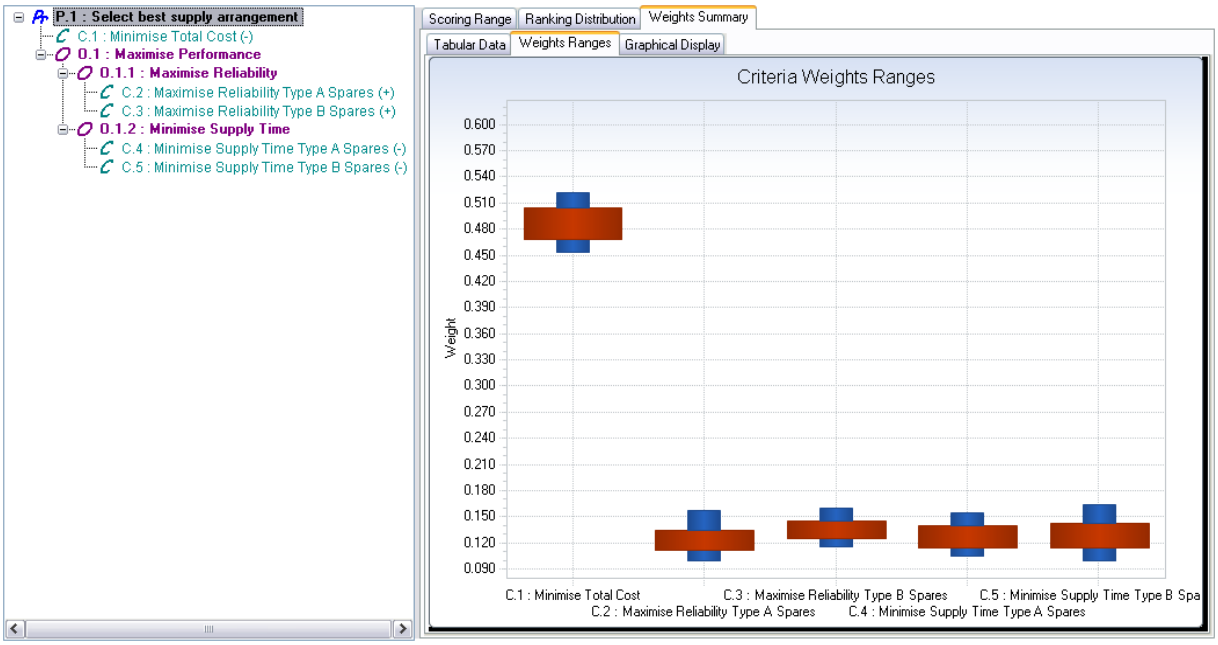


Figure 81. Weights Ranges (graphical example 1)

Figure 82. Weights Ranges (graphical example 2)

8.5.3 Graphical Display

Figure 83 shows a graphical representation of the weight data. Here the weights are shown for each simulation run. In this example, the weightings used for ***Maximise Reliability Type B Spares*** are almost always greater than for ***Maximise Reliability Type A Spares***. The Weights Distribution plot has a toolbar where changes can be made to the format of the plot. One item of particular use is the Gallery Chooser, on the right hand side of Figure 83, where a different form of plot can be selected.

Figure 83. Graphical display of the Weights Distribution plot

9. Scoring Matrix

The ***Scoring Matrix Viewer*** can be used independently or in conjunction with the other analysis windows. It is a useful guide in the initial analysis stages to assist in short-listing alternatives for a more thorough analysis. It provides a rapid method for identifying the more preferred solutions using a simple pivot table. This table compares alternatives directly against one another for all objectives and criteria values based on an entire set of simulation runs.

The Scoring Matrix calculates the fraction of simulation runs that one alternative has scored better than another alternative for the overall problem; or, similarly, for any objective or criteria. The Scoring Matrix viewer can be opened from the **Advanced Analysis | Scoring Matrix** menu as shown in Figure 84.

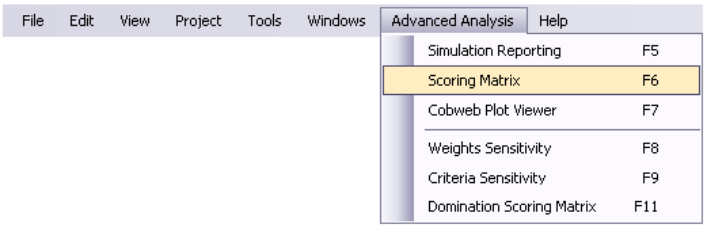
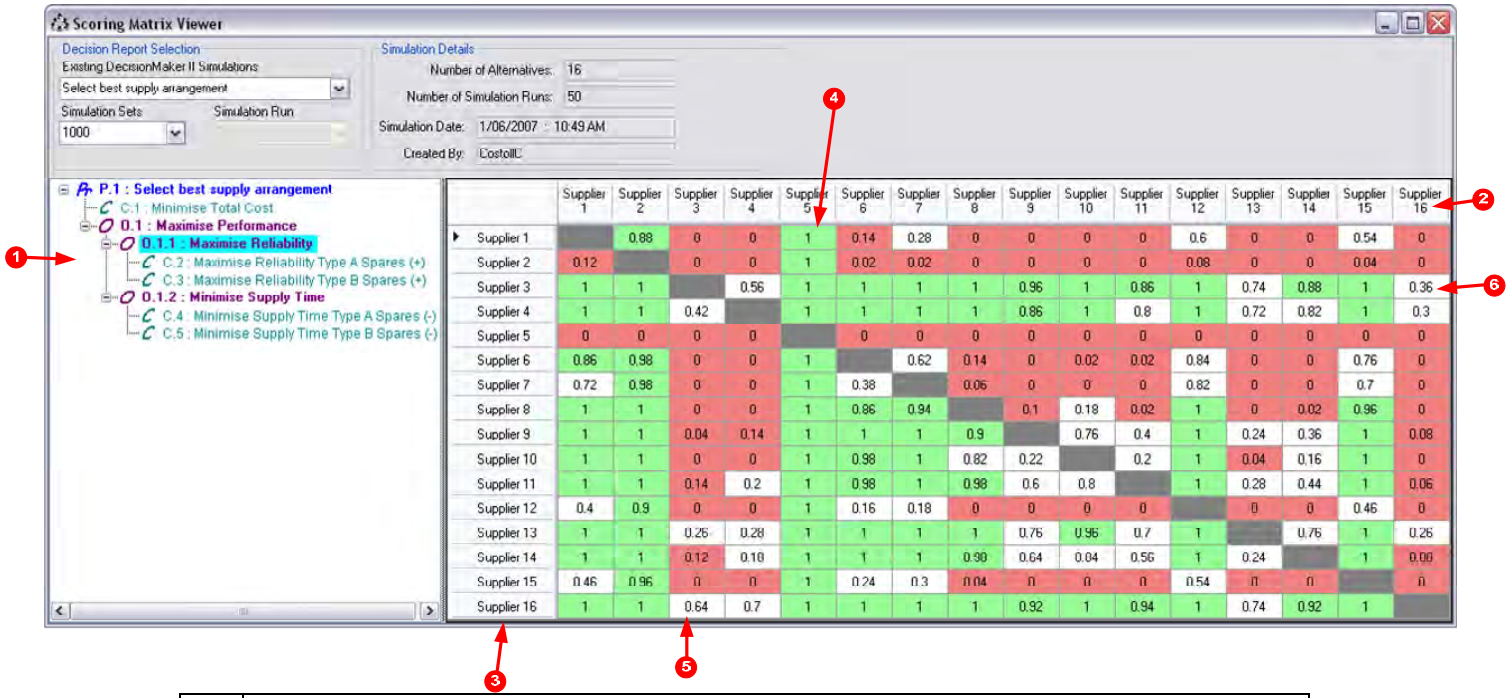


Figure 84. Starting the Scoring Matrix

When the ***Scoring Matrix Viewer*** is opened it will appear as shown in Figure 85. The matrix is used by selecting a column and a corresponding row from the ***Scoring Matrix Viewer***. Where the two intersect the cell will contain a number and be colour coded. The number

represents the fraction of simulation runs that the column alternative scored higher than the row alternative.



1	The Simulation Reporting Decision Tree is used to select the element for viewing.
2	The columns are used as the first alternative in the comparison.
3	The rows are the second alternative in the comparison.
4	Predominantly green columns indicate high scoring alternatives.
5	Predominantly red columns indicate low scoring alternatives.
6	The matrix can also be read along the row and then the column. If it is used in this manner then the colours have the opposite meanings and the value represents the fraction of simulation runs the alternative scored lower. For example in the cell with row selection ***Supplier 3*** and column selection ***Supplier 16***, this can be interpreted as ***Supplier 3*** scored lower than ***Supplier 16*** in 64% of the simulation runs, which is the same as ***Supplier 16*** scoring higher 36% of the time.

Figure 85. Scoring Matrix Viewer

The colour coding identifies the relative performance of the problem alternatives. For example, columns that are predominantly green indicate alternatives that scored highly for the selected problem, objective or criteria; the opposite is true for predominantly red columns. The colour coding is based on a range of values shown in Table 12.

Table 12. Scoring Matrix colour coding ranges

Colour	Scoring Range
Red	< 0.15
White	0.15 ≤ & ≤ 0.85
Green	> 0.85

10. Domination Scoring Matrix

The Domination Scoring Matrix is an advanced view that encompasses the features of the Scoring Matrix into one single view with only *Criteria* elements. It is a useful stand-alone tool and is also useful when used with the CWViewer (Section 11). It allows for a more comprehensive understanding of the level of performance of alternatives within the simulation context. The Domination Scoring Matrix can be started from the **Advanced Analysis | Domination Scoring Matrix** menu as shown in Figure 86.

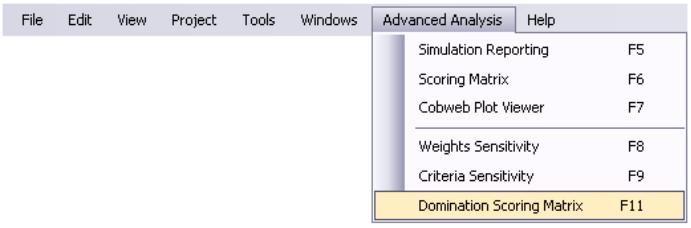


Figure 86. Starting the Domination Scoring Matrix

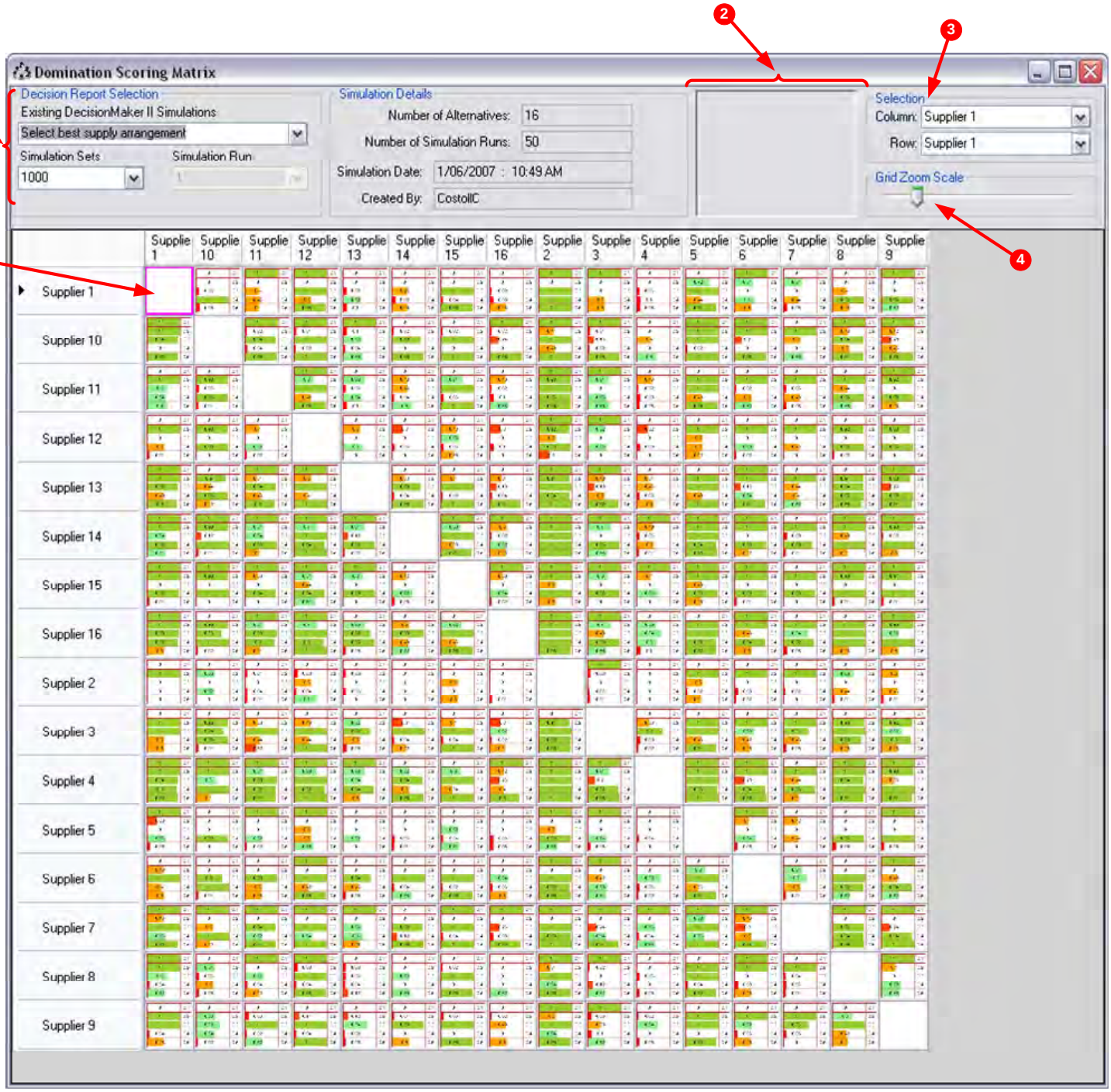
10.1 Basics

The base view for the Domination Scoring Matrix is a blank window. A Decision Problem or SimulationID selection must be made to populate the view. Once a selection is made, the view will appear similar to Figure 87. Cell selection is shown in Figure 88.

10.2 Using the Domination Scoring Matrix

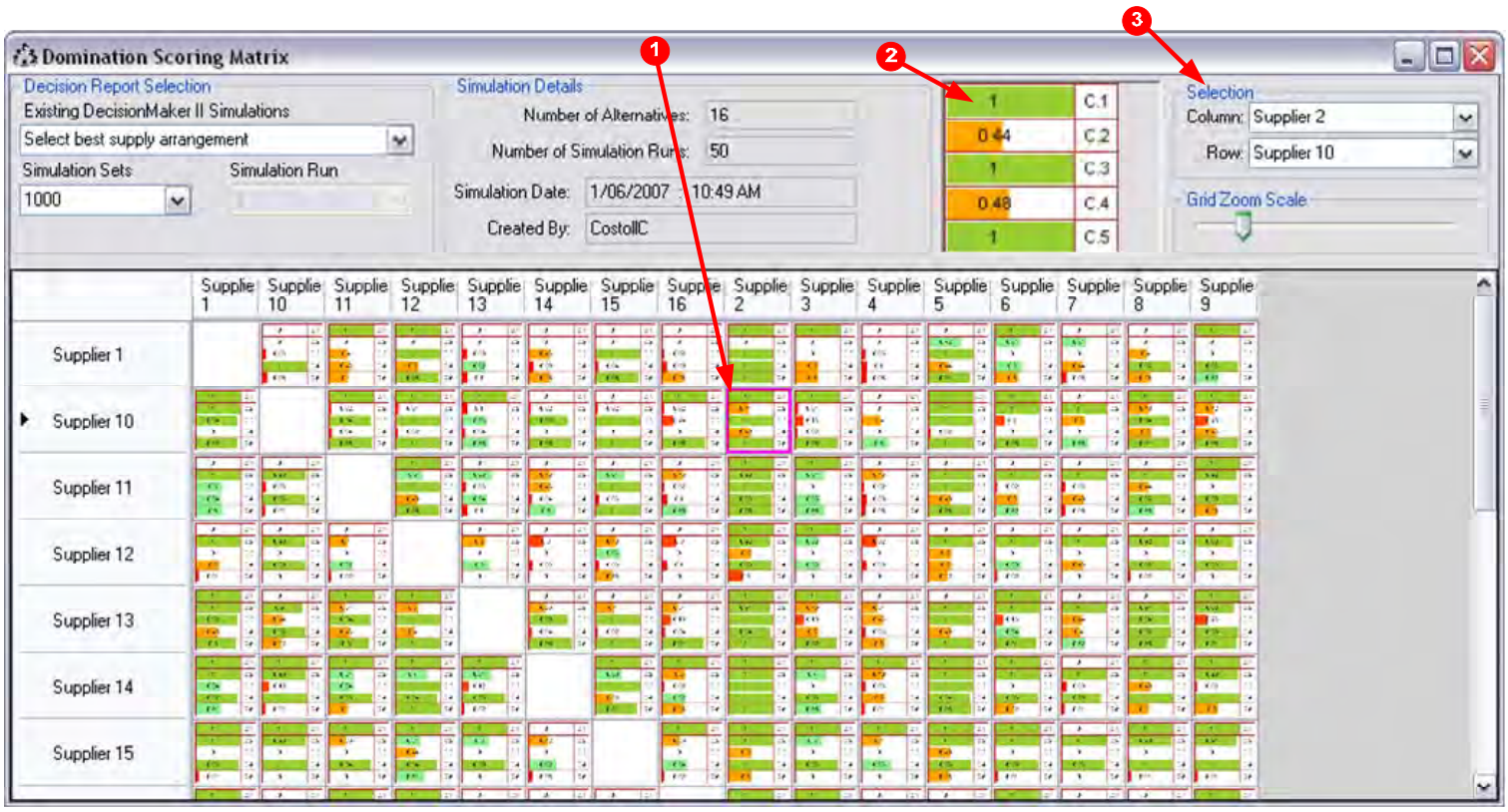
As mentioned, the Domination Scoring Matrix can be used individually or in combination with the CWViewer. On its own the Domination Scoring Matrix provides an overview of how the criteria values of various alternatives compare over an entire simulation. This is the same method employed by the Scoring Matrix, except in the Scoring Matrix interface all the criteria are visible at once, including a graphical and numerical representation providing more holistic detailed information.

Each cell in the Domination Scoring Matrix view is comprised of five components, namely a set of colour coded meter bars each with a superimposed number. This indicates the fraction of times that the column selected alternative criteria value was 'better' than the row selected alternative criteria value. For example, if the criterion direction of preference was to ***maximise*** then the alternative with a higher value would be the better alternative for this criterion alone. Figure 89 shows an example of the Domination Scoring Matrix and the colour coding indicates common ranges of performance, as presented in Table 13.



1	***Decision Report Selection*** (in this view the simulation run has no effect).
2	This region of the display shows an enlarged view of a cell, when the cell is clicked with the mouse or when a selection is made in the ***Selection*** drop boxes (seen in Figures 88 and 90).
3	The ***Selection*** drop boxes can be used to select two alternatives directly, without having to locate them in the grid view (this can be seen in Figure 88).
4	The ***Grid Zoom Scale*** can be used to increase/decrease the scale of the grid view to enable more, or less, cells to be displayed.
5	When a selection is made, the cell will be highlighted with a pink square.

Figure 87. Domination Scoring Matrix



1	This cell has been selected.
2	A zoomed view of this cell is now displayed.
3	The column and row selections will be updated to show the two alternatives being compared.

Figure 88. Domination Scoring Matrix cell selection

Table 13. Colour codes and corresponding range of performance

Colour	Range
Red	≤ 0.10
Orange-Red	0.10 < & ≤ 0.33
Orange	0.33 < & ≤ 0.50
Light Green	0.50 < & ≤ 0.75
Olive Green	> 0.75

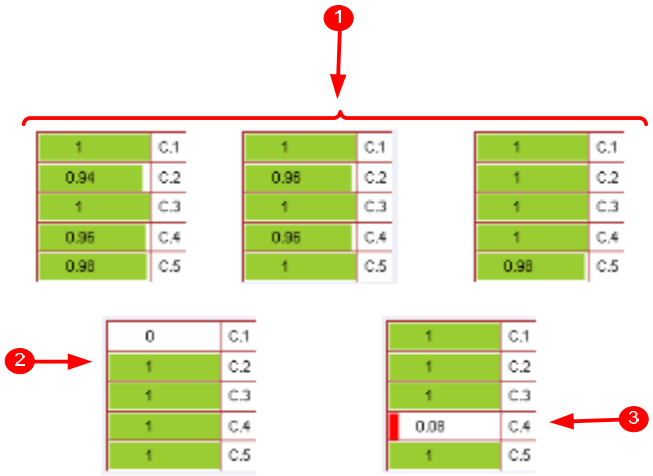
1	This shows an example of the appearance when the alternative criteria never scores better than the other alternative, i.e. here ***Supplier 13*** scores better 0% of the time for ***C.1 Minimise Total Cost***. This is not a surprising result since there was no uncertainty for this criterion and so, for every simulation run, the values remained the same.
2	For ***C.2 Maximise Reliability Type A Spares***, ***Supplier 13***'s reliability was better than ***Suppler 3***'s reliability 52% of the time.
3	For ***C.5 Maximise Reliability Type B Spares***, ***Supplier 13***'s reliability was only better than ***Supplier 3***'s reliability 8% of the time.
4	For ***C.4 Minimise Supply time Type A Spares***, ***Supplier 13***'s supply time was better than ***Supplier 3***'s supply time 50% of the time.
5	For ***C.3 Maximise Reliability Type B Spares*** in all simulations, ***Supplier 14***'s cost value was better than the other Suppliers.
6	This shows the selection of alternatives. Here the comparison being made is what fraction of simulations ***Supplier 13***'s criteria scored better than ***Supplier 3***'s criteria.

Figure 89. Domination Scoring Matrix example

10.3 Dominant Alternatives

One of the uses of the Domination Scoring Matrix is to determine dominant alternatives. A completely dominant alternative is one where all of its criteria values score better than all the criteria values of another alternative. This has the effect that the dominant alternative will always be more preferred than any other alternative regardless of the decision tree or weights that are used (provided all directions of preference for each and every criterion remains the same).

Within the Domination Scoring Matrix, for every criterion, any alternative that scores 1.0 against another alternative is a dominant alternative in every simulation. Due to the nature of simulations there may be a scenario where no alternative is completely dominant. Hence, the Domination Scoring Matrix can assist in finding the alternatives that are almost dominant and for all practical purposes should be considered as dominant. Figure 90 shows some examples of dominant alternatives using criteria that correspond to the *Supply Manager's Dilemma* presented in Section 2.



1	In these examples, the column alternative could safely be considered dominant.
2	Here ***C.1*** has a weighting of approximately 50% (not shown in diagram) while it scores better on performance it could be premature to dismiss this alternative as being superior.
3	In this example ***C.4*** has a weighting of approximately 13% (not shown in diagram). This is a case of not complete dominance in the true sense, however for practical purposes 'could' be considered to be so.

Figure 90. Domination Scoring Matrix examples

10.4 Holistic View

When the Grid Zoom Scale is set to the maximum zoom out value, the grid appears as shown in Figure 91. This view can initially be used after running a simulation to assess the various alternatives and eliminate some of the poor scoring alternatives before analysis of the remainder using the CWViewer. It is important to use the Domination Scoring Matrix and Scoring Matrix to determine if alternatives should be considered for short-listing, especially if some of the middle range alternatives score well at times in the simulation, or if many alternatives score well and it is difficult to determine which is more preferred.

1	Here is an example of what the column should look like for the higher scoring alternatives, i.e. the column should have cells that appear predominantly green.
2	The columns that are predominantly white, red and/or have small amounts of green indicate poorly performing alternatives.

Figure 91. Domination Scoring Matrix holistic view (maximum zoom out)

11. Cobweb Plot Viewer

The CWViewer is used for a cobweb graphical analysis of the decision problem. It can be started from the **Advanced Analysis | Cobweb Plot Viewer** menu as shown in Figure 92. The Window shown in Figure 93 will then appear. The features and functionalities for the CWViewer are presented in the following subsections.

For a large number of simulation runs the plot area can be slow to refresh and, because of this, the plot will only redraw based on some special selection events. If you have made a selection change and the plot does not redraw itself, it can be forced to redraw by moving the mouse in and out of the Plot Element Selector.

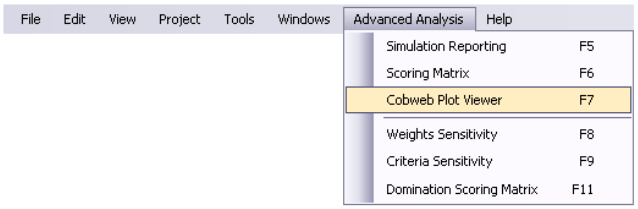
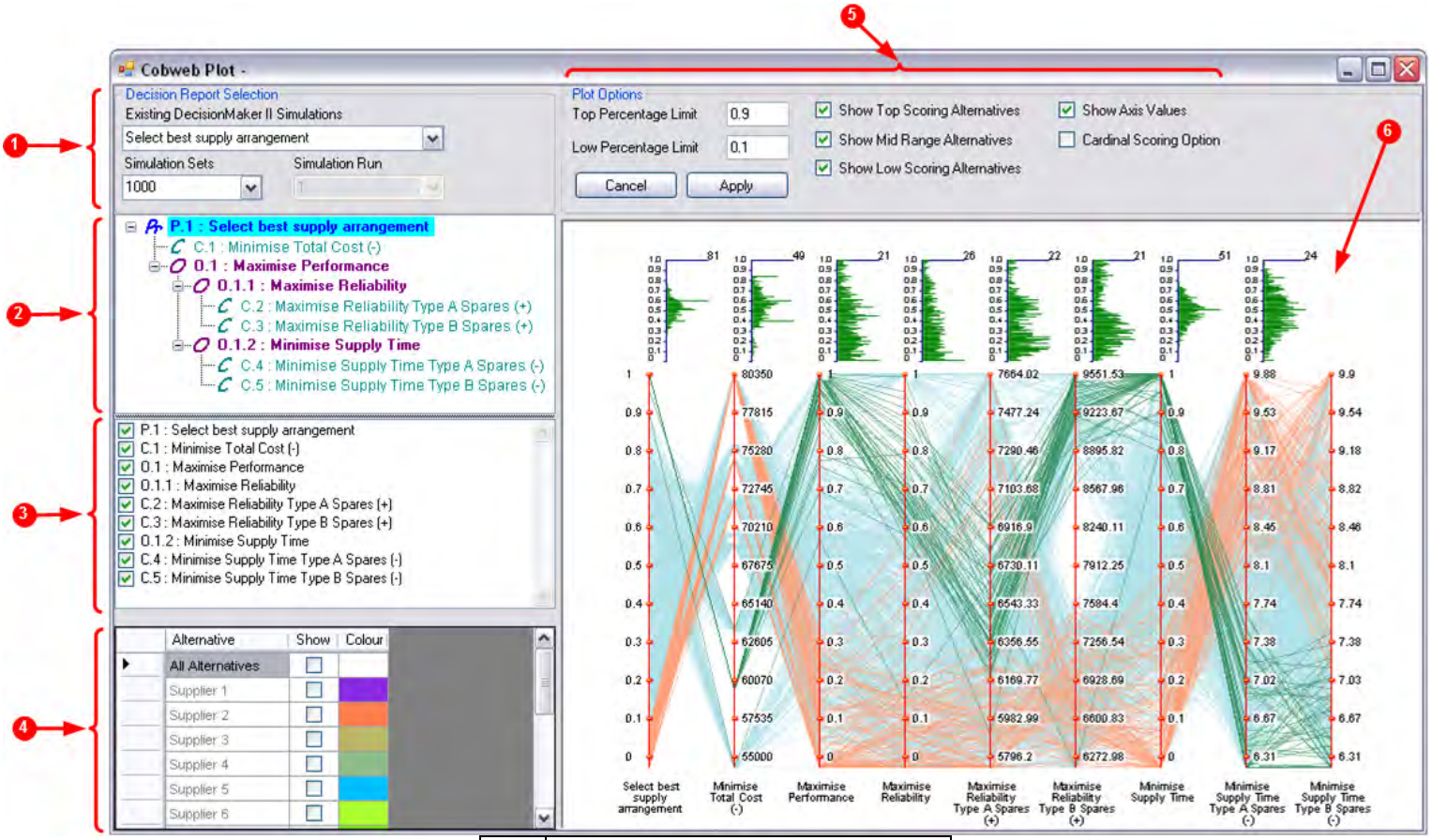


Figure 92. Starting the CWViewer

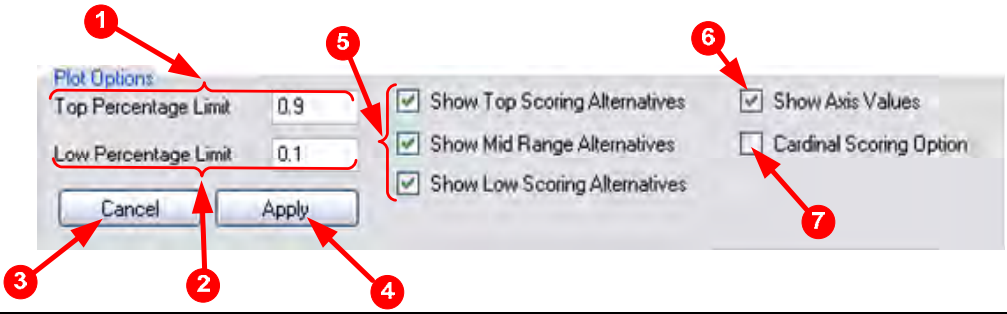


1	Simulation Selector.
2	Simulation Decision Reporting Tree.
3	Plot Element Selector.
4	Alternative Selector.
5	Plot Options.
6	Plot Area.

Figure 93. CWViewer (overview)

11.1 Plot Options

Figure 94 presents a closer view of the ***Plot Options*** area of the CWViewer (Figure 93).



1	***Top Percentage Limit***: any alternatives with a cardinal score for element ***P.1*** that is above this value will be deemed to be Top Scoring alternatives.
2	***Low Percentage Limit***: any alternatives with a cardinal score for element ***P.1*** that is below this value will be deemed to be Low Scoring alternatives.
3	Cancels any change to the ***Top Percentage Limit*** or ***Low Percentage Limit***.
4	Applies changes to the ***Top Percentage Limit*** or ***Low Percentage Limit*** and redraws the plot.
5	Selecting or unselecting any of these checkboxes will hide/display the applicable group: • Alternatives with a cardinal score above the ***Top Percentage Limit*** will be coloured green. • Alternatives with a cardinal score below the ***Low Percentage Limit*** will be coloured rust. • Alternatives with a cardinal score between the ***Top Percentage Limit*** and ***Low Percentage Limit*** will be coloured pale blue colour.
6	Toggles the axis labels on the plot.
7	Displays plot with the cardinal scoring option (Section 11.3.2).

Figure 94. CWViewer Plot Options

11.2 Plot Area

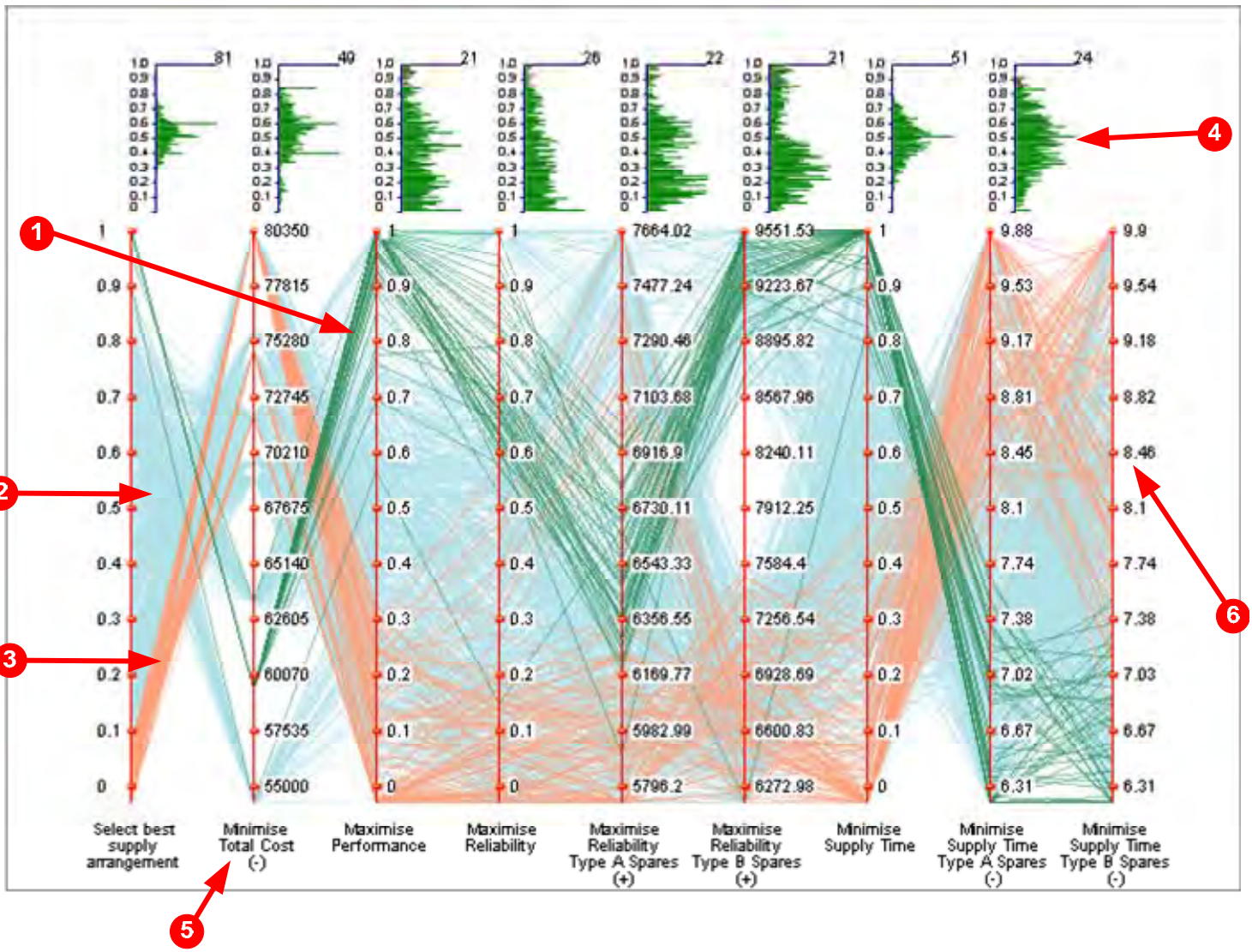
The Plot Area is used for a graphical analysis of the decision problem. A special feature available on the plot area is a context menu to enable the plot graphic to be copied to the Microsoft *Windows* clipboard. This will allow for pasting the copied area into other applications, such as Microsoft *Word* or *Excel*. The menu for copying the plot graphic is opened by clicking the right mouse button in the Plot Area.

11.2.1 Plot Area (Without Cardinal Scoring Option)

The CWViewer, without the cardinal scoring option, facilitates the identification of correlations between the criteria in the decision problem. This is shown in Figure 95.

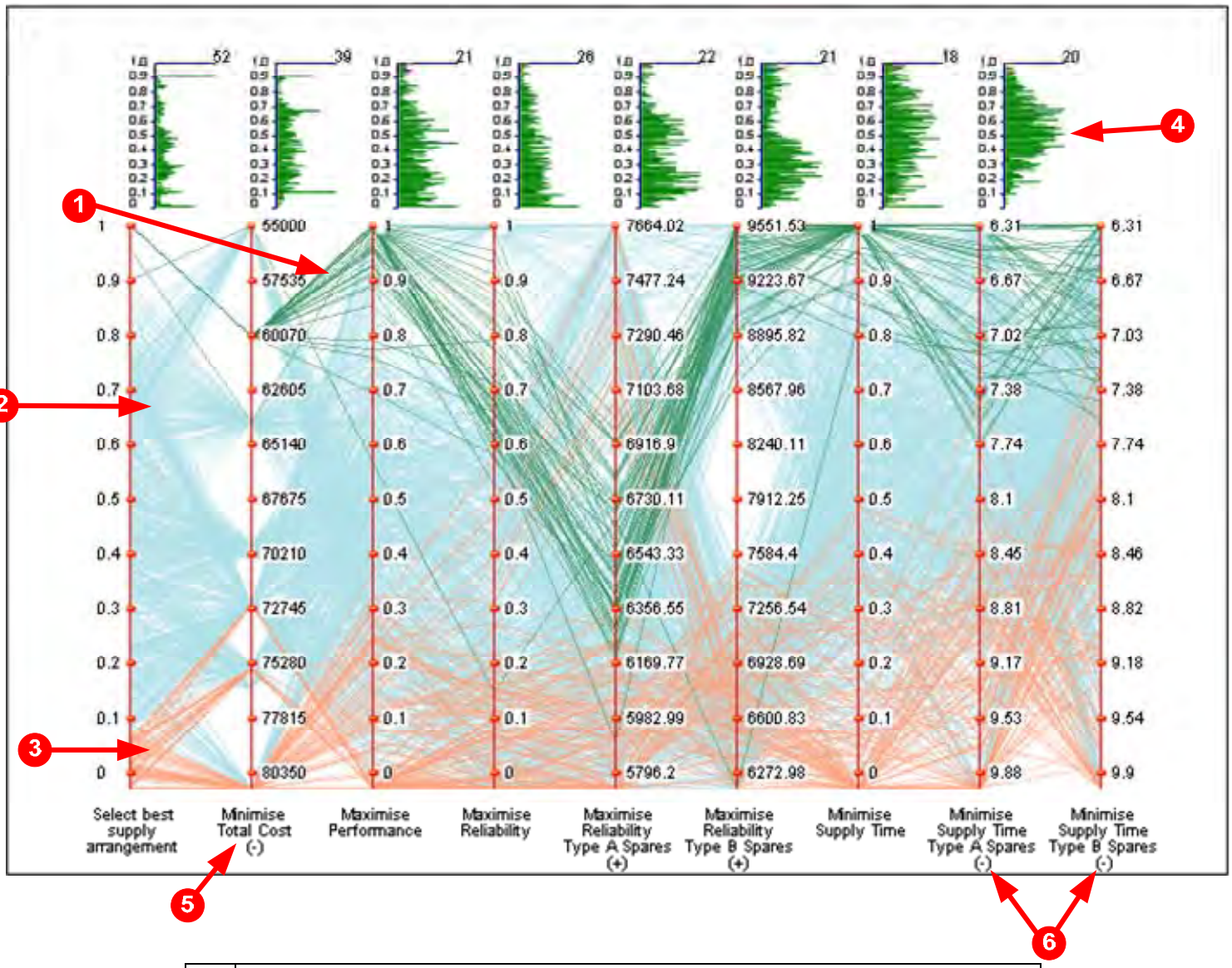
11.2.2 Plot Area (with Cardinal Scoring Option)

The CWViewer with the cardinal scoring option provides a view where each axis is rescaled so the most preferable point of crossing for any alternative is at the top most point. This provides a way to identify the more preferable alternatives since they will intersect each axis at or near the top, even if the criteria's direction of preference is ***minimise***. This is shown in Figure 96.



1	The top 10% scoring alternatives are displayed by default with a dark green colour.
2	The Mid-Range scoring alternatives are displayed by default with a pale blue colour.
3	The Lowest 10% scoring alternatives are displayed by default with a pale rust colour.
4	Stem Plots (Cross Densities). These are explained in Section 11.2.3.
5	Objectives and criteria can be selected as required.
6	Values on the axes can be turned on or off as desired.

Figure 95. CWViewer (basic view without Cardinal Scoring Option)

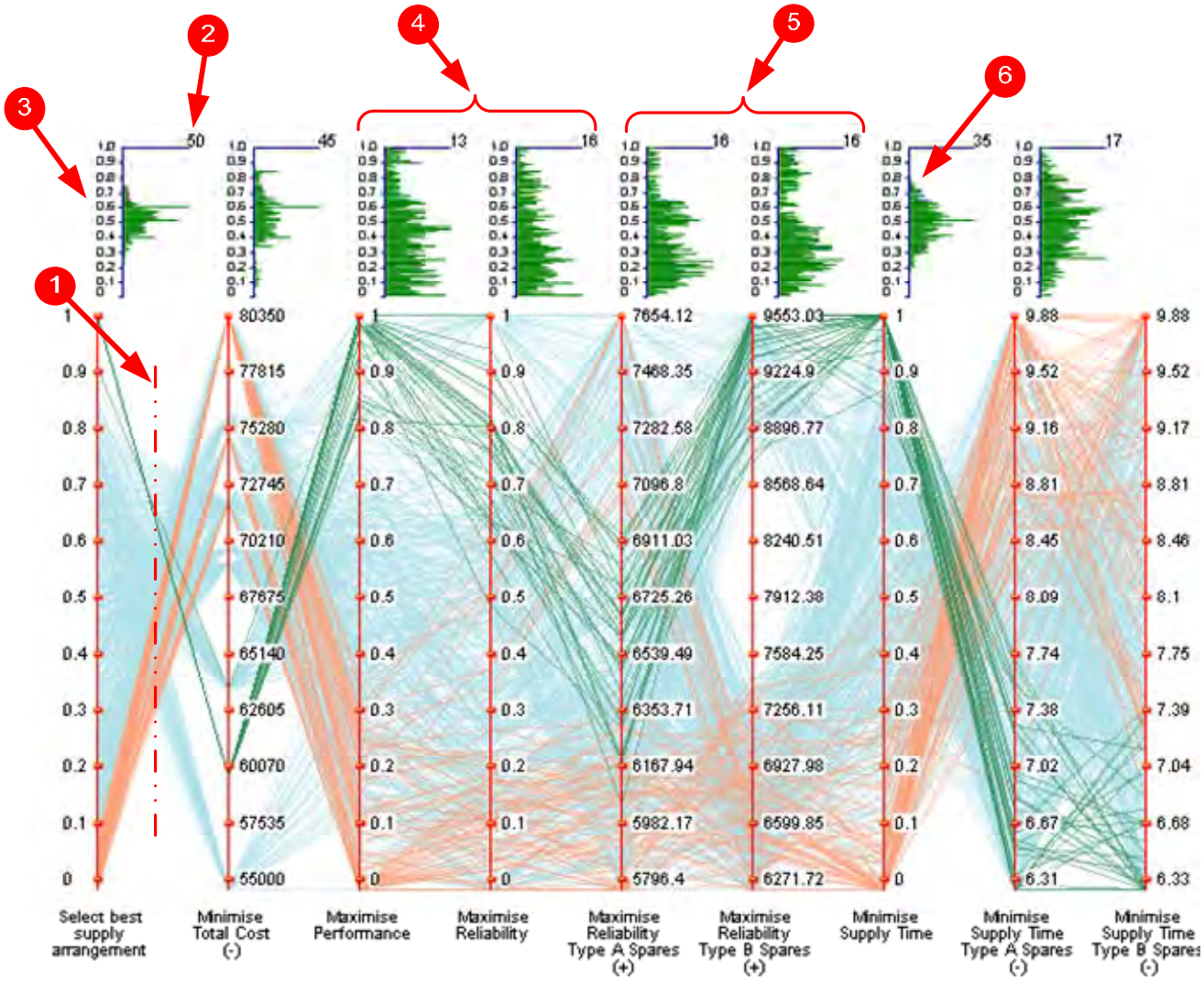


1	The top 10% scoring alternatives are displayed by default with a dark green colour.
2	The Mid-Range scoring alternatives are displayed by default with a pale blue colour.
3	The Lowest 10% scoring alternatives are displayed by default with the pale rust colour.
4	Stem Plots (Cross Densities). These are explained in Section 11.2.3.
5	Note the ***Minimise Total Cost*** axis now has the lowest cost at the top.
6	***Minimise Supply Time*** – shortest supply times are now at the top of the axis.

Figure 96. CWViewer (plot area with Cardinal Scoring Option)

11.2.3 Stem Plots (Cross Densities)

Stem Plots are histograms of the crossing point between a pair of axes and are used to determine the relationships between criteria within a decision. This is shown in Figure 97.

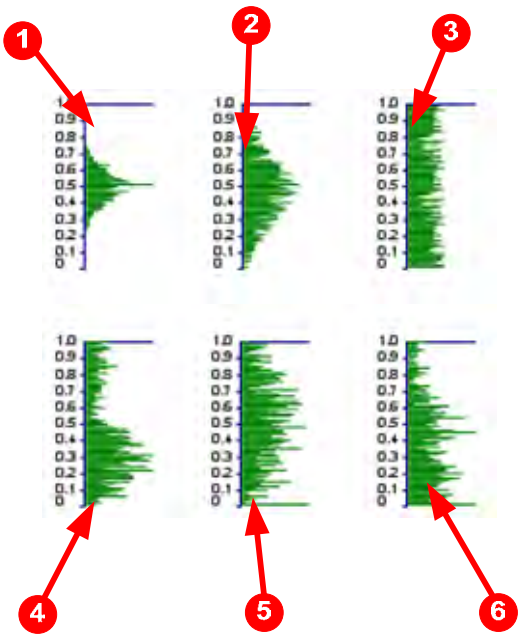


1	This is the vertical crossing point used to populate the cross densities.
2	The number indicates the largest count in the stem plot. In this example the 50 indicates that there are 50 crossing points at approximately 60%.
3	The vertical axis indicates the percentage at the crossing point of the two criteria plots.
4	These two plots indicate the criteria are proportional.
5	These two plots have a region of relatively directly proportional relationships and another region of somewhat inversely proportional relationships.
6	This is an example of an inversely proportional relationship between the two. However, since the count is 35 as opposed to 50, as indicated for the ***Select Best Supply Arrangement*** and ***Minimise Total Cost***, it can be concluded that the higher the number the greater the magnitude of the relationship.

Figure 97. Cross Density Plot (example)

To reinforce the concept of the relationships indicated by the Cross Density Plots, some ideal Cross Density Plot examples are shown in Figure 98. Across the top row in Figure 98, the Cross Density Plots show the ideal shapes representing inversely proportional, independent and directly proportional elements, respectively. However, the overall cross

densities for any two criteria can of course be a combination of the ideal types and examples are presented in the second row of Figure 98.



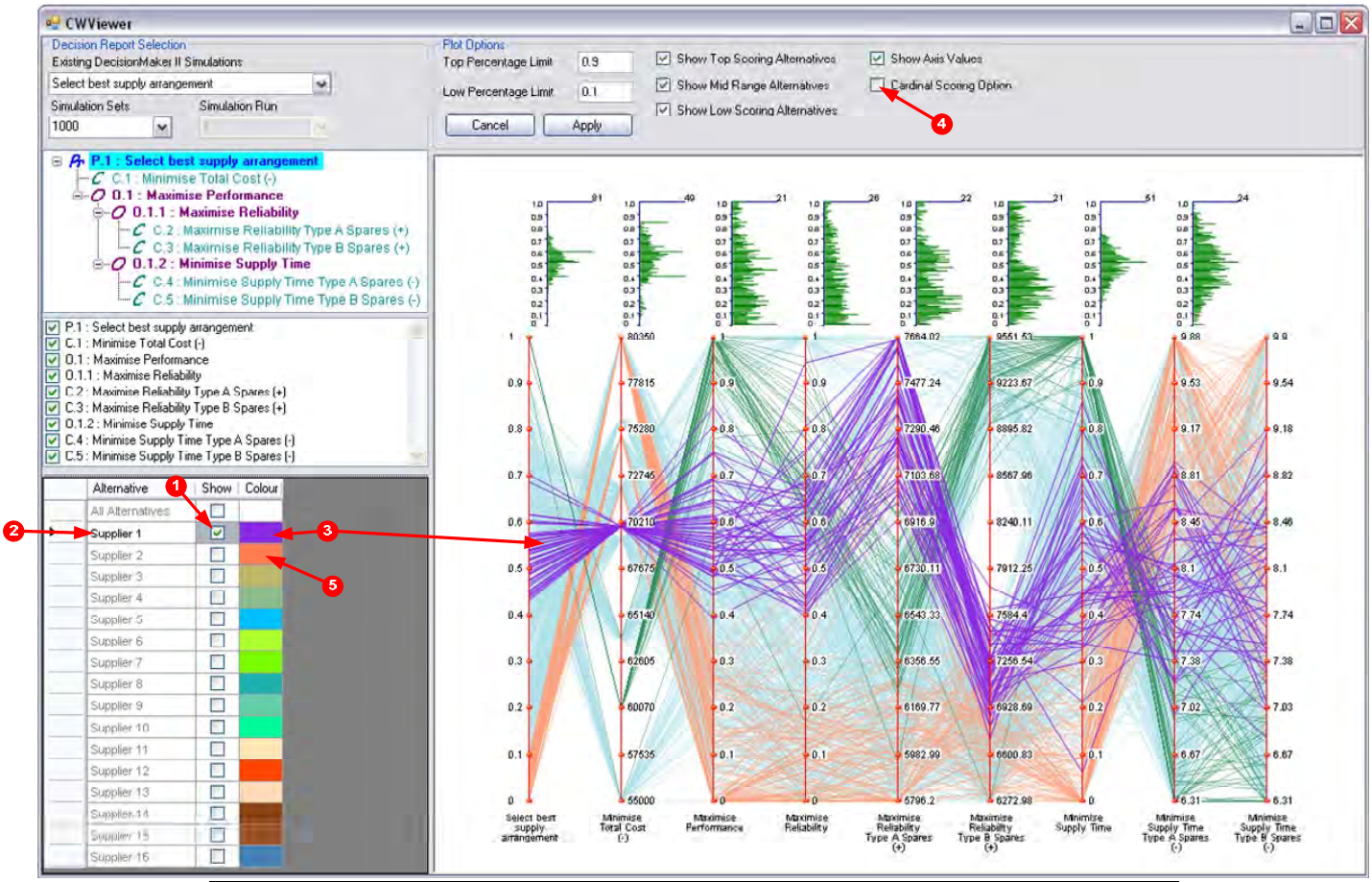
1	Ranking correlation between the two structural elements is inversely proportional.
2	The two elements are independent.
3	The ranking correlation of the two elements is directly proportional.
4	The structural elements are independent and directly proportional.
5	The structural elements are independent and directly proportional.
6	The structural elements are independent and directly proportional.

Figure 98. Cross Density Plots

The data displayed in the Stem Plots is for all alternatives and does not change even when filtering is applied.

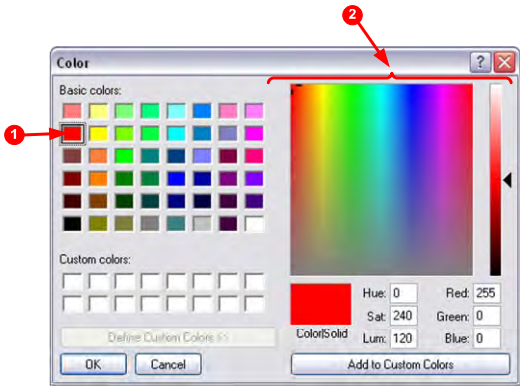
11.3 Filtering Alternatives

The CWViewer can filter alternatives for one-to-one comparison or many-to-many comparisons. Figure 99 illustrates how to filter alternatives, while Figure 100 shows the colour chooser to manually change the colours for each alternative. The plot area should now appear as shown in Figure 101. Figure 102 shows the CWViewer Filtering Options when various options have been deselected to make it easier to view the plot.



1	To uniquely plot an alternative, check the box as indicated.
2	The alternative name will now appear black.
3	The colour used to identify the alternative is shown in the box in the colour column.
4	Note, in this view the ***Cardinal Scoring Option*** is not selected.
5	To change the colour, double click in the colour cell as indicated. A colour dialog box will appear as shown in Figure 100.

Figure 99. CWViewer - filtering alternatives (example 1)



1	Select a predefined colour.
	or
2	Select a custom colour.

Figure 100. Colour chooser

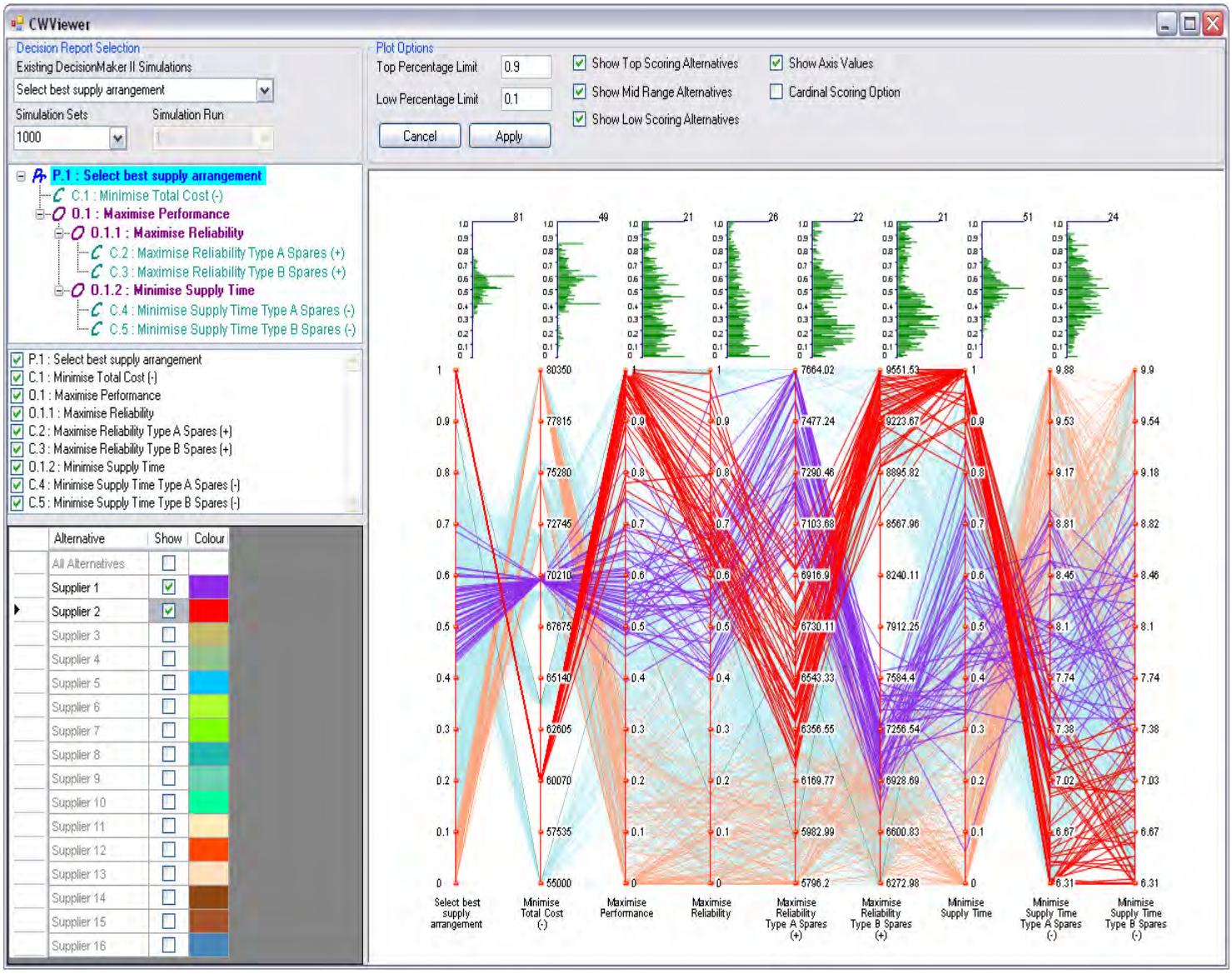
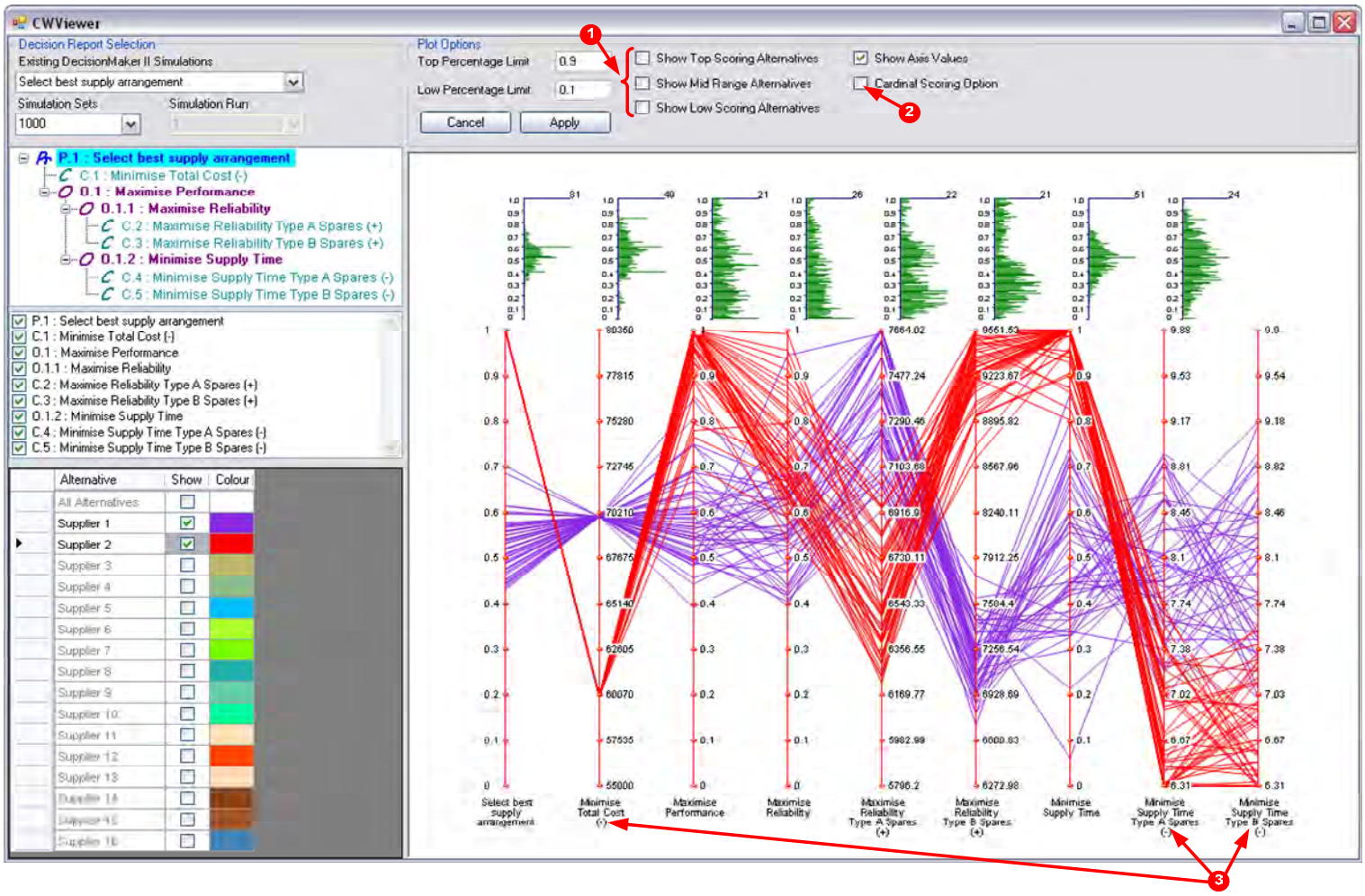


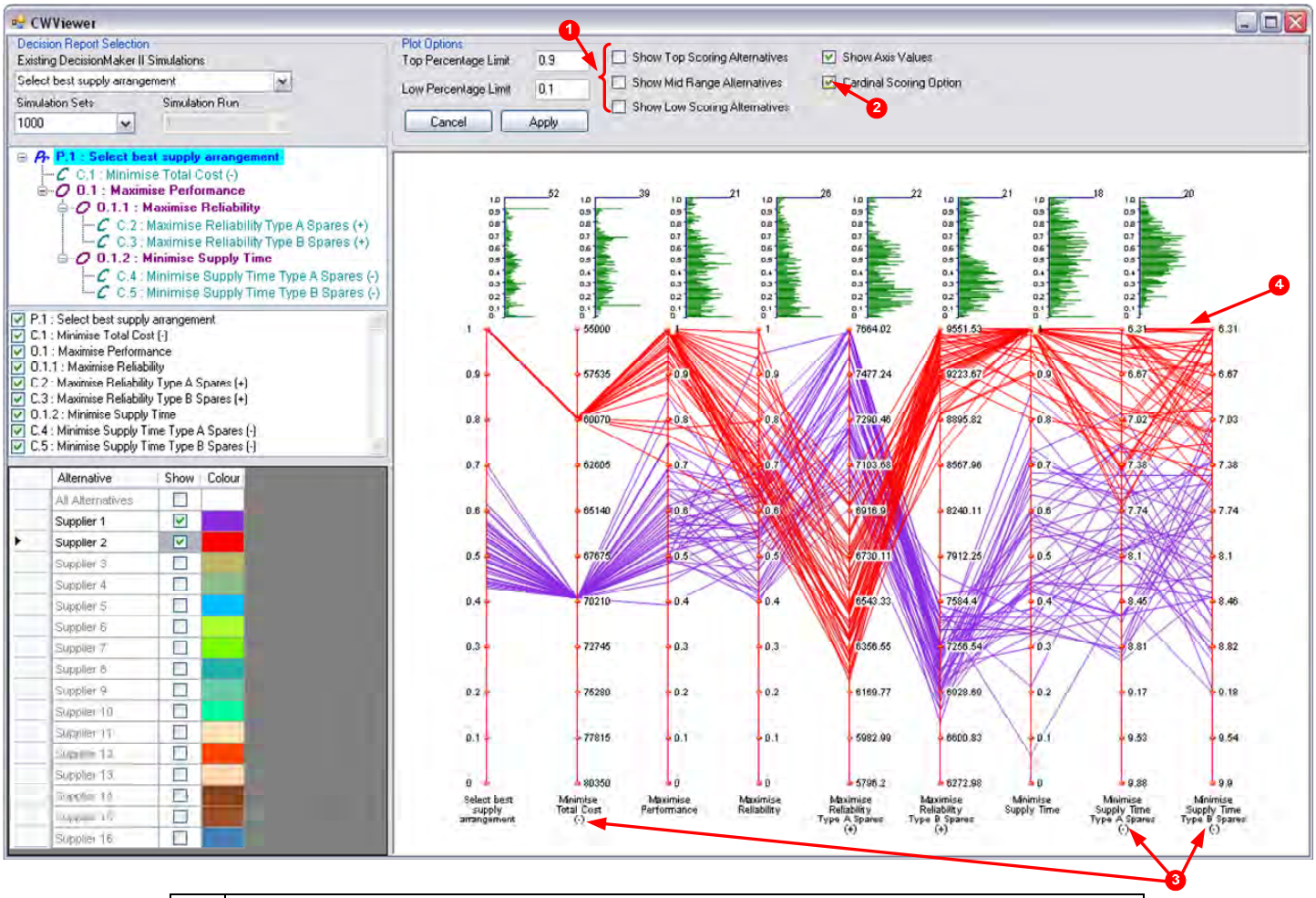
Figure 101. CWViewer - filtering alternatives (example 1 continued)



1	To make the plot area clearer, the top, mid and low level plot groups have been deselected.
2	***Cardinal Scoring Option*** has not been selected.
3	Note the axis scales of the minimise criteria.

Figure 102. CWViewer - filtering alternatives (example 1 continued)

When the ***Cardinal Scoring Option*** has been selected, the view will change as shown in Figure 103. This view can assist in locating dominant alternatives across multiple criteria. Using the ***Cardinal Scoring Option*** in the CWViewer enables identification of alternatives based on performance. Regardless of the direction of preference, the more preferable alternatives intersect each axis near the top. The ideal alternative would be a straight line across the top of the plot.



1	To make the plot area clearer: the top, mid and low level plot groups have been deselected.
2	***Cardinal Scoring Option*** is selected.
3	Note the axis scales of the minimise criteria. Now the preferred intersection of the alternative is at the top of the axis, i.e. the lower, or more preferred, values for these criteria are now located at the top of the axis while the higher values (less preferred) are located at the bottom of the axis.
4	Note that the lowest values of the criteria, where the direction of preference is ***minimise***, now appear at the top of the axis.

Figure 103. CWViewer - filtering alternatives (example 2)

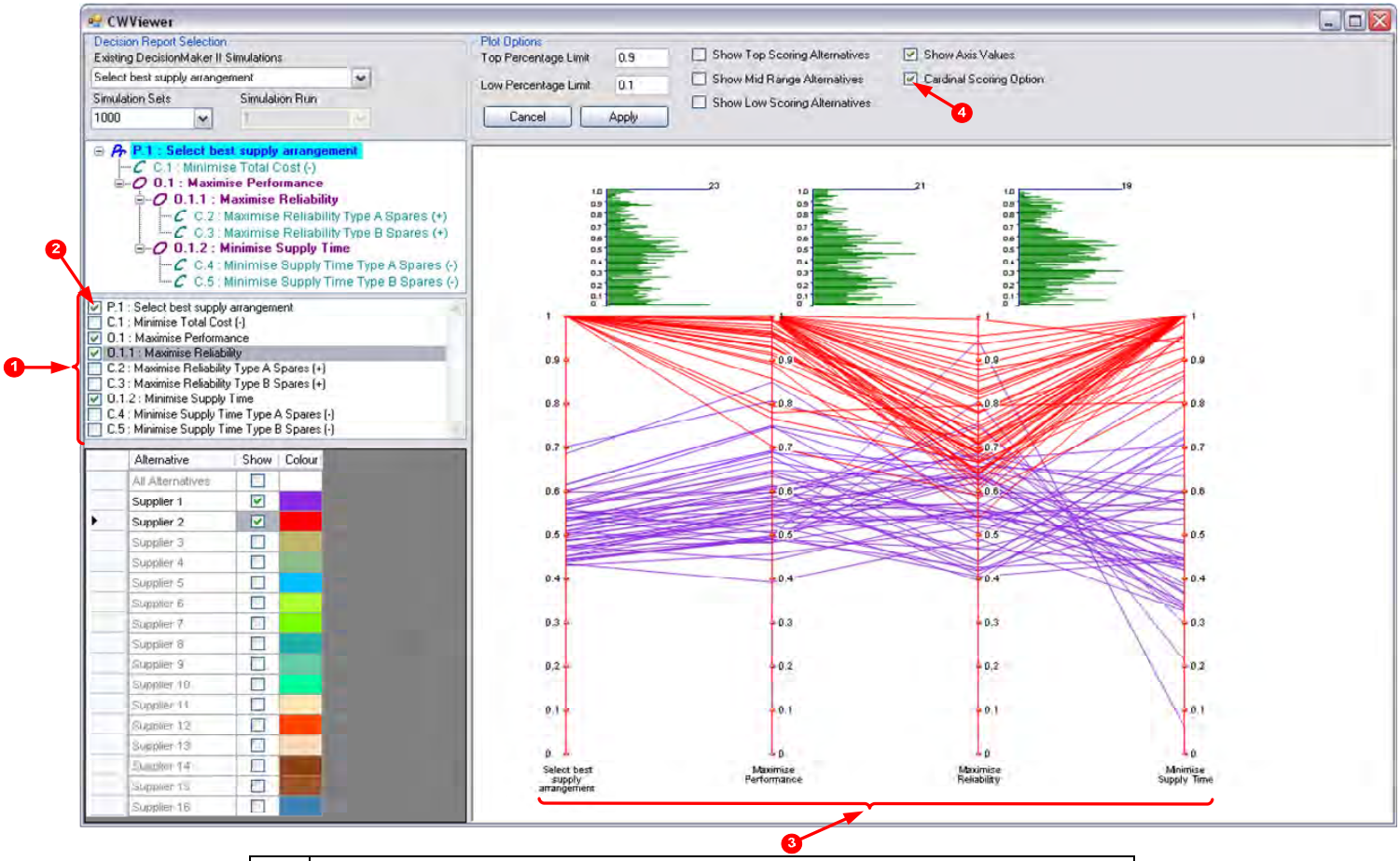
11.4 Filtering Elements

The CWViewer can also be used to filter *Decision Maker*'s structural elements. There are two primary types of filtering; however any combination can be used to suit various problems or reporting requirements.

> ⚠ *When filtering elements, it is highly recommended that the root element **P.1** is always selected since this element indicates the overall performance of each alternative.*

11.4.1 Filter by Objectives

The viewer can be used to display objective elements only. This assists identification of how alternatives perform in each of the objective areas. Figure 104 shows an example of filtering by objectives.

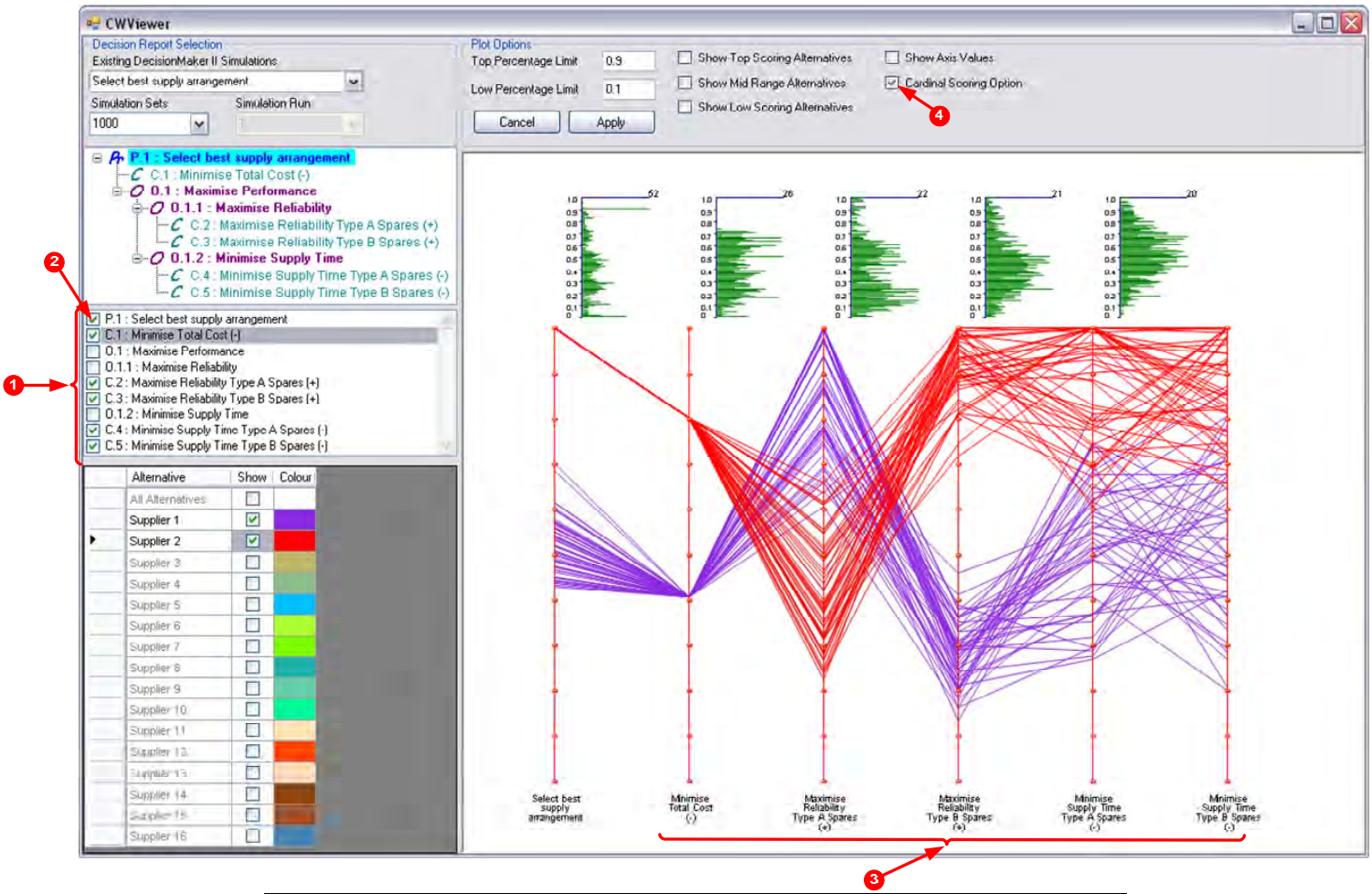


1	In the Plot Element Selector, only the objectives are selected.
2	Structural element ***P.1*** is also selected. This is highly recommended at all times.
3	The plot area now updates, reflecting the selections made in 2.
4	The ***Cardinal Scoring Option*** is selected, however given that the filtering is by objective, this has no effect on the display.

Figure 104. Filtering objective elements

11.4.2 Filter by Criteria

The viewer can be used to display *Criteria* elements only. This assists identification of how alternatives perform in each of the criteria areas. Figure 105 shows an example of filtering by criteria.



1	In the Plot Element Selector, only the criteria are selected.
2	Structural element ***P.1*** is also selected. This is highly recommended at all times.
3	The plot area now updates reflecting the selections made in 2.
4	The ***Cardinal Scoring Option*** is selected.

Figure 105. Filtering criteria elements

11.5 Interpreting Domination Alternatives

Dominant alternatives are ones that score better in all areas when compared to another alternative. Regardless of the changes made in the weights, a ranking preference of such an alternative will not change.

The CWViewer is a useful tool in visualising dominant alternatives and for short-listing the possible choices. In the first example, shown in Figure 106, the objectives, root problem and top-level criteria have been selected. The ***Minimise Total Cost*** criterion has also been selected since cost is an important factor in this decision problem.

> *It is highly recommended that the root element **P.1**, which shows the overall ranking, is always visible in the plot since it provides immediate understanding of the selected alternative preference over the others. This is demonstrated by (1) in Figure 106.*

Figure 106 is taken from the *Supply Manager's Dilemma* and for demonstration purposes three suppliers have been selected in the viewer (2). In this example the ***Cardinal Scoring Option*** is also selected (3).

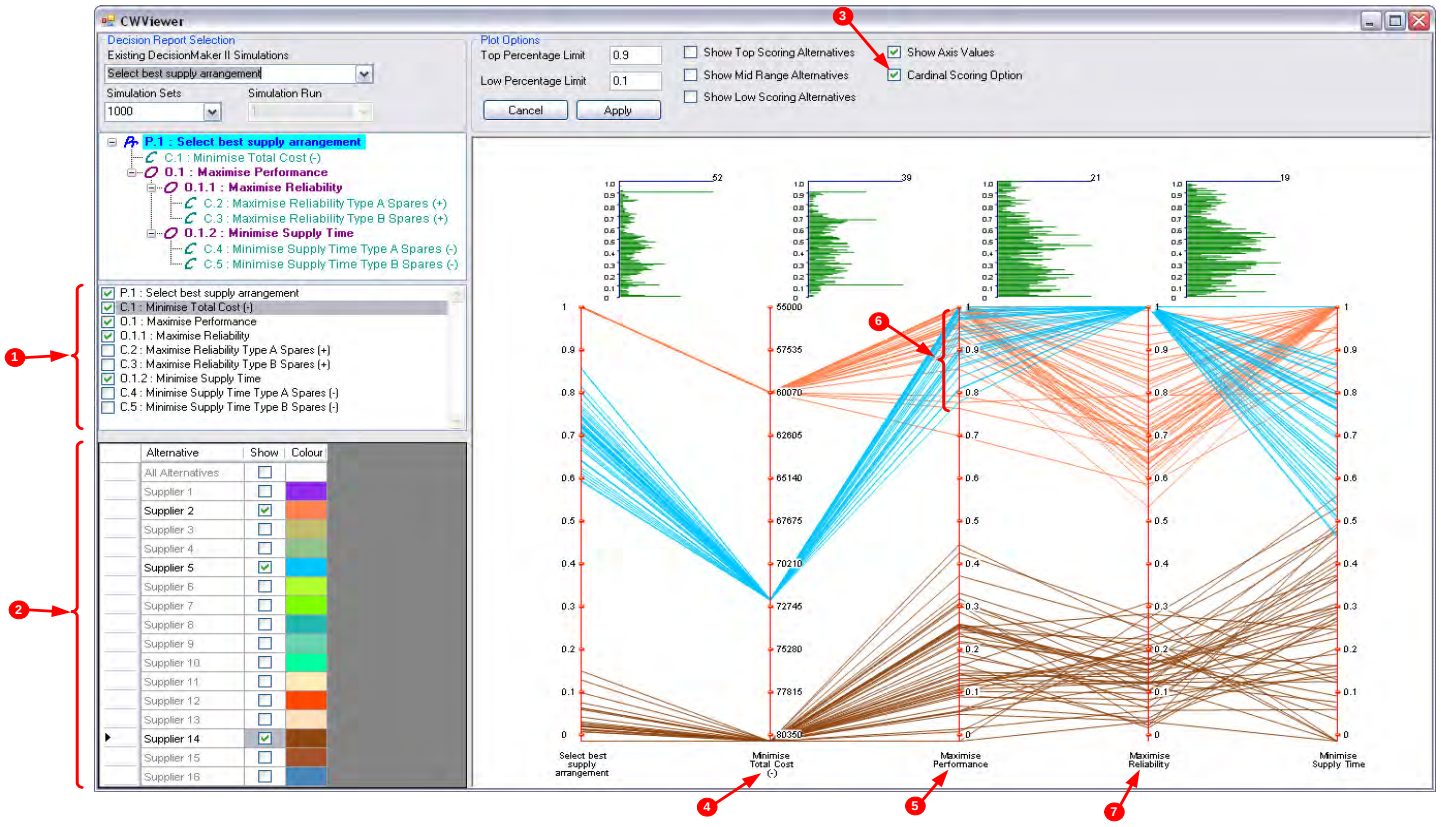


Figure 106. CWViewer interpreting dominant alternatives

Each of the selected elements (4), (5) and (6) of Figure 106 are described in the following subsections.

11.5.1 Minimise Total Cost (4)

It is important to recognise that this is a criteria axis and the preferred direction is to minimise. In the example shown in Figure 106 the ***Cardinal Scoring Option*** is selected and this means the more preferred criteria values occur at the top of the ***Minimise Total Cost*** axis. Therefore, ***Supplier 2*** dominates ***Supplier 5***, which, in turn, dominates ***Supplier 14***.

11.5.2 Maximise Performance (5)

This is an objective and, as a consequence, the preferred alternatives will intersect the axes near the top regardless if the objective is to minimise or maximise. In the example shown in Figure 106, ***Supplier 14*** is clearly dominated by both ***Supplier 2*** and ***Supplier 5***.

Therefore, ***Supplier 14*** does not perform well on the sub-objectives and/or sub-criteria that are the child elements of the decision tree, i.e. ***Maximise Performance*** is comprised of the objectives ***Maximise Reliability*** and ***Minimise Supply Time***. ***Supplier 14*** scored poorly in these two objectives and there is a direct relationship between the three. Comparing ***Supplier 2*** and ***Supplier 5*** for the objective ***Maximise Performance*** requires investigation of the plot area indicated by 6. Here, ***Supplier 2*** scores better than ***Supplier 5*** and to determine the exact amount requires the use of the Scoring Matrix Viewer.

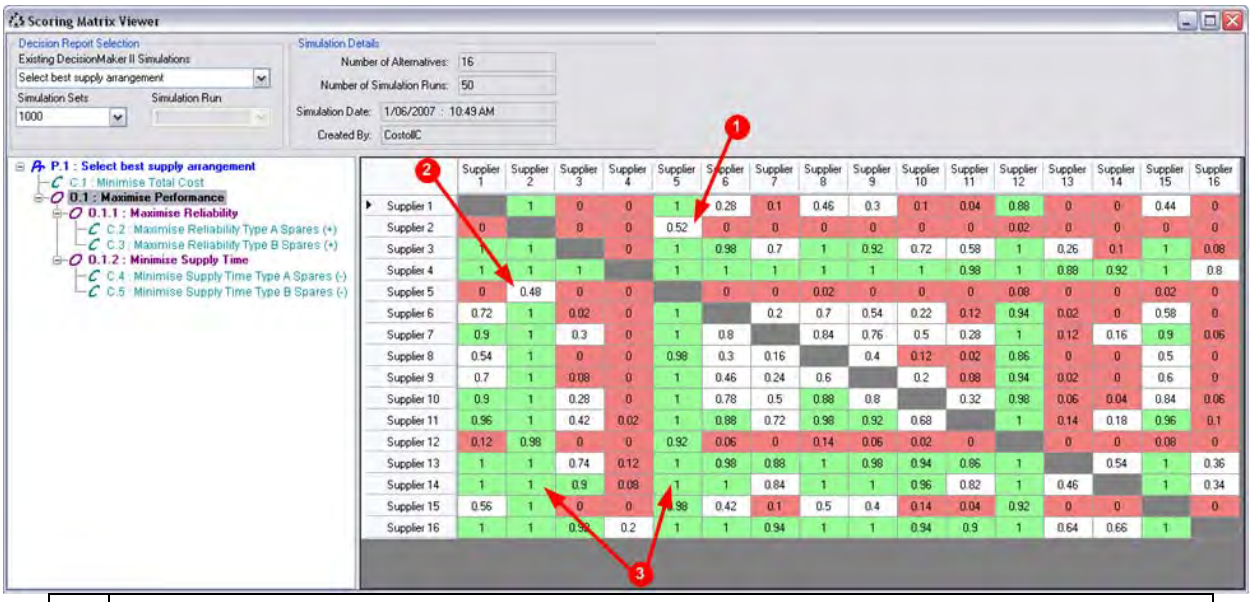
11.5.3 Maximise Reliability 7

Comparing ***Supplier 2*** and ***Supplier 5*** is a little more interesting for Maximise Reliability where ***Supplier 5*** appears to dominate ***Supplier 2***. In this example of 50 simulation runs, ***Supplier 5*** dominated ***Supplier 2*** 49 times for the objective of ***Maximise Reliability***.

The Scoring Matrix Viewer can also be used to assist in determining the degree of domination for a single element. Whilst the CWViewer provides a graphical display of domination across multiple elements simultaneously, it is necessary to use the CWViewer or Domination Scoring Matrix to obtain a complete picture.

11.5.4 Using Domination Scoring Matrix with CWViewer (Example 1)

Figure 107 presents a Domination Scoring Matrix to assist in determining the degree of domination for individual elements.



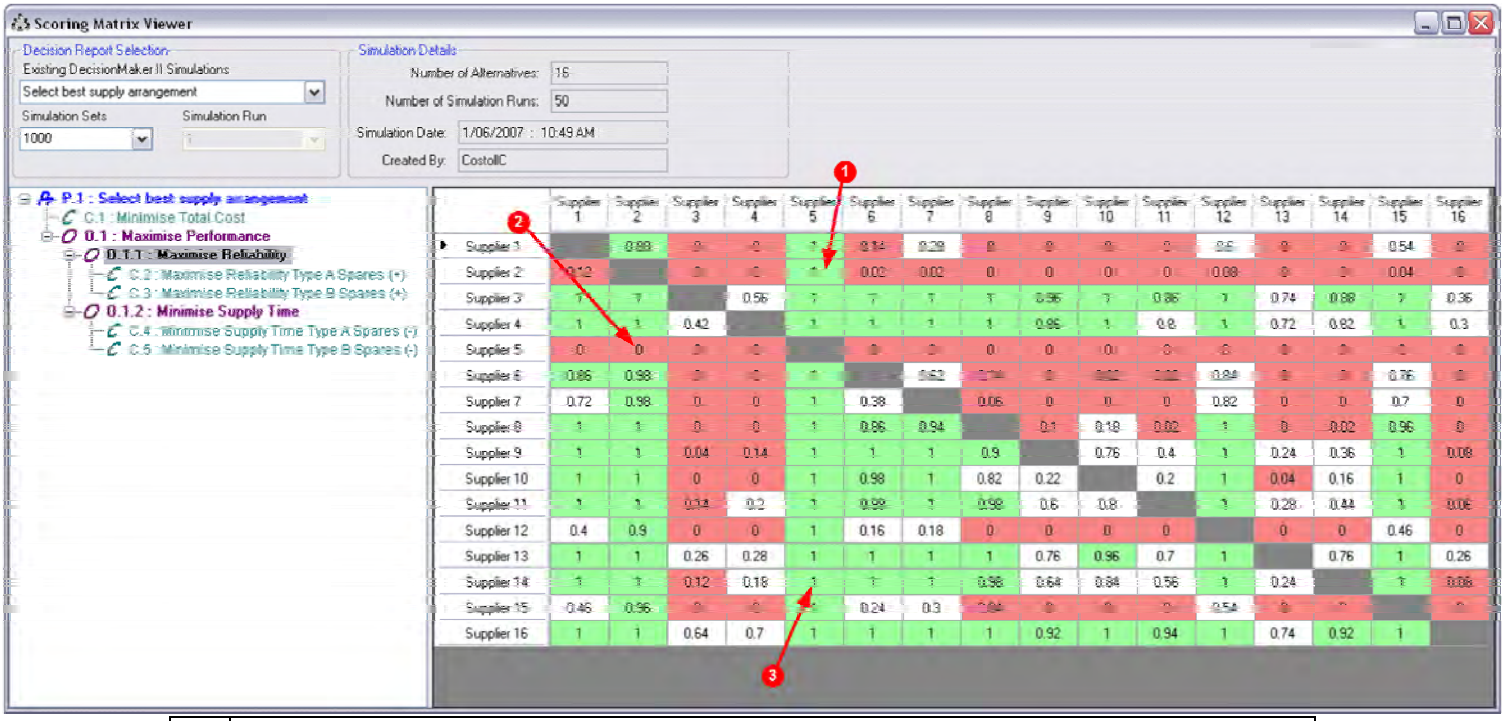
1	The analysis of ***Supplier 2*** and ***Supplier 5*** shows that ***Supplier 5*** scored better than ***Supplier 2*** in 52% of the simulations.
2	Similarly ***Supplier 2*** scored higher than ***Supplier 5*** in 48% of the simulation runs.
3	Analysis of the objective ***Maximise Performance*** in the CWViewer indicated that ***Supplier 14*** scored lower than ***Supplier 2*** and ***Supplier 5*** in all simulation runs. This is confirmed by the value that indicates the column alternative, i.e. ***Supplier 2*** and ***Supplier 5*** scored higher than ***Supplier 14*** 100% of the time.

Figure 107. Domination Scoring Matrix (interpretation: maximise performance)

> *Reminder: Ensure that the correct element is selected.*

11.5.5 Using Domination Scoring Matrix with CWViewer (Example 2)

To determine the extent of domination on a particular element, the Domination Scoring Matrix Viewer can be used with the CWViewer. This is shown in Figure 108.



1	Reading down the column ***Supplier 5*** and along the row ***Supplier 2***, the cell containing the value 1 is located. This indicates ***Supplier 5*** scored better than ***Supplier 2*** in 100% of the simulation runs.
2	Conversely, along the row ***Supplier 5*** and down the column ***Supplier 2***, the cell containing the value 0 is located. This indicates that ***Supplier 5*** scored lower than ***Supplier 2*** in 0% of the simulation runs.
3	Also shown is the comparison of ***Supplier 5*** and ***Supplier 14***. The value of 1 indicates that in 100% of the simulations ***Supplier 5*** scored better than ***Supplier 14***. This observation is more apparent when viewed in the CWViewer plot analysis.

Figure 108. Scoring Matrix (interpretation: maximise reliability)

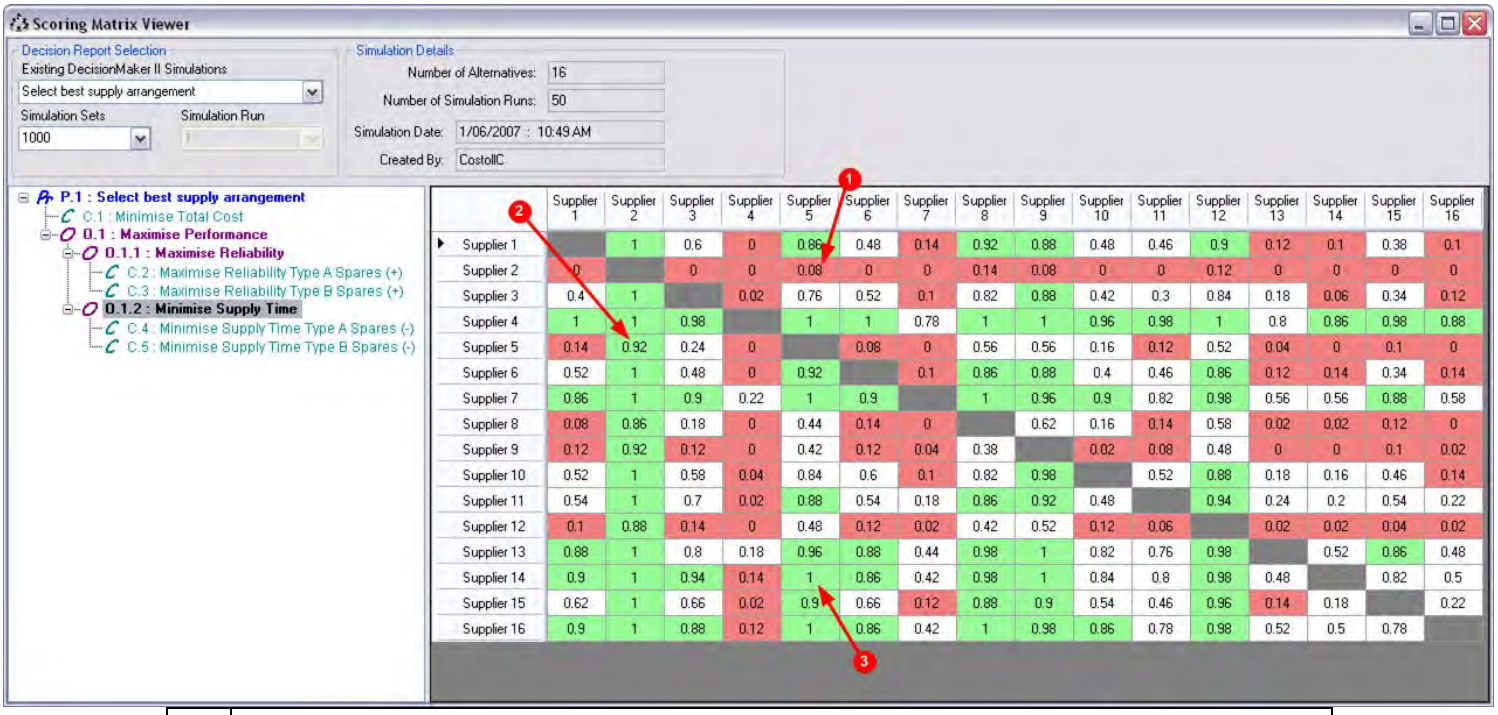
11.5.6 Using Domination Scoring Matrix with CWViewer (Example 3)

For the objective ***Minimise Supply Time***, it is necessary to determine the number of times, or the percentage of time, that one particular alternative ranks higher than another. This is shown in Figure 109. This example demonstrates the necessity of using the Domination Scoring Matrix in conjunction with the CWViewer for a thorough analysis of a decision simulation. This also shows that even though ***Supplier 5*** obtained a low score for the objective ***Minimise Supply Time*** for an individual simulation run, ***Supplier 14*** scored lower in the same simulation run. For example, in simulation run number 12, ***Supplier 5*** scored higher than ***Supplier 14***; while in simulation number 32, ***Supplier 14*** scored higher than ***Supplier 5***. This is shown in Table 14.

⚠	*This is not a comparison in which we are interested. However it is important to be aware of this issue when analysing a simulation.*

Table 14. Domination interpretation

Simulation Run	***Supplier 5***	***Supplier 14***
12	0.46	0.19
32	0.79	0.51



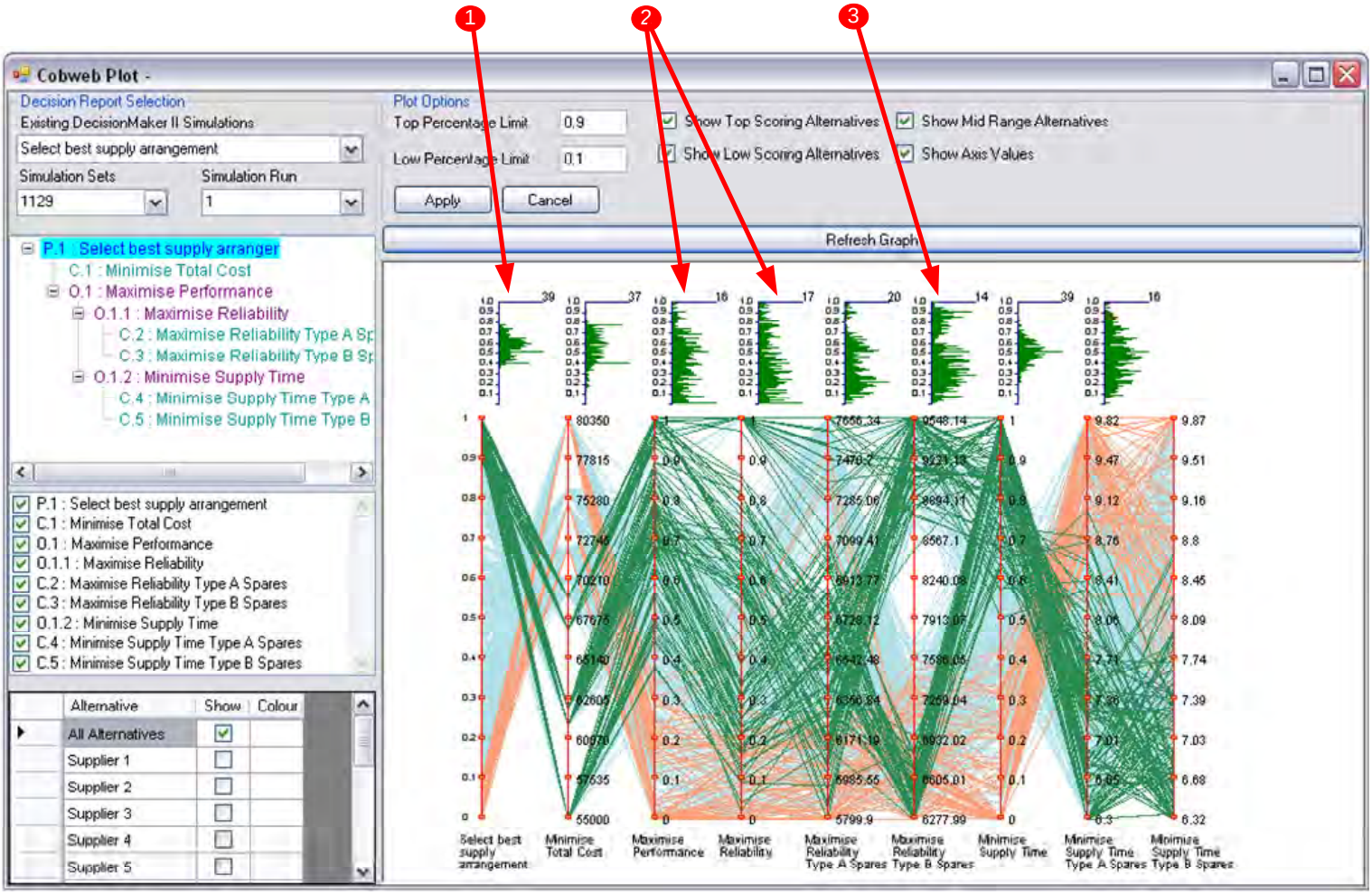
1	***Supplier 5*** ranked higher than ***Supplier 2*** in 8% of the simulations.
2	***Supplier 2*** ranked higher than ***Supplier 5*** in 92% of the simulations.
3	From the example Cobweb analysis it appears that on several occasions ***Supplier 14*** may have ranked higher than ***Supplier 5***. However, when using the Domination Scoring Matrix it shows that ***Supplier 5*** scored better than ***Supplier 14*** 100% of the time for the objective ***Minimise Supply Time***.

Figure 109. Scoring Matrix (interpretation: minimise supply time)

11.6 Criteria Relationships

The CWViewer can be used to determine the relationships between one or more criteria. This is especially useful when large complex decision trees with many criteria are being analysed. Elements can be selected and filtered in the view to determine factors such as what are the trends in criterion ***C.1*** when criterion ***C.3*** is low and so on.

The green Stem Plots shown above the main plot can be used to quickly determine the direction of the relationship (such as an inverse relationship or a direct relationship) between adjacent elements. This is shown in Figure 110.



1	A sharp spike indicates an inverse relationship. The location of the spike gives an indication to the region of values.
2	An even distribution over a region, or an entire plot, indicates a direct relationship.
3	This is an example of two regions of inversion with some degree of direct relationship.

Figure 110. Criteria relationships

11.7 Producing Meaningful Plots

The CWViewer is a useful tool; however it can also be cumbersome. The CWViewer works best with an appropriate number of simulations, but too many simulation runs can produce a plot that is meaningless. It will also take time to generate the plot for larger numbers of simulation runs when there are a large number of alternatives or criteria. Alternatively, too few simulation runs may not provide enough data for a thorough analysis. However, when comparing data with no uncertainties, this cannot be avoided.

The selection of ***Show Top Scoring Alternatives***, ***Show Mid Range Alternatives*** and ***Show Low Scoring Alternatives*** options can be used to show how all alternatives have performed during a simulation and may act as a guide for eliminating some alternatives when deciding on the final shortlist. For example, if you are analysing a set of alternatives and turn on the ***Show Top Scoring Alternatives*** option and only one alternative appears, then

perhaps you have omitted an alternative you should be considering. During the final stages of analysis this may not be the case, i.e. a top scoring alterative may be omitted at the discretion of the decision-maker.

12. Weights Sensitivity

Weights sensitivity analysis involves investigating the effect that changing weights will have on the ranking of alternatives. *Decision Maker* uses a genetic search algorithm technique[5] to locate the smallest variation on weights that will cause a ranking reversal between two alternatives. The weights sensitivity view also displays Pareto domination[6] in a 'tree view' to assist in multidimensional analysis of weights sensitivity. The Weights Sensitivity analysis window can be started from the **Advanced Analysis | Weights Sensitivity** menu as shown in Figure 111.

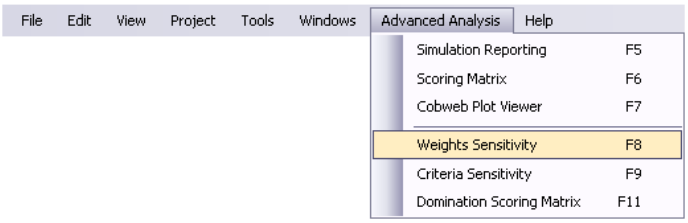
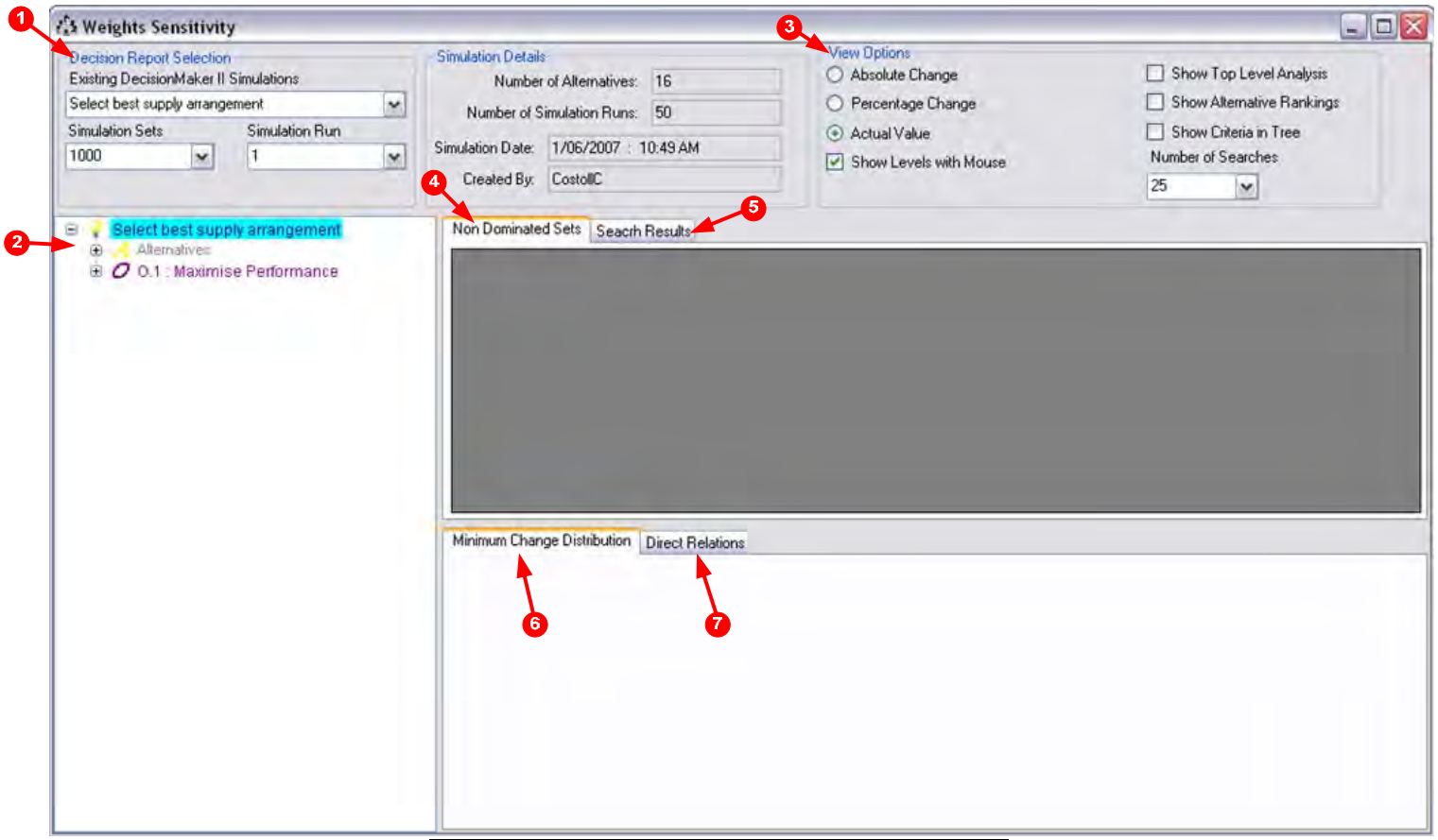


Figure 111. Starting Weights Sensitivity analysis

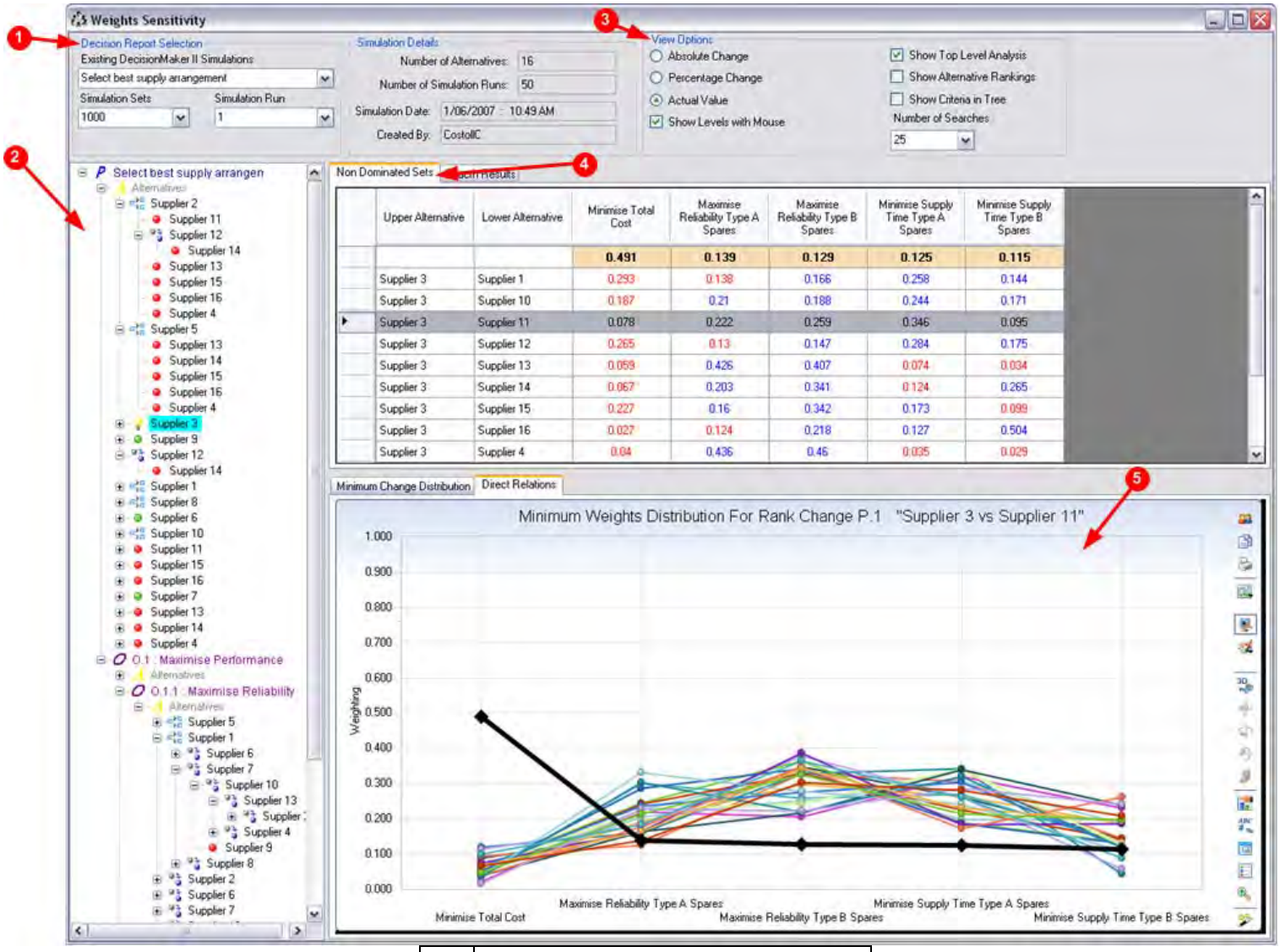
The Weights Sensitivity analysis window will appear as shown in Figure 112. After selections have been made in the window's various components, it will appear as shown in Figure 113.

[5] This is an Optimisation Search Algorithm, which is based on the principles of biological genetic evolution.
[6] After the Pareto principle, also known as the law of the vital few or the principle of factor sparsity.



1	***Decision Report Selection***.
2	Domination Tree View (Section 12.2).
3	***View Options*** (Section 12.3).
4	***Non-Dominated Sets*** (Section 12.4).
5	A tabular view of the search results.
6	***Minimum Change Distribution*** (Section 12.7).
7	***Direct Relations*** (Section 12.5).

Figure 112. Weights Sensitivity analysis window



1	***Decision Report Selection***.
2	Domination Tree View.
3	***View Options***.
4	Non-Dominated Sets.
5	Direct Relations.

Figure 113. Weights Sensitivity analysis window (after selections)

12.1 Total Domination

An alternative completely dominates another alternative when a change of weights to any other value will not cause a change in ranking. This is due to the criteria values of the dominating alternatives being more preferred than the lower alternatives. Table 15 shows an example where ***Alternative A*** completely dominates ***Alternative B***. A consequence of this is that any change of weights will not cause ***Alternative B*** to rank better than ***Alternative A***.

Table 15. Total domination

	Criteria 1 (Maximise)	Criteria 2 (Maximise)	Criteria 3 (Minimise)	Criteria 4 (Minimise)
Alternative A	56.7	210	86	110
Alternative B	15.3	175	92	133

12.2 Partial Domination

Partial domination occurs when some, but not all, criteria values for an alternative are more preferred than the second alternative's criteria values. When this occurs there is a possibility of the ranking order changing when the weights are changed. In Table 16, ***Alternative A*** ranks higher than ***Alternative B***. Now, if ***Criteria 2***'s weighting was increased, ***Alternative B*** would be the more preferred alternative. In this example, the weights would have to be unrealistic for this to occur, hence the reason for weights sensitivity analysis.

Table 16. Partial domination

	Criteria 1 (Maximise)	Criteria 2 (Maximise)	Criteria 3 (Minimise)	Criteria 4 (Minimise)
Alternative A	56.7	160	86	110
Alternative B	15.3	175	92	133

12.3 Some Final Notes on Dominating Alternatives

Within a problem's decision tree it is feasible that at various levels two alternatives can dominate each other at different points in the decision tree. However, at the root problem level (top-level) they would not dominate each other. This is best understood using an example from the *Supply Manager's Dilemma*, as shown in Figure 114.

12.4 Domination Tree View

The Domination Tree View has several features to assist in determining the level of domination for an alternative, i.e. the structure of the tree indicates the hierarchy of domination. For example, in Figure 114, ***Supplier 9*** dominated ***Supplier 10*** and ***Supplier 1***. ***Supplier 1*** in turn dominated ***Supplier 13***, which dominated ***Supplier 7***, which dominated ***Supplier 4***. The icons also indicate the basic domination categories of alternatives. Figure 115 describes the Domination Tree icons.

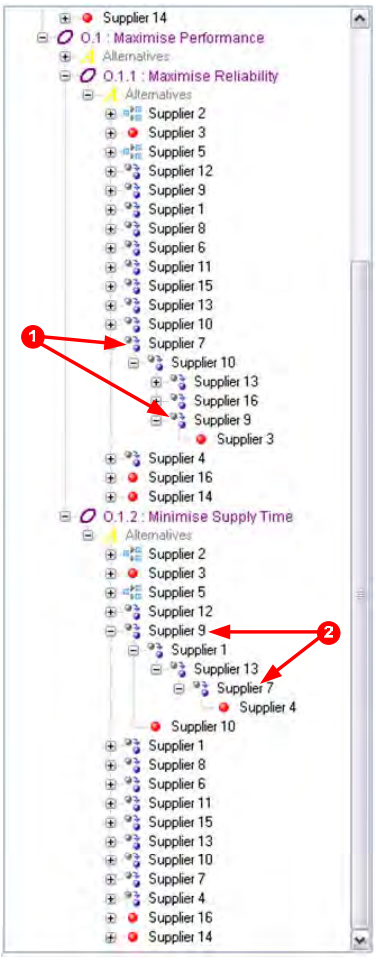
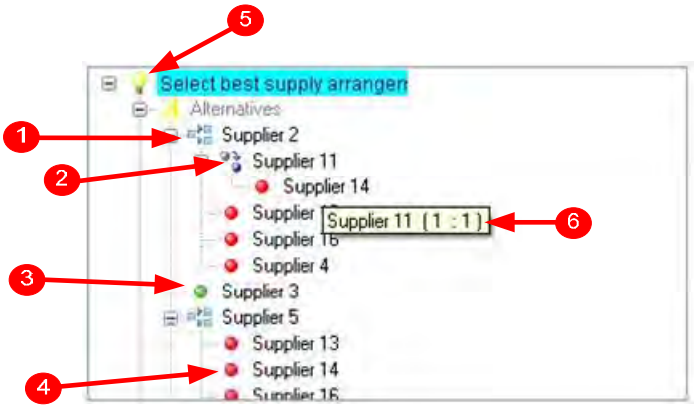


Figure 114. Partial domination example

1	Shows the objective ***Maximise Reliability*** where ***Supplier 7*** dominates ***Supplier 9.*** For the objective ***Minimise Supply Time***, ***Supplier 9*** dominates ***Suppler 7***.
2	For ***Supplier 13***, there is a case of partial domination occurring against ***Supplier 7*** and ***Supplier 9***.

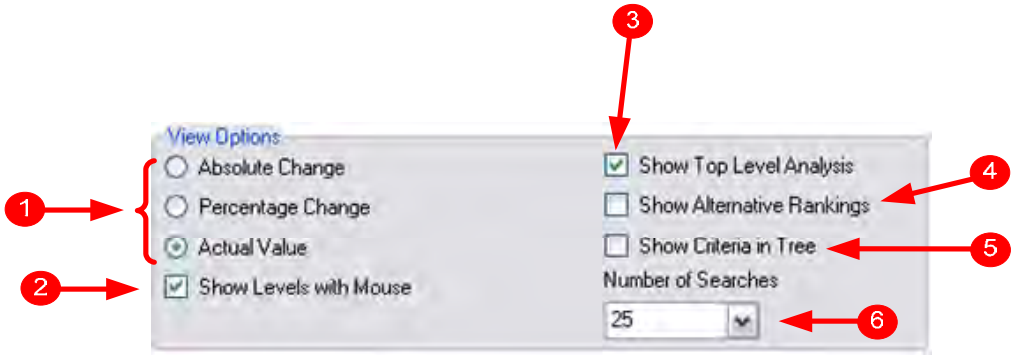


	Icon	Meaning
1		Only Dominates
2		Dominated and Dominates
3		Not Dominated and Does Not Dominate
4		Only Dominated
5		This indicates the selected node
6		When the mouse is moved over an alternative element within the tree, the alternative is enabled and a pop up text will appear. It displays the node name along with two numbers in brackets. The two numbers have the following meaning: (*The number of alternatives that dominate this alternative : the number of alternatives this alternative dominates*).

Figure 115. Domination Tree (icon examples)

12.5 View Options

When selecting ***Show Top-level Analysis*** the problem is viewed using the relative weights and all criteria that are children of the selected objective. Relative weights are the equivalent weights required for each criterion when the problem is analysed at the root node or branch of the decision tree. Another term, absolute weights, is used only when comparing criteria at the same branch level within the decision tree. Figure 116 shows the different view options.



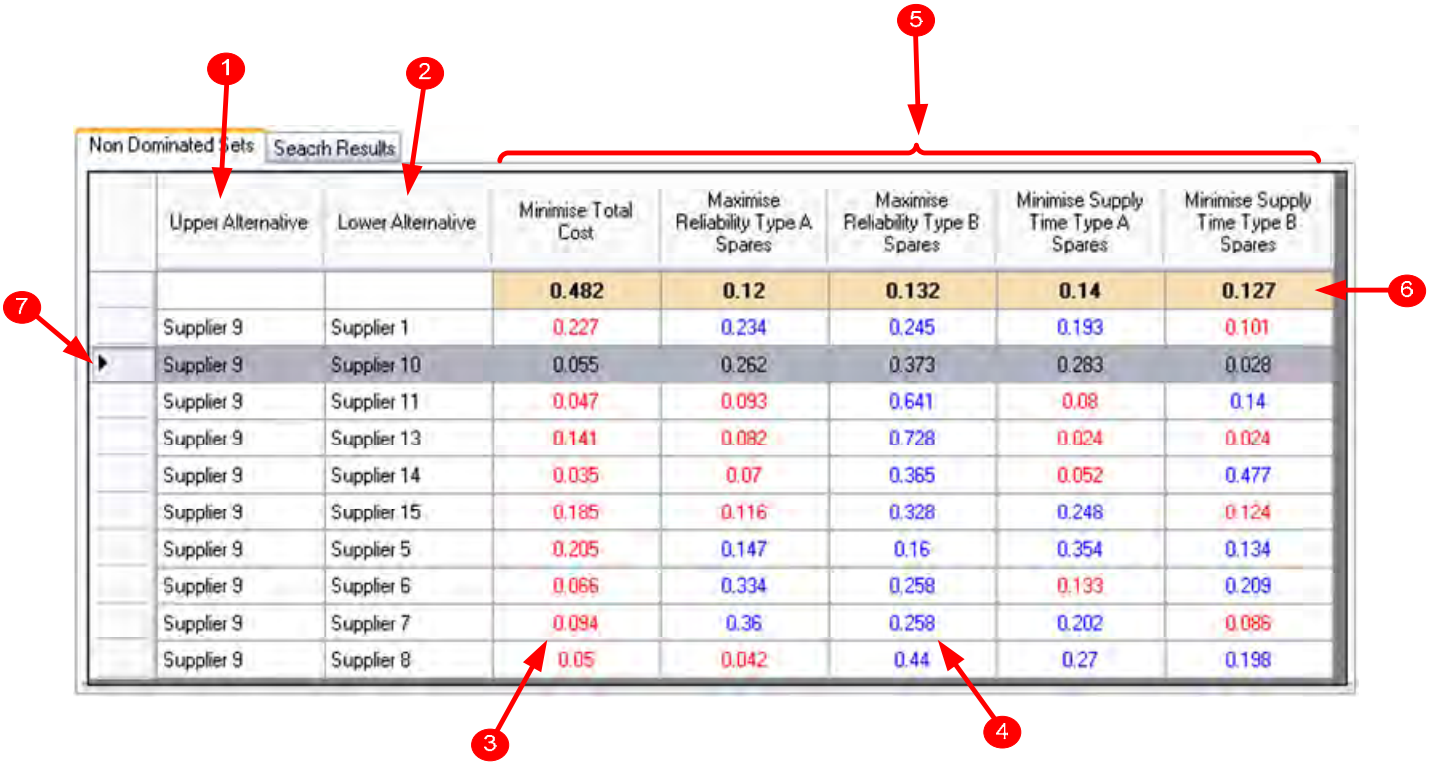
1	These are the types of value that will be displayed (***Actual Value*** is recommended).
2	This enables the mouse over node information display as shown in Figure 115.
3	Enabling this activates the ***Show Top Level Analysis*** using all criteria and their relative weights.
4	Shows the rank of the criteria that are selected.
5	Displays the criteria in the tree view.
6	This is the number of searches that will be performed. Usually 20-50 will give a good range of results. Large search numbers will increase the processing time.

Figure 116. Weights Sensitivity view options

12.6 Non-Dominated Sets Table

When a node in the Domination Tree is selected, the Non-dominated Sets table is automatically populated. This provides a quick summary of the change required in the weightings of the criteria to produce a ranking reversal of two alternatives. The Upper Alternative is the alternative with the higher cardinal score and the Lower Alternative is the alternative with the lower cardinal score[7]. Remember the best ordinal score is 1 and the worst ranking is equal to the number of alternatives in the problem. The list of lower alternatives contains all the alternatives that are not dominated by the upper alternative, based on the selected criteria or objective values used to determine domination. Figure 117 shows an example of top level analysis where all problem criteria are considered.

[7] Remember, a high cardinal score translates to a low ordinal ranking (preferred alternatives); while a low cardinal score translates to a high ordinal score (non-preferred alternatives).



1	***Upper Alternative***: the selection in the domination tree.
2	***Lower Alternative***: all non-dominated alternatives scoring worse than the upper alternative.
3	Decreases in weights are coloured red.
4	Increases in weights are coloured blue.
5	Each column corresponds to one of the selected criteria.
6	The first row shows the actual weights that are used.
7	Clicking on the row header activates a search.

Figure 117. Non-dominated sets table

12.7 Direct Relations

To start a search, click on the row header in the Non-dominated Sets table. The search will find a range of weights that will result in a ranking change for the selected alternatives. The results are easily interpreted when viewed graphically. The Search Results Table contains the individual weights sets that would be required to implement a ranking change. Figures 118 and 119 are some examples of the search results viewed graphically. Figure 118 shows that significant changes in ***Minimise Total Cost*** and ***Supply Time Type B Spares*** are required for a change in ranking, i.e. to make ***Supplier 14*** more preferable than ***Supplier 8***. Figure 119 shows that changes for all criteria are relatively minimal. This indicates that it would not require a significant change in weighting to change the ranking.

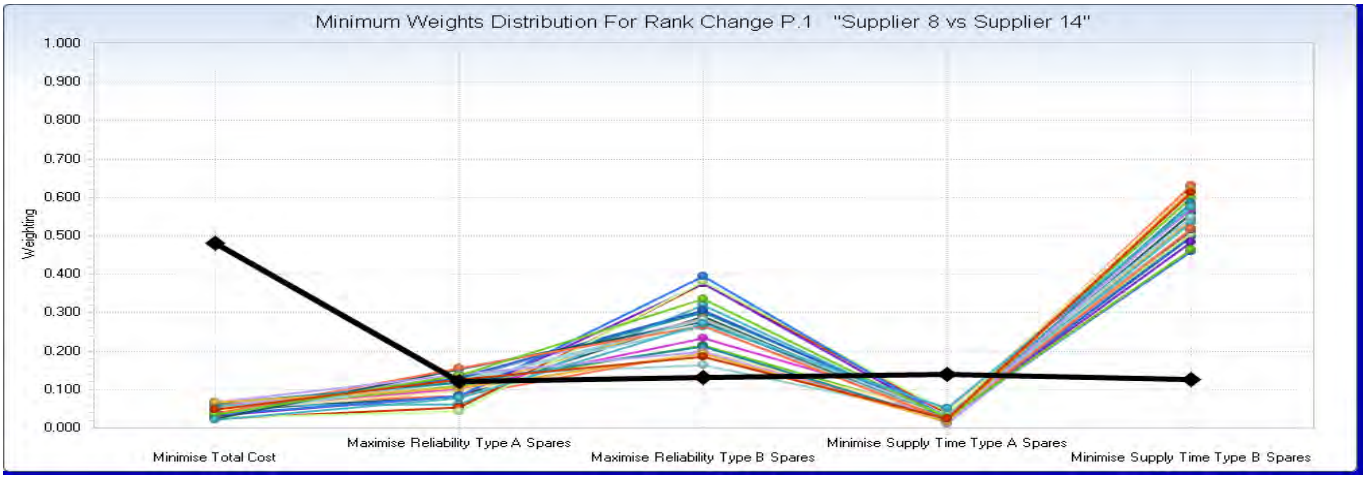


Figure 118. Weights Search plot (example 1)

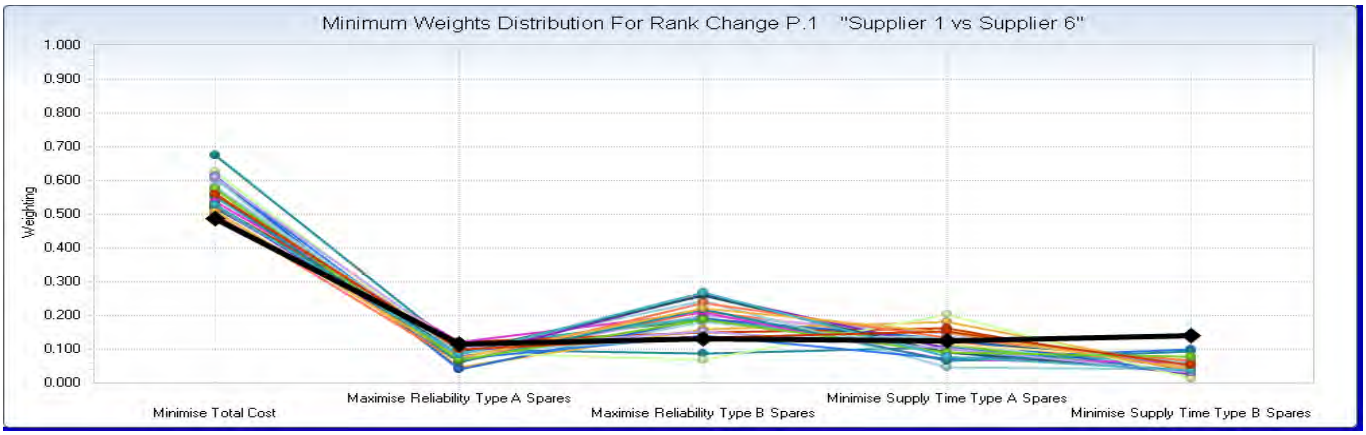
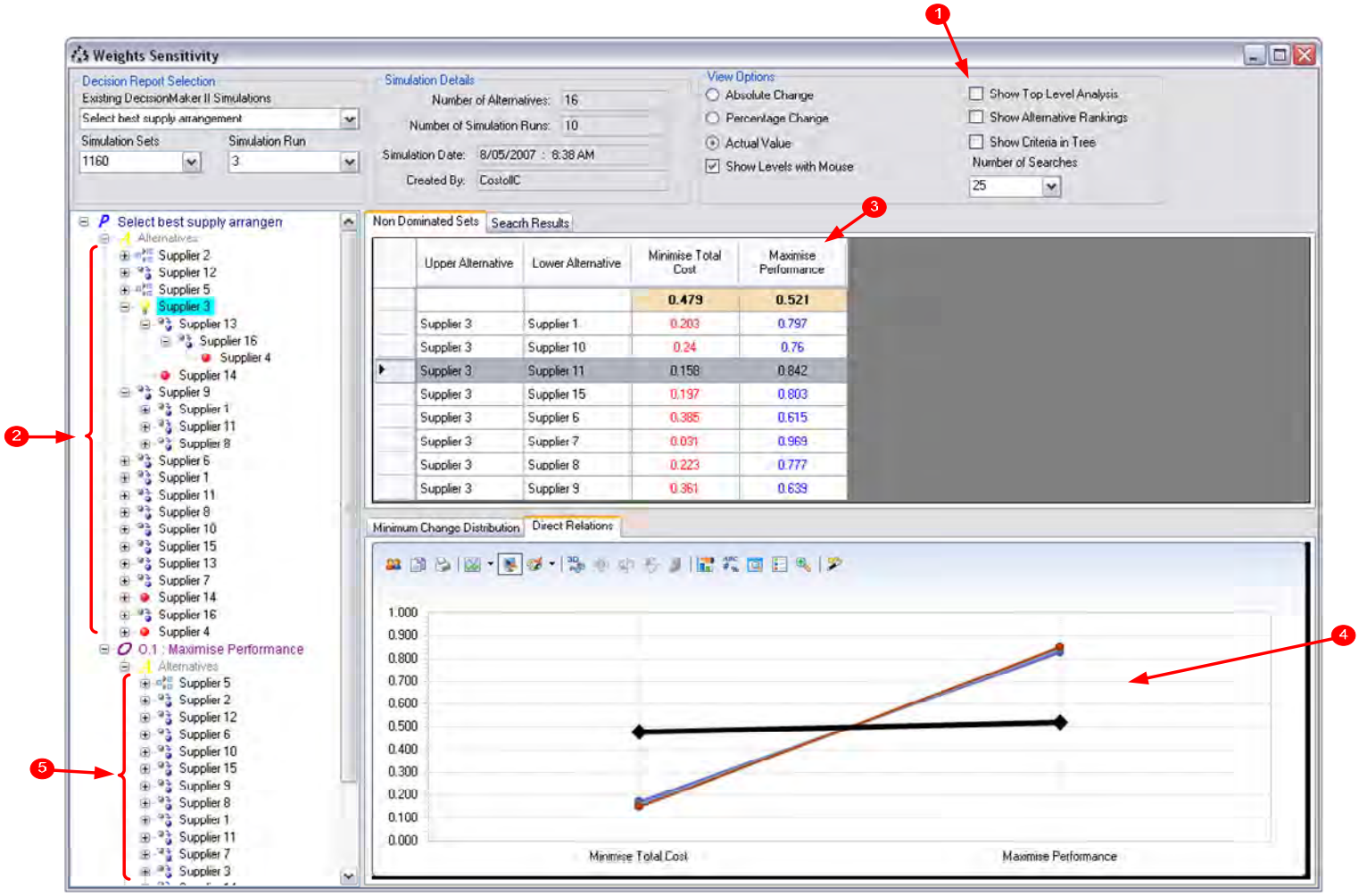


Figure 119. Weights Search plot (example 2)

12.8 Sub-Level Weights Analysis

Sub-level weights analysis provides a method for analysing the weights sensitivity at various levels within the decision tree. In Figure 120 a sub-level analysis is shown for the *Supply Manager's Dilemma*. ***Supplier 3*** has been selected at the element level of ***P.1 Select Best Supply Arrangement***. Since this is a sub-level analysis only, the immediate children of ***P.1*** will be selected for analysis. These are ***C.1 Minimise Total Cost*** and ***O.1 Maximise Performance***, as shown in the column headings for the ***Non-dominated Sets***. The Domination Tree View will be populated based on these two elements alone. The search results shown indicate that, in general, the weighting for ***Minimise Total Cost*** needs to be decreased and the weighting for ***Maximise Performance*** increased proportionally. This is clearly visible in the plot of the ***Direct Relations***. The black line in the plot shows the current weighting assigned to the objective and criteria selected.

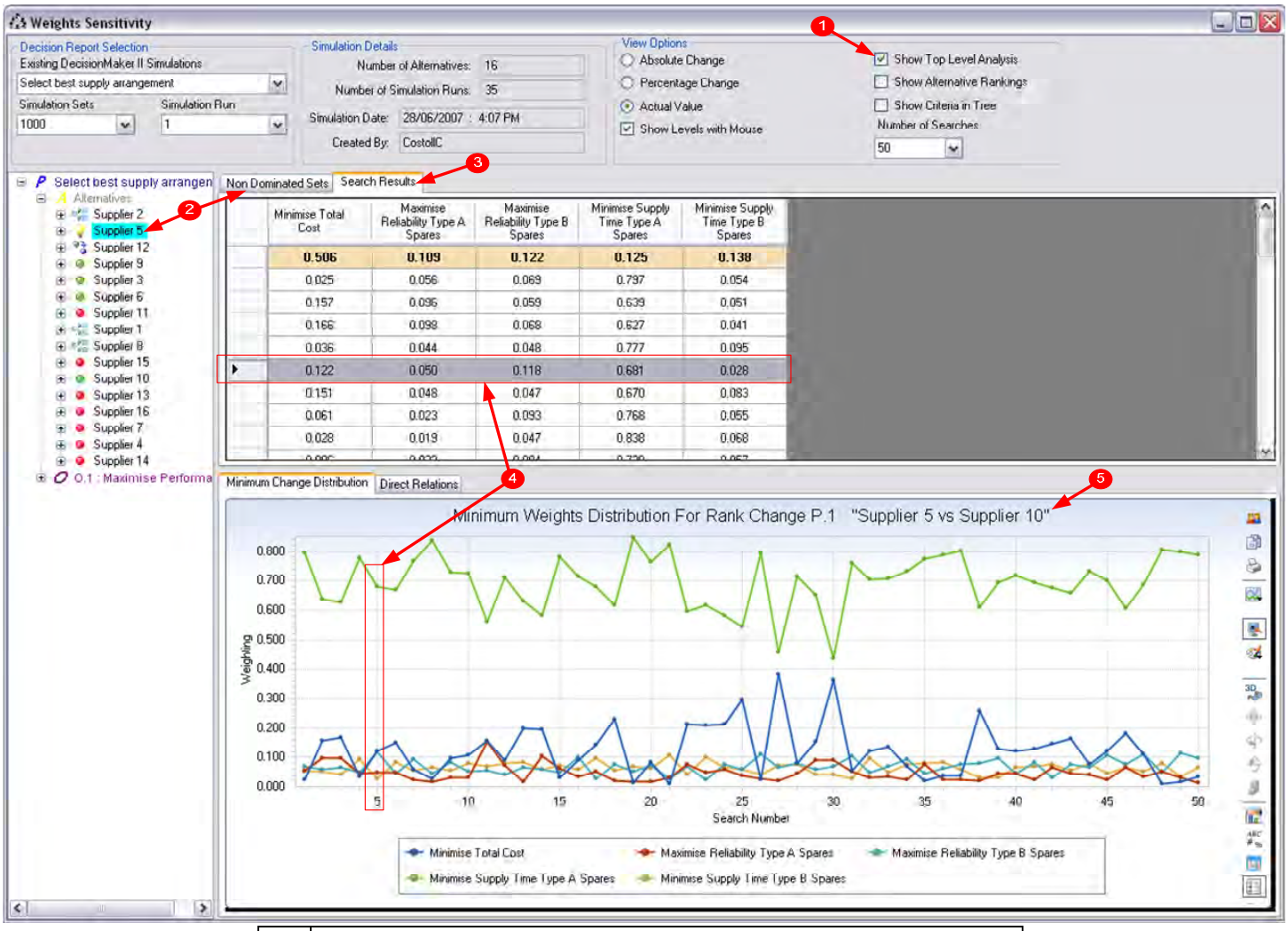


1	***Show Top Level Analysis*** is not selected.
2	This section of the Domination Tree is built based on ***Maximise Performance*** and ***Minimise Total Cost***.
3	Weights for selected elements are displayed in the ***Non Dominated Sets***.
4	Graphical representation of the weights ranges in the ***Search Results*** table.
5	This section of the domination tree is based on ***Maximise Reliability*** and ***Minimise Supply Time***.

Figure 120. Weights Sensitivity sub-level analysis

12.9 Minimum Change Distribution

The Minimum Change Distribution is a graphical display of the search results. It is designed to assist the decision-maker in determining the range of weights that can cause a ranking reversal. The Minimum Change Distribution graphical display is shown in Figure 121.

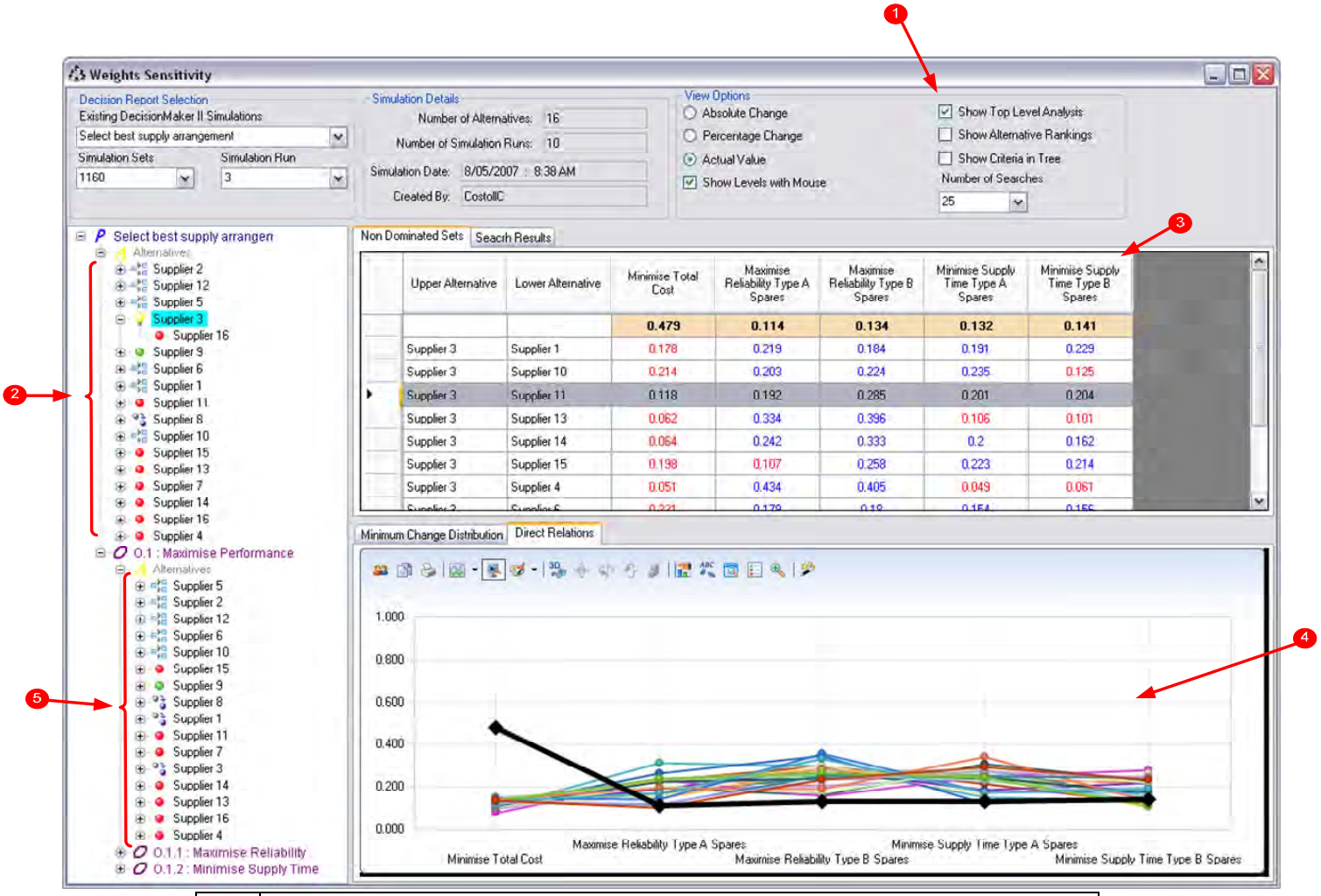


1	***Show Top Level Analysis*** is selected.
2	Select an alternative and perform a search by clicking the row header in the ***Non Dominated Sets***.
3	The ***Search Results*** tab can be selected to view the results as a table.
4	Graphical representation of the search results is displayed. Each set of points corresponds to a row in the search results table.
5	The title of the ***Minimum Weights Distribution*** indicates the alternatives that are being compared.

Figure 121. Example of the Minimum Change Distribution

12.10 Top-Level Analysis

The top-level analysis only considers criteria elements. It also uses relative weights values. This means that if the root problem is selected then all criteria in the decision problem will be used in the analysis. Similarly, if an objective is selected then all the criteria that exist in the decision tree below that objective will be used in the analysis. Figure 122 shows an example of top-level analysis. If the decision tree is small, this is the preferred weights analysis to use when analysing the tree structure of the problem. For large decision problems with complex trees it may be more preferable to use the sub-level analysis at various sections within the tree to assist in decision structure development.



1	***Show Top Level Analysis*** is selected.
2	This section of the domination tree is built based on all the criteria in the problem.
3	Selected criteria weights are shown in the Non-dominated sets table view.
4	Graphical analysis of the search results showing the range of weights that will produce a change.
5	This section of the domination tree is based on all criteria below ***Maximise Performance*** in the decision tree. In this example the criteria are ***C.2***, ***C.3***, ***C.4*** and ***C.5***.

Figure 122. Weights Sensitivity top-level analysis

13. Criteria Sensitivity

Criteria Sensitivity analysis is *Decision Maker*'s is most advanced tool. It is important to understand how to interpret the information presented since, in some instances, the predictions can produce spurious results. This is an inherent problem with the Artificial Intelligence (AI) technique that has been used to perform the searches. However, if some simple guidelines are followed, these problems can be easily identified and understood. Criteria Sensitivity analysis can be started from the **Advanced Analysis | Criteria Sensitivity** menu as shown in Figure 123.

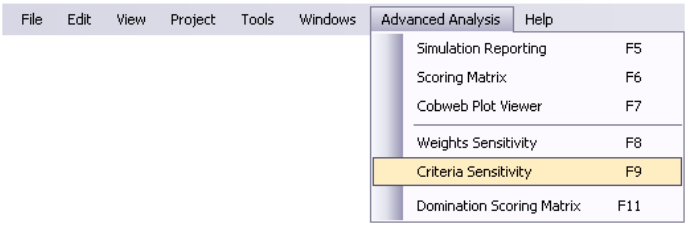


Figure 123. Starting Criteria Sensitivity analysis

Unlike Weights Sensitivity analysis, Criteria Sensitivity analysis does not involve domination. Instead the aim is to determine the amount that one or more criteria values need to change in order to make one alternative more preferable than another. This is achieved by finding the point where the two alternatives are equal and hence any further criteria value changes in the direction of preference will only make the search alternative more superior.

Decision Report Selection within the Criteria Sensitivity analysis is based on the selection of individual simulation runs. Figure 124 shows the Criteria Sensitivity Analysis window. Details of specific components and their uses are explained in the following subsections.

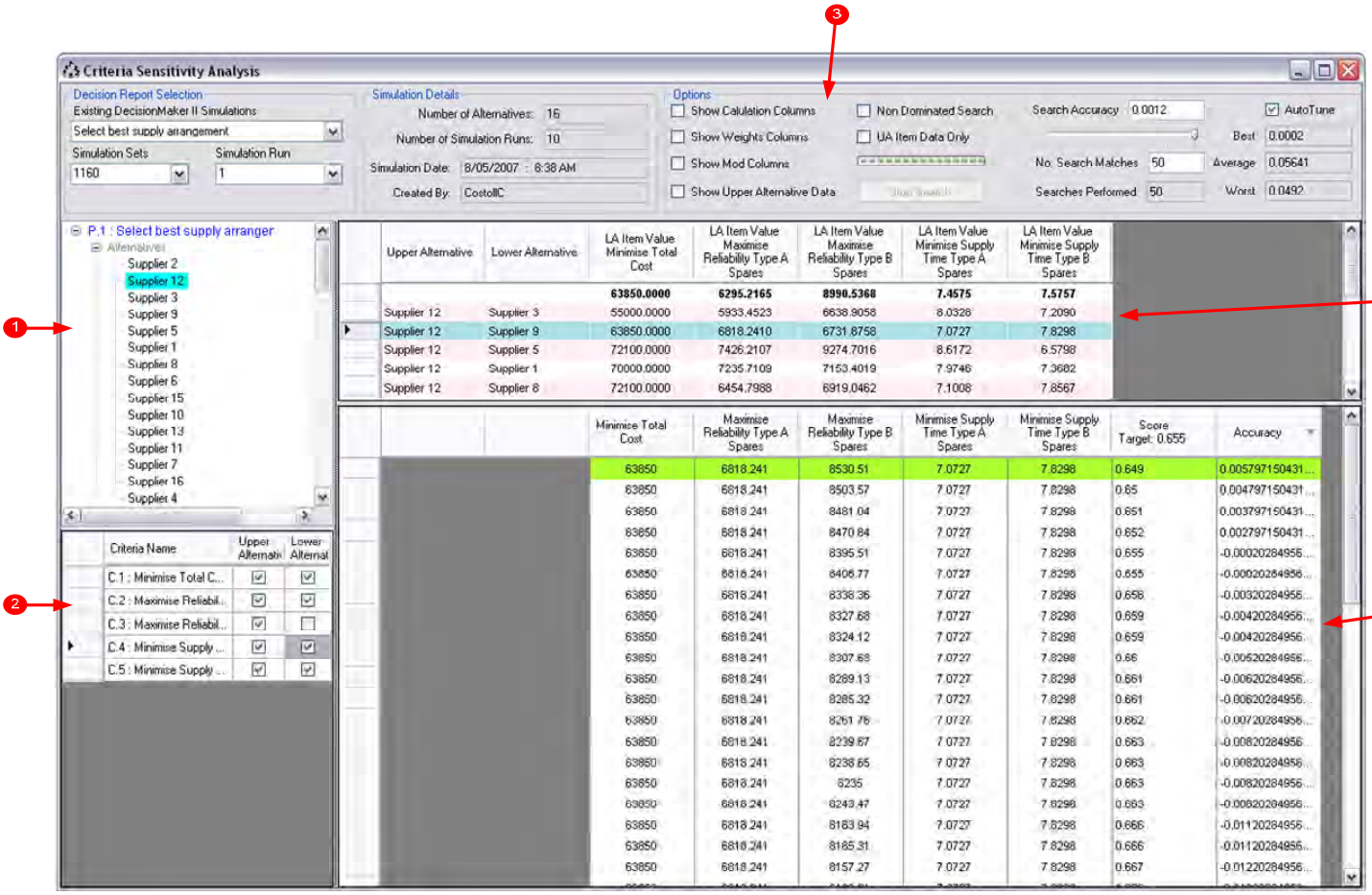
When the Criteria Sensitivity Analysis window is open, selecting a simulation run in the ***Decision Report Selection*** panel will populate the tree view. Other tables will be populated after selections are made and searches performed.

When searching for criteria, the upper alternatives criteria values are kept constant and some, or all, of the lower alternatives values are allowed to change. Generally, some of the lower alternatives criteria can be kept constant. For example, the alternatives ***Supplier 2*** and ***Supplier 5*** are compared in Table 17. This example shows how the criteria values for ***Supplier 5*** would have to change to make it more preferred than ***Supplier 2***.

Table 17. Criteria Sensitivity analysis example

Supplier	Minimise Total Cost	Maximise Reliability Type A Spare	Maximise Reliability Type B Spares	Minimise Supply time Type A Spares	Minimise Supply time Type B Spares
Supplier 2	60000	6847	8729	7.35	6.56
Supplier 5	72100	7426	9274	8.61	6.57

In Table 17, consider the directions of preference for each criterion (the superior values have been coloured blue). To search for changes in the values of ***Supplier 5*** that will make it more preferred than ***Supplier 2*** only the lower values would be allowed to change. These are: ***Minimise Total Cost***; ***Minimise Supply Time Type A Spares***; and possibly ***Minimise Supply Time Type B Spares***. This last criterion could also be kept constant since the two values are almost equivalent. This comparison allows for the formulation of the following search problem:



1	The tree view alternatives are displayed in ordinal ranking order of the parent objective or root problem.
2	Criteria Search selector.
3	***Options*** panel.
4	Simulation Results table.
5	Search Results table.

Figure 124. Criteria Sensitivity analysis

"What values of Minimise Total Cost and Minimise Supply Time Type A Spares, given that the Reliability of Type A spares is 7426 and Reliability of Type B spares is 9274 and Minimise Supply Time Type B Spares is 6.57, will make Supplier 5 equal to Supplier 2."

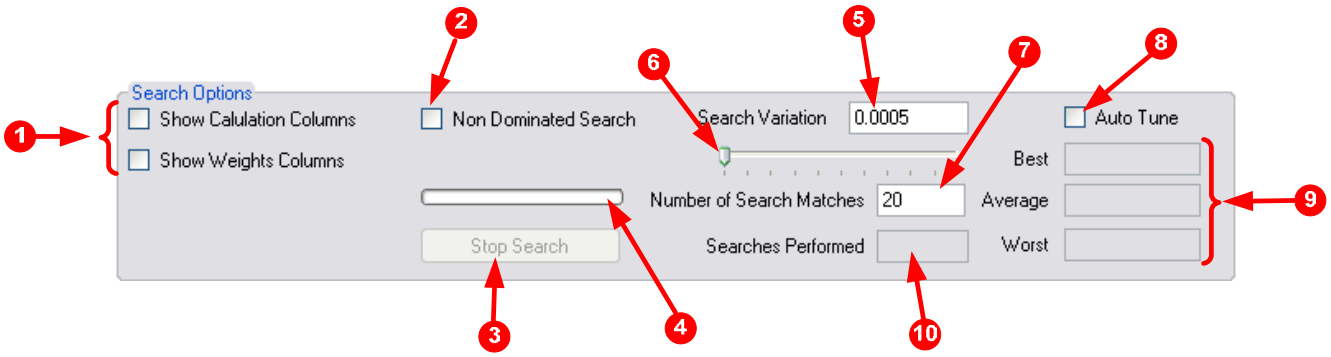
To solve the above search problem using the Criteria Search Selector, the desired criteria are selected as shown in Figure 125. The criteria that will remain constant are the ones that have been selected in both columns. The search settings then need to be set and in most searches the default setting will be sufficient, as explained in Section 13.1.

	Criteria Name	Upper Alternative	Lower Alternative
	C.1 : Minimise Total Cost (-)	☑	☐
	C.2 : Maximise Reliability Type A Spares (+)	☑	☑
	C.3 : Maximise Reliability Type B Spares (+)	☑	☑
	C.4 : Minimise Supply Time Type A Spares (-)	☑	☐
▶	C.5 : Minimise Supply Time Type B Spares (-)	☑	☑

Figure 125. Criteria Search Selector (example 1)

13.1 Criteria Sensitivity Search Options

Figure 126 describes the search options used in the Criteria Sensitivity Search.



1	These options show some hidden details.
2	***Non Dominated Search***: enabling this will provide only non-dominated results. For almost all searches this should not be used, since it will limit the number of sets returned and not provide enough data for trade-off analysis.
3	***Stop Search***: this button can be used to stop a search.
4	Search progress bar (Section 13.1.2).
5	***Search Variation***: this is the maximum difference between the Target Cardinal Score and the Search Result Cardinal score (Section 13.1.1).
6	Search relaxation slider (Section 13.1.3).
7	***Number of Search Matches***: the total number of results to find and return in the Search Results table (Section 13.1.4).
8	***Auto Tune*** (Section 13.2).
9	These three boxes show the best, worst and average variations in Target and Search Cardinal Scores (Section 13.1.7).
10	***Searches Performed***: the number of searches that have been performed (Section 13.1.5).

Figure 126. Criteria Sensitivity Search Options

13.1.1 Search Variation

Search Variation is the absolute difference between the upper alternative's cardinal score and the lower alternative's cardinal score. For example, if the target cardinal score is

0.8033, a search variation of 0.0005 indicates that any search results between 0.80328 and 0.80338 will be accepted and added to the search results table.

13.1.2 Search Progress Bar

The Search Progress Bar progresses as the number of search matches increases. It is complete when the total number of search matches has been reached.

13.1.3 Search Relaxation Slider

There are times when a search will not return any results. When this occurs it can be due to two factors:

1. Most commonly, search results may fall just outside the search variation range. When this happens, moving the Search Relaxation Slider to the right will increase the search variation. This relaxes the search constraints and allows matches to be added to the results table; and
2. The constant criteria value of the lower alternative is significantly inferior, i.e. it is impossible to find any results unless the variation is set to a larger value. This signifies that the variable criteria will not cause a ranking reversal.

13.1.4 Number of Search Matches

The ***Number of Search Matches*** is the desired number of results to search. When performing searches for the purposes of trade-off analysis, a large number will provide more clarity. Usually a minimum number of 50 search matches is recommended.

13.1.5 Searches Performed

The ***Searches Performed*** indicator shows the number of searches that have been run. If this number increases significantly and very few results have been added, it is probably necessary to relax the search variation using the slider. This can also be performed manually by entering a value in the ***Search Variation*** text box.

13.1.6 Enable Auto Tune

Using Auto Tune allows *Decision Maker* to automatically determine the search variation. If you are unsure of the initial values to use for the search variation, use the Auto Tune function. However, if the results are very close to the target score, the variation will become very small and usually it will be necessary to relax the variation using the slider. Auto Tune uses the values from the best, worst and average variation boxes.

13.1.7 Best, Worst and Average Variation

These three boxes can be very helpful when performing searches. It is recommended that the first search be for a small number of searches, such as the default of 10. When the search is complete, the Best, Worst and Average variation boxes will be populated. These

values can be used to manually set the variation for a more thorough search of, for example, 30 to 50 or more results.

13.1.8 Starting a Search

To start a search, click on a row header of the applicable selection. In the example shown in Figure 127, the values of ***Supplier 12*** are being compared to ***Supplier 2***, as indicated by 1.

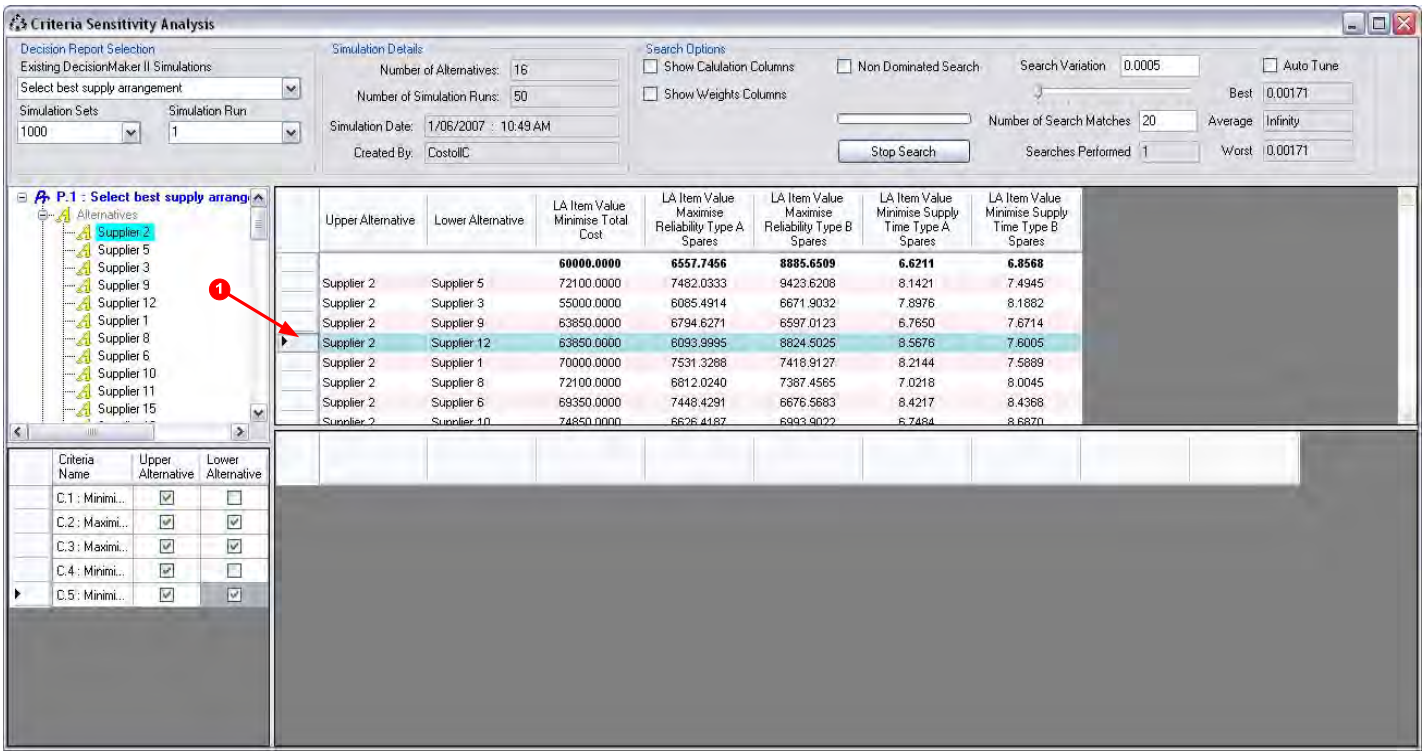
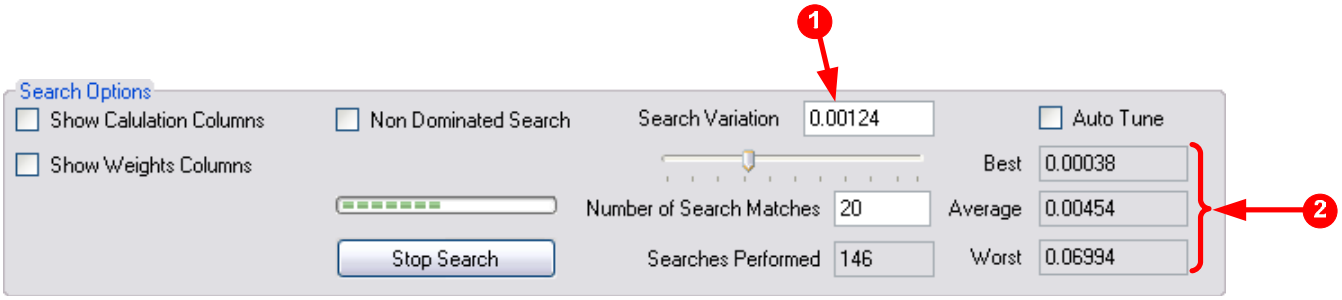


Figure 127. Criteria Sensitivity - starting a search

When the search begins, the Options Panel and Search Results Table will update the progress and provide feedback. As mentioned earlier, this information can be used to further refine searches as shown in Figure 128.



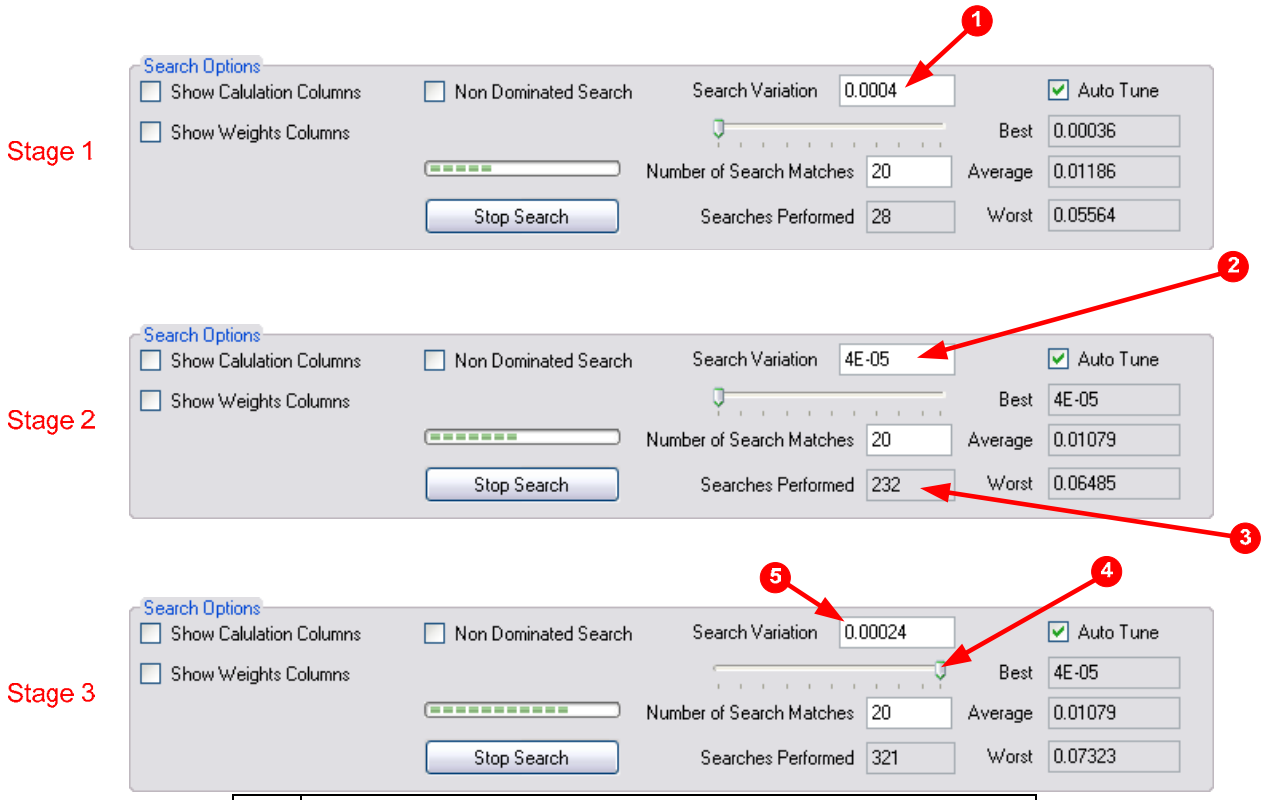
1	Manual search variation is set (i.e. not Auto Tune).
2	Simple analysis of the best, worse and average results indicate that the Search Variation could be smaller, for example 0.0001.

Figure 128. Criteria Sensitivity Search Options (in progress)

13.2 Using the Auto Tune Option

The Auto Tune option assists in finding the optimal search variation range. However, it can slow the progress of a search by refining the variation to a range which is impractically too small. Figure 129 shows a three stage process to deal with this issue:

1. Stage 1 shows the search soon after it has started.
2. Stage 2 shows the view after 232 searches have been run and only approximately 7 results found as indicated by the green progress bar. This is due to the very low variation value assigned by Auto Tune. As the search progresses, the variation rapidly decreases and locating new matches begins to slow down.
3. Stage 3 shows the view when the relaxation slider has been used and it can be seen that progress has increased by relaxing (i.e. increasing) the search variation.



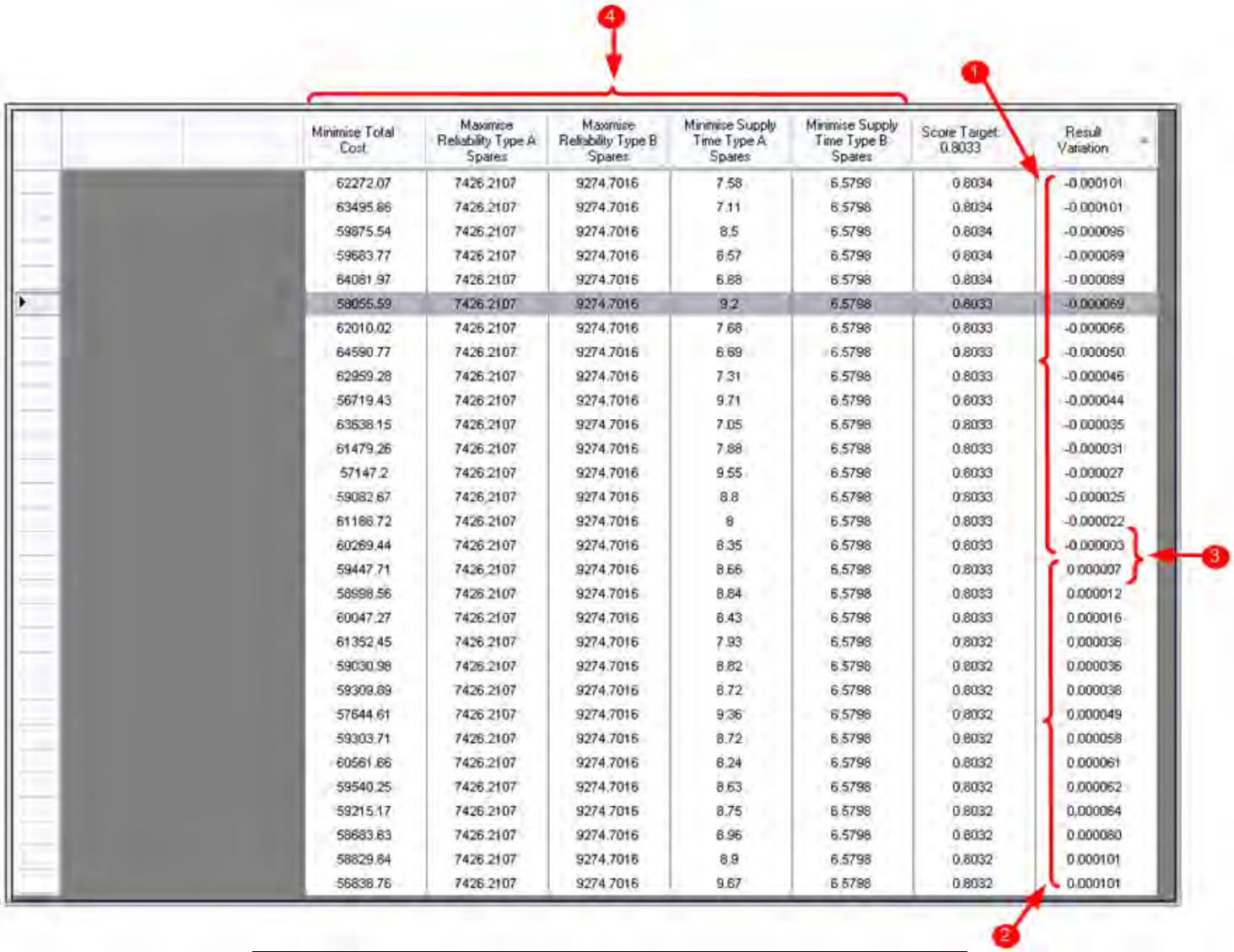
1	A suitable starting search variation value.
2	The search variation is too small.
3	A high number of searches with slow progress is an indication that the search variation value needs to be increased. This can be accomplished using the relaxation slider.
4	The relaxation slider has been moved to the right.
5	A suitable search variation value is set again.

Figure 129. Criteria Sensitivity Search Options (using Auto Tune)

When Auto Tune has found some best, worse and average scores, Auto Tune can be turned off and the values used. In Stage 3 of Figure 129, the best, worse and average values indicate a variation value between 0.00066 and 0.00005 could be used. For example, 0.0001 would be almost halfway between these two values.

13.3 Analysing Search Results

The results from a search can be used for different types of analyses, with the most simple being 'what if' questions. The data presented can also be used for trade-off analysis since it presents ranges of values for the various criteria. When sorted by column, trade-off analysis is simple. This is explained in Section 13.3.2. Figure 130 shows an example of the search results.



Minimise Total Cost	Maximise Reliability Type A Spares	Maximise Reliability Type B Spares	Minimise Supply Time Type A Spares	Minimise Supply Time Type B Spares	Score Target: 0.8033	Result Variation
62272.07	7426.2107	9274.7016	7.58	6.5798	0.8034	-0.000101
63495.86	7426.2107	9274.7016	7.11	6.5798	0.8034	-0.000101
59875.54	7426.2107	9274.7016	8.5	6.5798	0.8034	-0.000095
59683.77	7426.2107	9274.7016	8.57	6.5798	0.8034	-0.000089
64081.97	7426.2107	9274.7016	6.88	6.5798	0.8034	-0.000089
58055.59	7426.2107	9274.7016	9.2	6.5798	0.8033	-0.000069
62010.02	7426.2107	9274.7016	7.68	6.5798	0.8033	-0.000066
64590.77	7426.2107	9274.7016	6.69	6.5798	0.8033	-0.000050
62959.28	7426.2107	9274.7016	7.31	6.5798	0.8033	-0.000046
56719.43	7426.2107	9274.7016	9.71	6.5798	0.8033	-0.000044
63638.15	7426.2107	9274.7016	7.05	6.5798	0.8033	-0.000035
61479.26	7426.2107	9274.7016	7.88	6.5798	0.8033	-0.000031
57147.2	7426.2107	9274.7016	9.55	6.5798	0.8033	-0.000027
59082.67	7426.2107	9274.7016	8.8	6.5798	0.8033	-0.000025
61186.72	7426.2107	9274.7016	8	6.5798	0.8033	-0.000022
60269.44	7426.2107	9274.7016	8.35	6.5798	0.8033	-0.000003
59447.71	7426.2107	9274.7016	8.66	6.5798	0.8033	0.000007
58998.56	7426.2107	9274.7016	8.84	6.5798	0.8033	0.000012
60047.27	7426.2107	9274.7016	8.43	6.5798	0.8033	0.000016
61352.45	7426.2107	9274.7016	7.93	6.5798	0.8032	0.000036
59030.98	7426.2107	9274.7016	8.82	6.5798	0.8032	0.000036
59309.89	7426.2107	9274.7016	8.72	6.5798	0.8032	0.000038
57644.61	7426.2107	9274.7016	9.36	6.5798	0.8032	0.000049
59303.71	7426.2107	9274.7016	8.72	6.5798	0.8032	0.000058
60561.66	7426.2107	9274.7016	8.24	6.5798	0.8032	0.000061
59540.25	7426.2107	9274.7016	8.63	6.5798	0.8032	0.000062
59215.17	7426.2107	9274.7016	8.75	6.5798	0.8032	0.000064
58683.83	7426.2107	9274.7016	8.96	6.5798	0.8032	0.000080
58829.84	7426.2107	9274.7016	8.9	6.5798	0.8032	0.000101
56838.76	7426.2107	9274.7016	9.67	6.5798	0.8032	0.000101

1	Negative values indicate criteria values produce a cardinal score slightly lower than the target.
2	Positive values indicate criteria values produce a cardinal score slightly higher than the target.
3	This is the region of change. These two sets of criteria values are the closest to the target.
4	The results variation table showing the constant and varying criteria values.

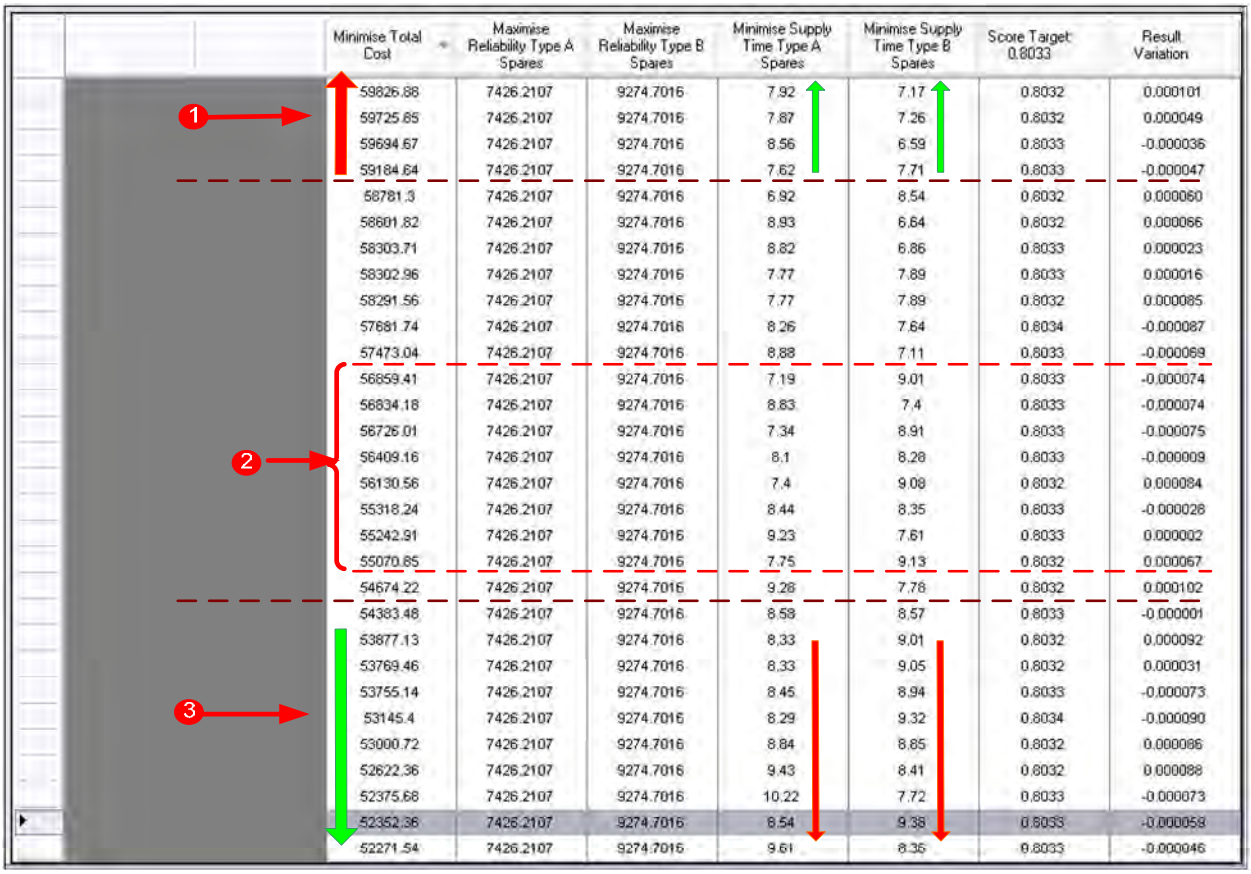
Figure 130. Search results table

13.3.1 The Result Variation Column

The actual variation of each result from the target score is shown in the result variation column. A negative value indicates a slightly lower score and a positive value indicates a slightly higher score. Sorting on this column has the same effect as sorting by the Target Score column. When sorted, it can be used to locate the closest solutions to the target value, which are the sets of result where the scores change from lower to higher than the target as indicated by 3 in Figure 130.

13.3.2 Trade-Off Analysis

Figure 131 shows an example of how the search results can be used for criteria sensitivity trade-off analysis. If a search is run and the number of matches is significant to give a range of solution sets, then the results can be sorted for each criterion by clicking on the column header in the search results table. The sorted results can then be used to determine what trade-offs can be made within the alternative. In the example shown in Figure 131, three regions are highlighted. The green and red arrows indicate the criteria value directional movement in the preferred (green) and non-preferred (red) directions.



Minimise Total Cost	Maximise Reliability Type A Spares	Maximise Reliability Type B Spares	Minimise Supply Time Type A Spares	Minimise Supply Time Type B Spares	Score Target: 0.8033	Result Variation
59826.88	7426.2107	9274.7016	7.92	7.17	0.8032	0.000101
59725.85	7426.2107	9274.7016	7.87	7.26	0.8032	0.000049
59694.67	7426.2107	9274.7016	8.56	6.59	0.8033	-0.000036
59184.64	7426.2107	9274.7016	7.62	7.71	0.8033	-0.000047
58781.3	7426.2107	9274.7016	6.92	8.54	0.8032	0.000060
58601.82	7426.2107	9274.7016	8.93	6.64	0.8032	0.000066
58303.71	7426.2107	9274.7016	8.82	6.86	0.8033	0.000023
58302.96	7426.2107	9274.7016	7.77	7.89	0.8033	0.000016
58291.56	7426.2107	9274.7016	7.77	7.89	0.8032	0.000085
57681.74	7426.2107	9274.7016	8.26	7.64	0.8034	-0.000087
57473.04	7426.2107	9274.7016	8.88	7.11	0.8033	-0.000069
56859.41	7426.2107	9274.7016	7.19	9.01	0.8033	-0.000074
56834.18	7426.2107	9274.7016	8.83	7.4	0.8033	-0.000074
56726.01	7426.2107	9274.7016	7.34	8.91	0.8033	-0.000075
56409.16	7426.2107	9274.7016	8.1	8.28	0.8033	-0.000009
56130.56	7426.2107	9274.7016	7.4	9.08	0.8032	0.000084
55318.24	7426.2107	9274.7016	8.44	8.35	0.8033	-0.000028
55242.91	7426.2107	9274.7016	9.23	7.61	0.8033	0.000002
55070.85	7426.2107	9274.7016	7.75	9.13	0.8032	0.000067
54674.22	7426.2107	9274.7016	9.28	7.78	0.8032	0.000102
54383.48	7426.2107	9274.7016	8.58	8.57	0.8033	-0.000001
53877.13	7426.2107	9274.7016	8.33	9.01	0.8032	0.000092
53769.46	7426.2107	9274.7016	8.33	9.05	0.8032	0.000031
53755.14	7426.2107	9274.7016	8.45	8.94	0.8033	-0.000073
53145.4	7426.2107	9274.7016	8.29	9.32	0.8034	-0.000090
53000.72	7426.2107	9274.7016	8.84	8.65	0.8032	0.000086
52622.36	7426.2107	9274.7016	9.43	8.41	0.8032	0.000088
52375.68	7426.2107	9274.7016	10.22	7.72	0.8033	-0.000073
52352.36	7426.2107	9274.7016	8.54	9.38	0.8033	-0.000058
52271.54	7426.2107	9274.7016	9.61	8.35	0.8033	-0.000046

1	Higher cost for better supply times.
2	Mid-range costs with a mix of average supply times.
3	Lower costs but higher supply times.

Figure 131. Criteria Sensitivity trade-off analysis

14. Database Management Interface

Decision Maker uses a Microsoft *SQL Express* compact database engine for the recording and reporting of simulation results. As the data in the database increases, performance will deteriorate. It is therefore important to perform regular maintenance of the simulation database. A user interface provides a simple method for deleting all, or selected, simulations. It also facilitates the export of simulation data for storage or transfer. The ***Database Management*** interface can be opened from the **Tools | Options** menu as shown in Figure 132. The following subsections describe the *Decision Maker* ***Database Management*** interface.

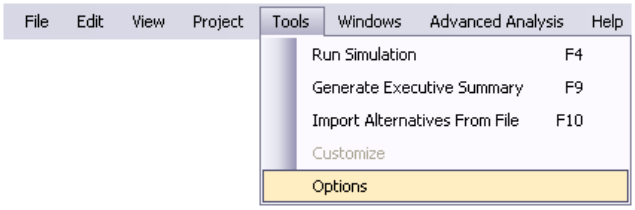
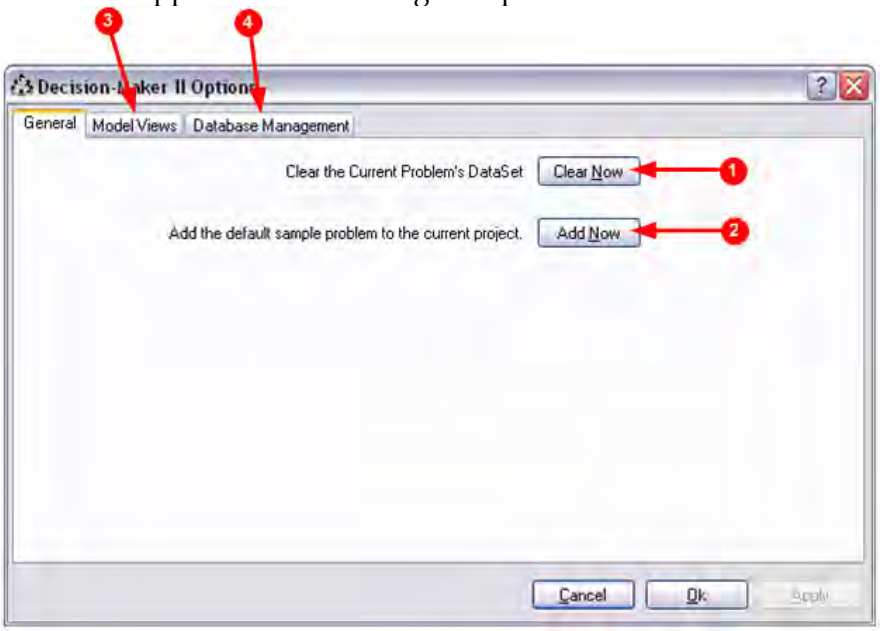


Figure 132. Opening the Decision Maker database management interface

14.1 General

The initial window to appear when selecting the options interface is shown in Figure 133.



1	Clears all data from the problem (this deletes all alternatives).
2	Creates the *Supply Manager's Dilemma* problem as given in the example.
3	***Model Views***: this is not enabled and is part of further development.
4	Database management is divided in two sections: ***Simulations*** (Section 14.2.1) and ***Database File Administration*** (Section 14.2.2)

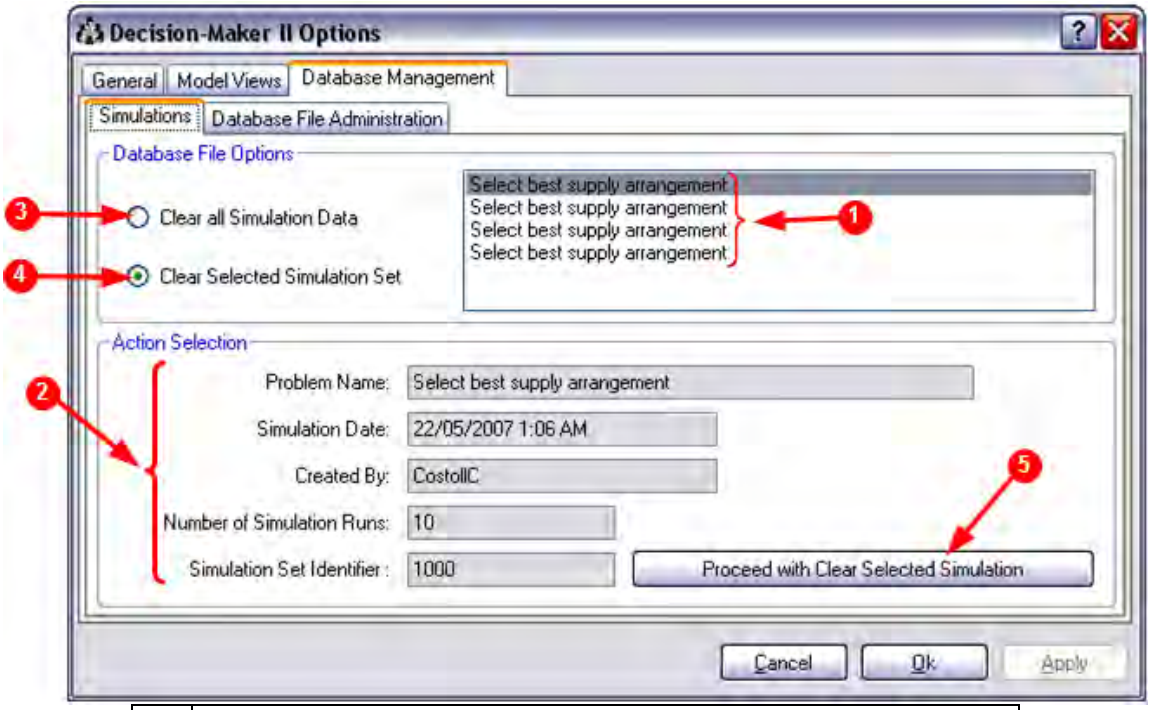
Figure 133. Decision Maker Options window

14.2 Database Management

The ***Database Management*** tab contains two sub-tabs: ***Simulations*** and ***Database File Administration***. Both tabs contain options and tools to manage the database files that *Decision Maker* uses to store simulation data. The ***Database File Administration*** options tab contains tools to assist in archiving and importing/exporting simulation database files.

14.2.1 Simulations

The ***Simulations*** tab, shown in Figure 134, provides an interface to clear (i.e. delete) individual simulations or all the simulations contained within a database file.



1	Available simulation sets - selecting one item in the list will display summary details in the ***Action Selection*** area of the ***Simulations*** tab.
2	This shows details of the selected simulation set in 1.
3	This will clear all simulation sets shown in 1.
4	This will clear the selected simulation set in 1.
5	This performs the selected action 3 or 4.

Figure 134. Database Management – Simulations

THIS IS A PERMANENT DELETION AND CANNOT BE REVERSED.

When a selection has been made, click the ***Proceed with Clear Selected Simulation*** button and the confirmation prompt shown in Figure 135 will appear. Alternatively, if ***Clear all***

Simulation Data is selected, click the ***Proceed with Clear All*** button to erase the entire contents of the database file. Figure 136 shows this confirmation prompt.

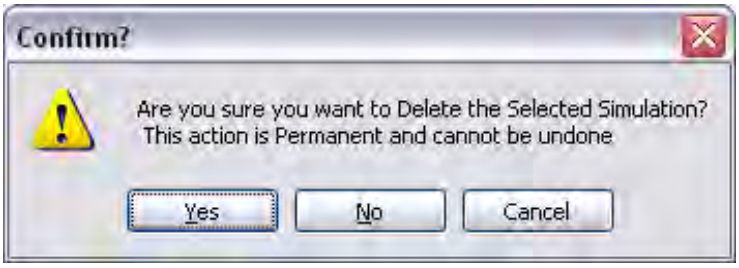


Figure 135. Confirm delete selected simulation

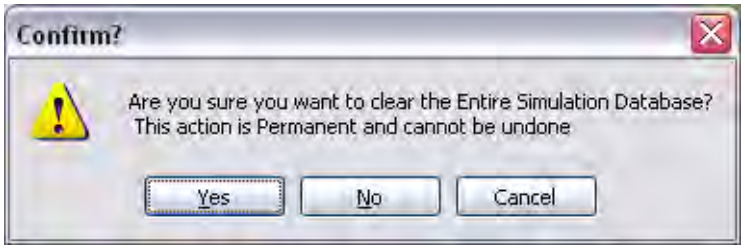


Figure 136. Confirm delete all simulations

In both cases, ***No*** and ***Cancel*** will return you to the ***Database Management*** options tab. Clicking on ***Yes*** will perform the requested action(s). When the data has been cleared, a notification will display as shown in Figure 137.

Figure 137. Deleting data completed

14.2.2 Database File Administration

An example of the ***Database File Administration*** tab is shown in Figure 138.

14.2.3 Export to Zip Archive.

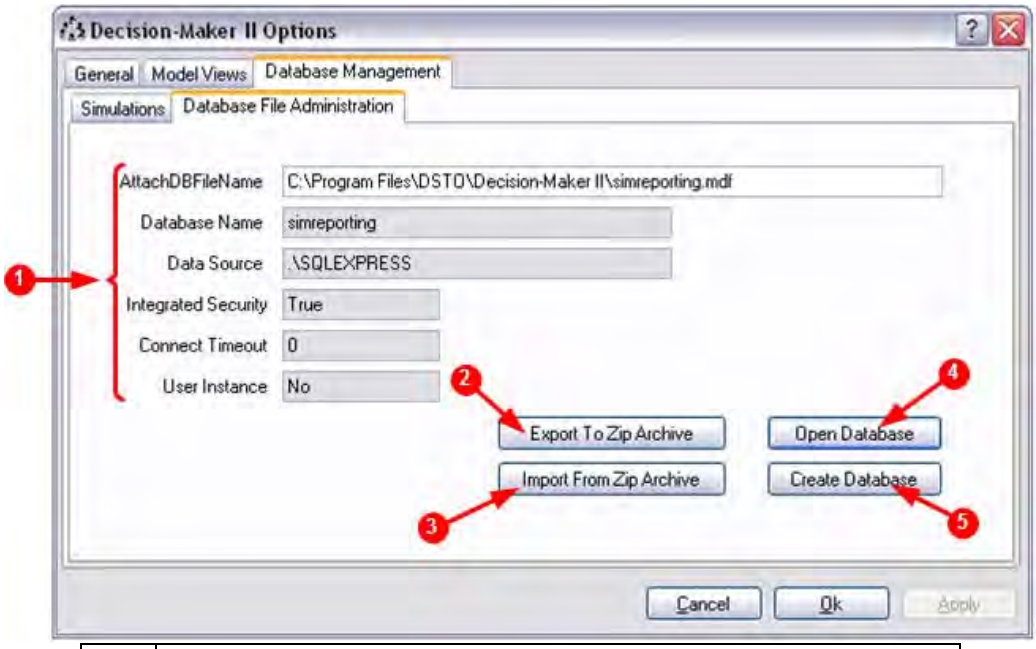
This utility compresses the current database file and creates a new file on the user desktop with the file extension ***.dmzip***. The file name will be created automatically and include the name of the database file.

When the *simreporting* database is exported, the following file will be created:

Decision Maker_DB_*simreporting*.***dmzip***

⚠	***DO NOT RENAME THIS FILE!*** *If it is renamed there will be problems when attempting to import the file.*

To create an export file click the ***Export To Zip Archive*** button as indicated by ❷ in Figure 138. When complete, the ***Finished*** export complete dialog box will appear as shown in Figure 139.



❶	Shows details of the current database file.
❷	Exports and compresses the current database file (Section 14.2.3).
❸	Imports a database file and sets it to the current database (Section 14.2.5).
❹	Opens an existing database file (Section 14.2.4).
❺	Creates a new database file (Section 14.2.6).

Figure 138. Database Management - Database File Administration

Figure 139. Export Complete dialog box

14.2.4 Import from Zip Archive

To import a zip archive, click the ***Import From Zip Archive*** button as indicated by ❸ in Figure 138. An ***Import DMZip Archive*** dialog box will appear, as shown in Figure 140. Browse to the location of the archive file and click ***Open.*** When the import is complete, a

dialog box will appear as shown in Figure 141. The details of the current database, indicated by 1 in Figure 138, will update to reflect the newly imported file.

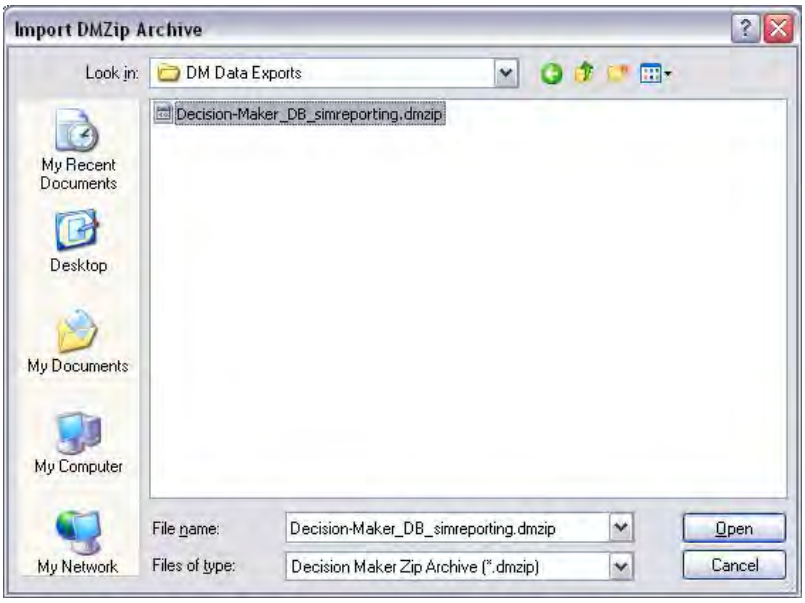


Figure 140. Import DMZip Archive dialog box

Figure 141. Import Complete dialog box

14.2.5 Open Database

To open an existing database, click the ***Open Database*** button as indicated by 4 in Figure 138. An ***Open Simulation Database*** dialog box will appear as shown in Figure 142. Browse to the location of the database file, select the file and click ***Open***. When the file has been opened, the dialog box shown in Figure 143 will appear. The details of the current database, indicated by 1 in Figure 138, will update to reflect the newly opened file.

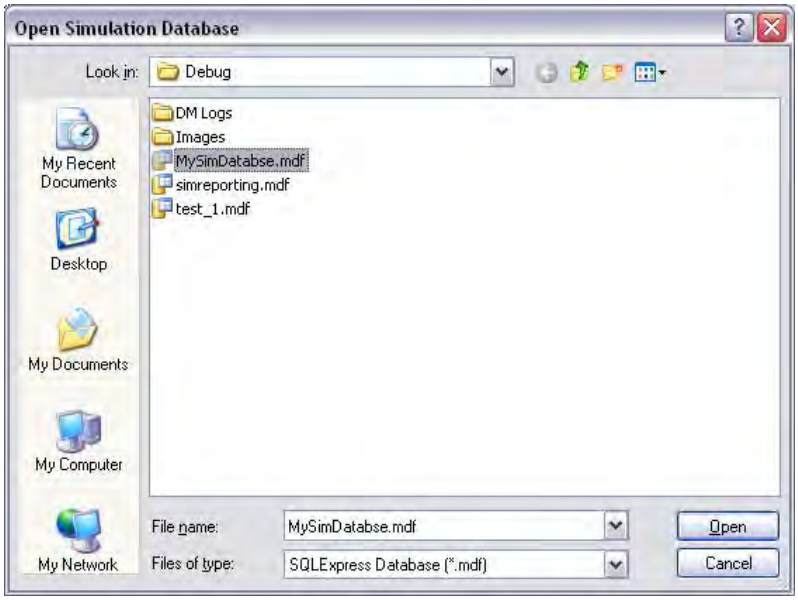


Figure 142. Open Simulation Database dialog box

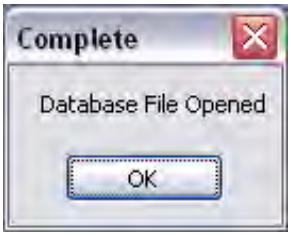


Figure 143. Database File Opened dialog box

14.2.6 Create Database

To save a database, click the ***Create Database*** button as indicated by 5 in Figure 138. A ***Save As*** dialog box will appear, as shown in Figure 144. To save the database, type in a meaningful name, do not use spaces or any punctuation characters, and click ***Save.*** A progress bar will indicate the progress of creating the new database file. When complete it will appear as shown in Figure 145. Click on the dialog box and it will close. The details of the current database, indicated by 1 in Figure 138, will update to reflect the newly created file.

15. Importing Data from File

Data for alternatives can be imported from a formatted text file, which has been delimited by commas, tabs or semi-colons. This can be used when there are a large number of alternatives and/or a large number of criteria to input. This utility can also be used to add alternatives to an existing decision problem.

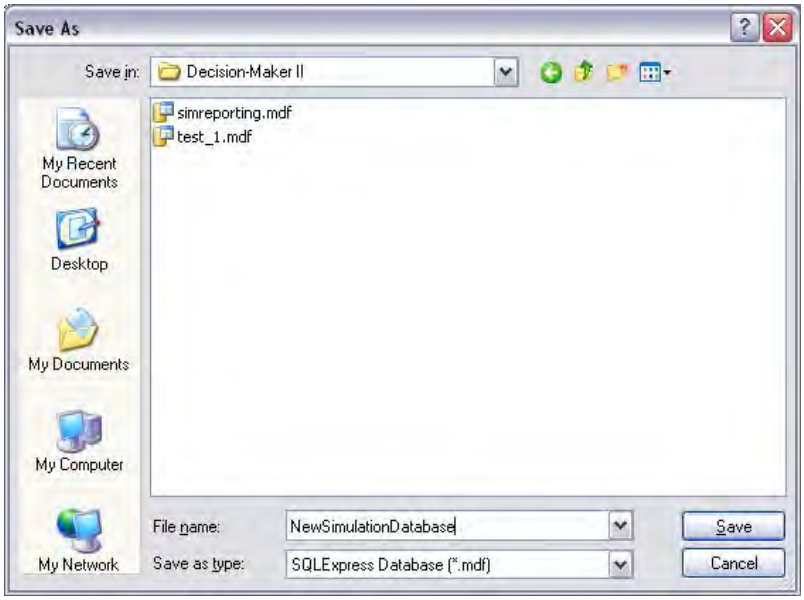


Figure 144. Save As dialog box (create new database file)

Figure 145. New Database Creation Complete dialog box

For the import utility to work it is necessary to have a project open that contains the criteria that will be mapped against the values in the data file. Then, select the **Tools | Import Alternatives From File** menu option**.** This is shown in Figure 146. The dialog box shown in Figure 147 will then appear. Browse to the data file location, select the file and click ***Open.*** The ***Alternative Input Mapping*** window will then appear. Figure 148 provides an overview of the functions that can be performed.

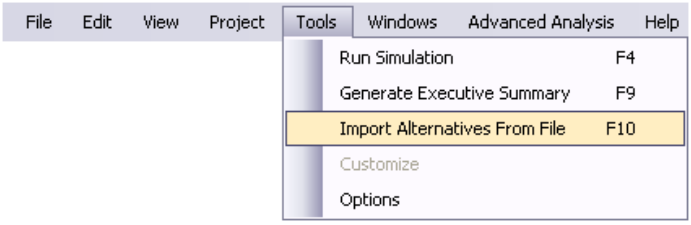


Figure 146. Starting the data import utility

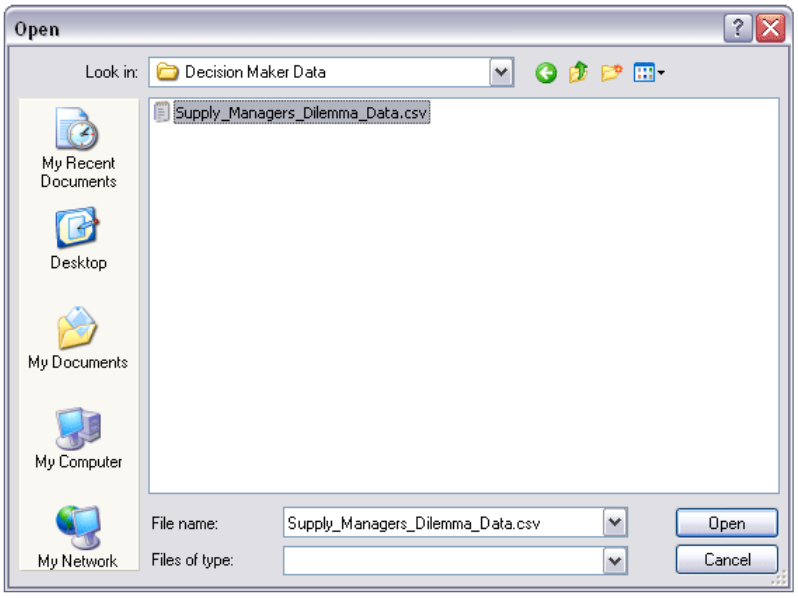
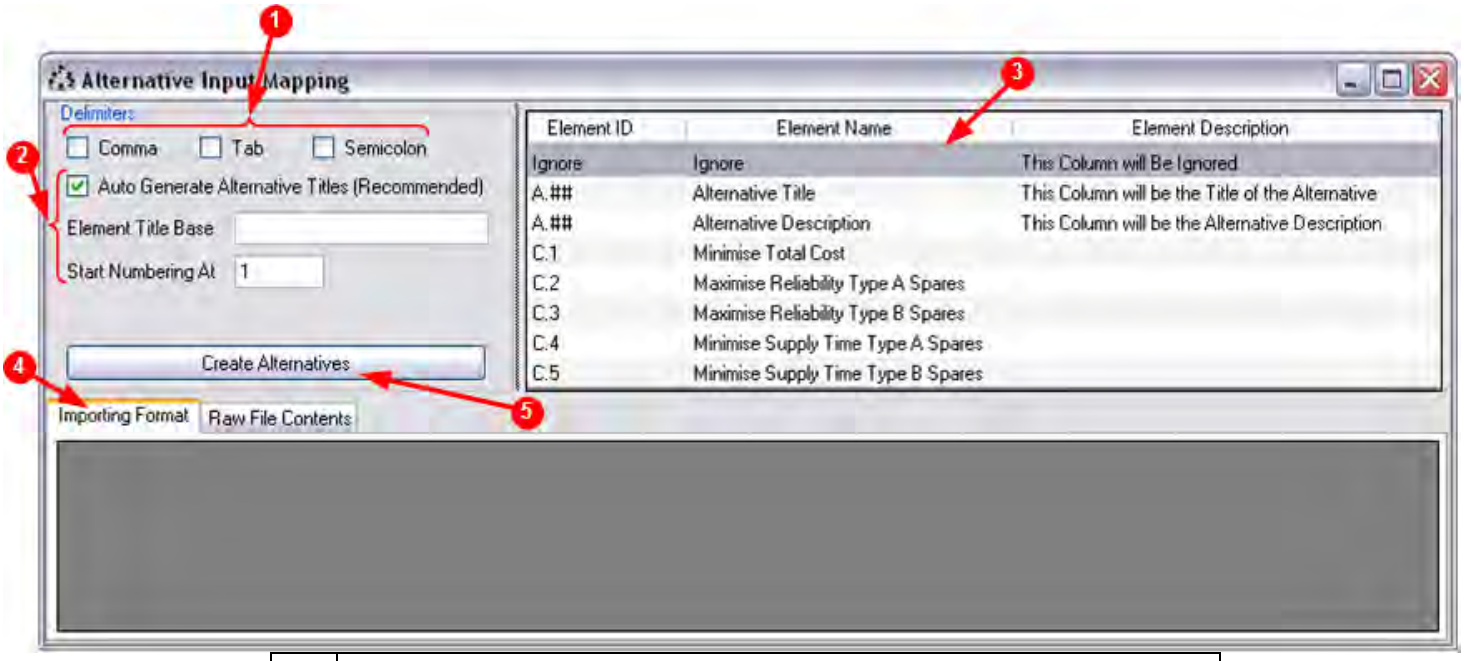


Figure 147. Open data file for import dialog box



1	There are three types of delimiter selection available and they can be combined to format the input into individual columns.
2	The utility can automatically generate alternative titles.
3	The table view shows the available items that can be used for column mappings.
4	These two tabs show the import process. The ***Importing Format*** tab is the main tab used in mapping the columns to criteria and/or alternative titles and descriptions. The ***Raw File Contents*** tab provides a view of the contents of the data file and is for viewing purposes only.
5	When the mapping is complete and ready for importing, this button will process the mappings that have been set.

Figure 148. Overview of Alternative Input Mapping

15.1 Setting the Delimiter

Figure 149 shows the window after the delimiter selection has been made. In this example the data file was tab delimited (indicated by 1 in Figure 149). Also, the contents of the file already contained the title for each alternative. Hence, ***Auto Generate Alternative Titles*** is unchecked (indicated by 2 in Figure 149). Finally the table is shown at the location indicated by 3 in Figure 149. In Figure 149, no mapping has yet been performed. This is evident by the default column names in the importing table. Mapping column names is described in Section 15.2

15.2 Mapping Column Names

The process of mapping column names is shown in Figure 150. The mapping was performed by selecting 2 with the left mouse button and holding it down and dragging the mouse to the column indicated by 3. When the + symbol appears next to the mouse, release the left mouse button and the column title will change to show the mapping selected. This process is repeated until all the desired columns have been mapped. 4 and 5 show another mapping pair. In the example all columns have been mapped.

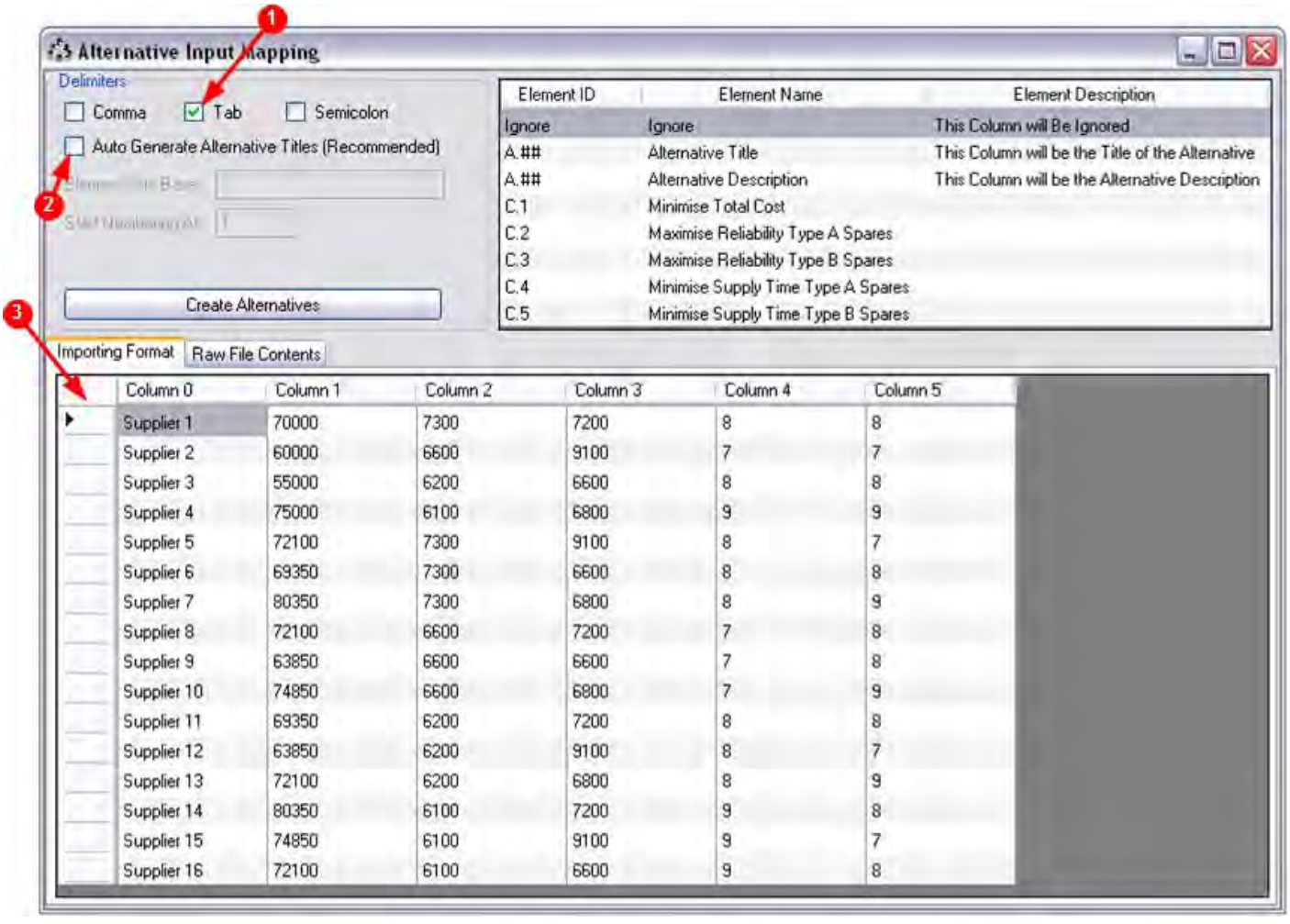
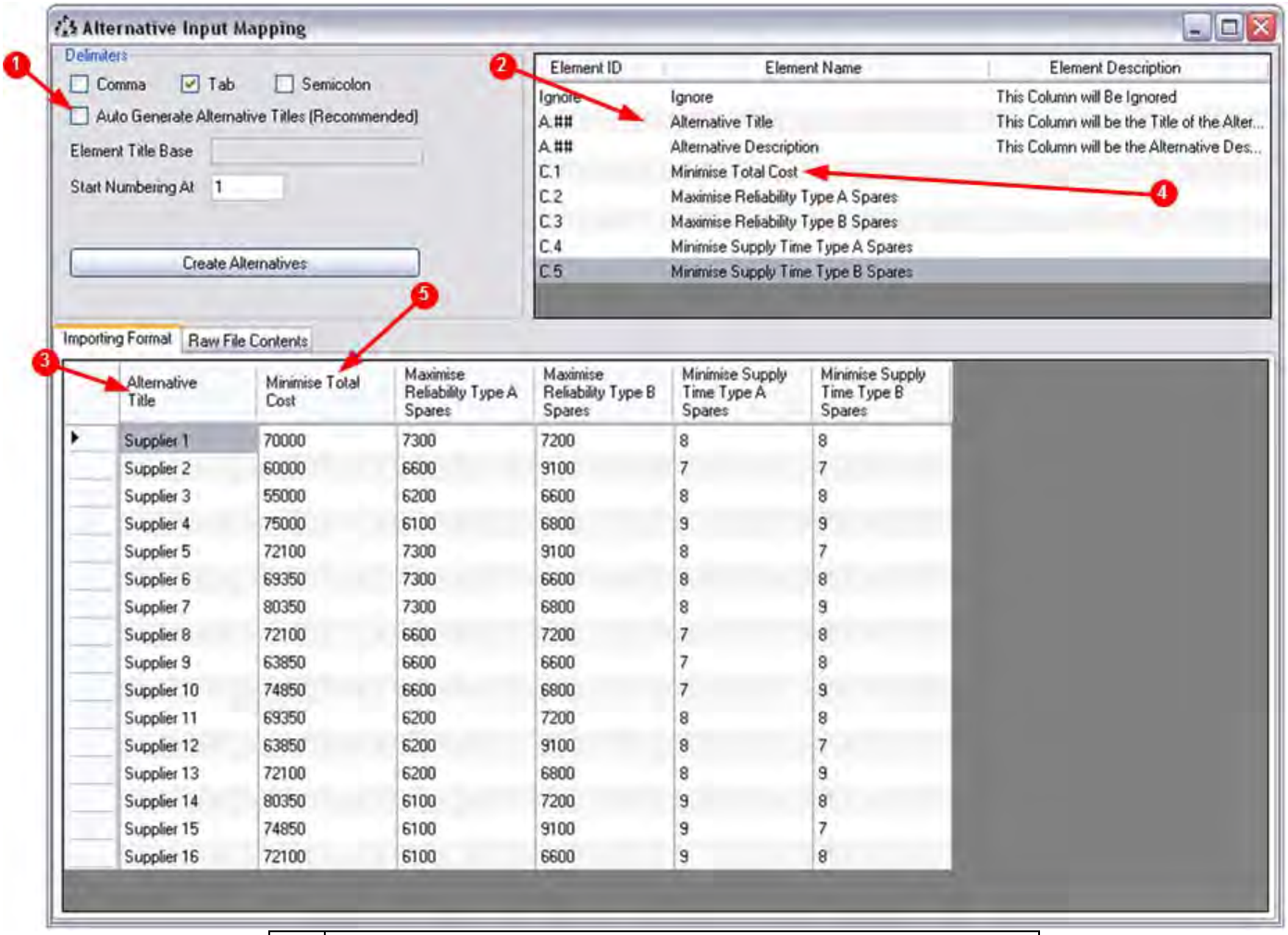


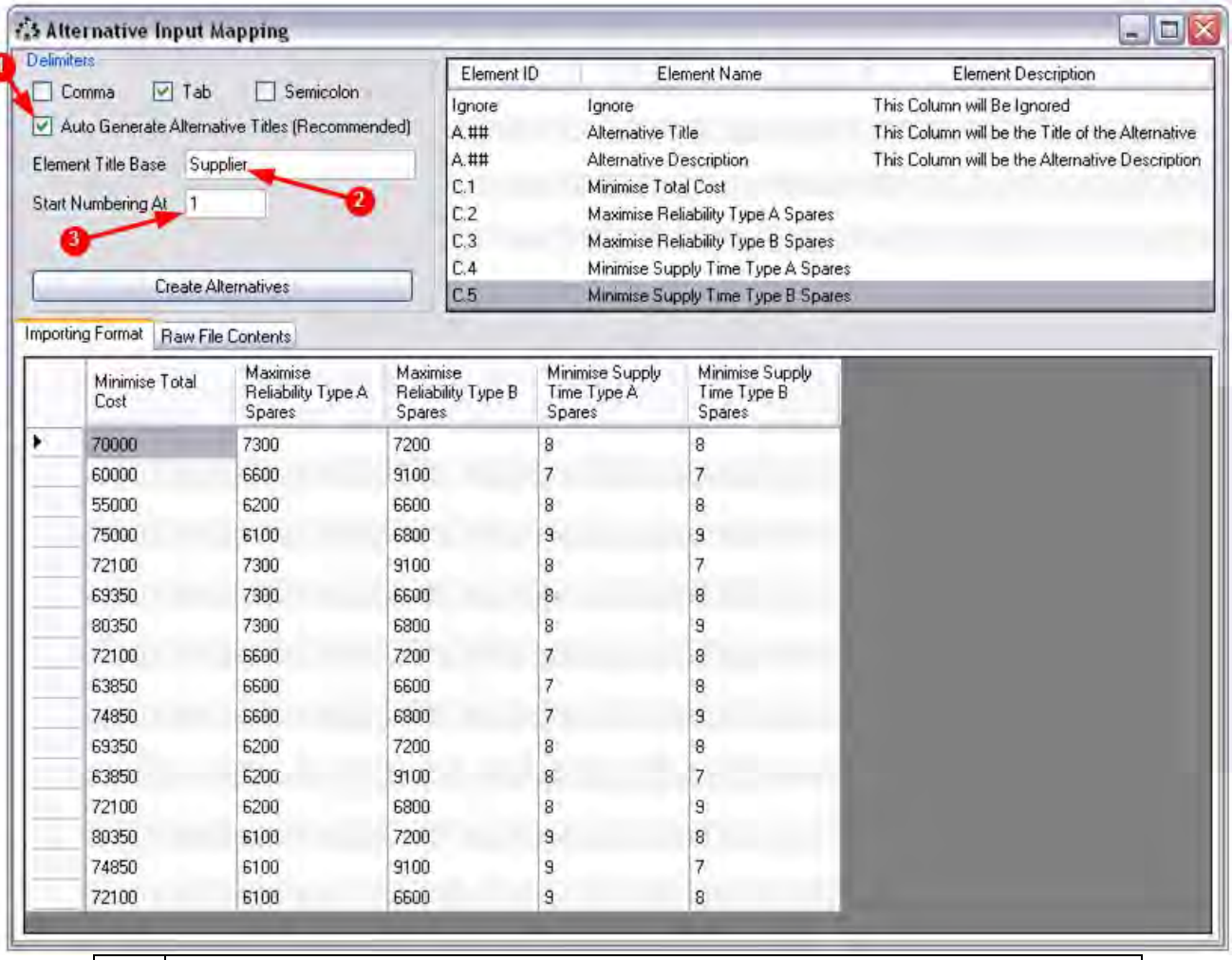
Figure 149. Alternative Input Mapping (Step 1)



1	This shows that ***Auto Generate Alternative Titles*** has been disabled, since the data file already contains titles for the alternatives.
2	This row has been mapped to the column indicated by 3.

Figure 150. Alternative Input Mapping (Step 2)

In Figure 151 the data file did not contain the alternative titles so, in this example, they will be created using the ***Auto Generate Alternative Titles*** option indicated by 1.



2	The ***Element Title Base*** used here will be the word ***Supplier***.
3	***Start Numbering At*** is the starting suffix to add to the ***Element Title Base***. In this example the starting index is ***1***. Also, the alternatives will be named: ***Supplier 1***, ***Supplier 2***, ***Supplier 3***, …, ***Supplier*** *n*, where *n* is the total number of alternatives being added. This is a useful input when alternatives already exist and new ones are added to the problem. For example, in the *Supply Manager's Dilemma* new alternatives would be numbered from 17 onwards hence the ***Element Title Base*** would be ***Supplier*** and the ***Start Numbering At*** would be ***17***.

Figure 151. Alternative Input Mapping (generate titles)

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17. References

1. Diakoulaki, D., Mavrotas, G. and Papayannakis, L., 1995, Determining Objective Weights in Multiple Criteria Problems: The CRITIC Method, *Computers and Operations Research*, **22** (7), Pergamon.
2. Pomerol, J.-C. and Barba-Romero, S., 2000, *Multicriterion Decision in Management: Principles and Practice*, Kluwer Academic Publishers, Norwell, Massachusetts, United States of America.
3. Mollaghasemi, M. and Pet-Edwards, J., 1997, *Technical briefing: making multiple-objective decisions*, IEEE Computer Society Press, Los Alamos, California, United States of America.
4. Hammond, J. S., Keeney, R. L. and Raiffa, H., 1999, *Smart choices: a practical guide to making better decisions*, Harvard Business School Press, Boston, Massachusetts, United States of America.

Appendix A: Known Faults in Decision Maker

Mathematical Rounding Errors: At times rounding errors may appear. The magnitude of these errors is minimal and the maximum error that can be expected is approximately 1-2%.

Use of the Single Quote ‘: *Decision Maker* may produce errors if the Single Quote is used in fields. This includes element titles and descriptions. It is ***highly recommended*** to avoid their use.

File Import Values: When importing data from files, numerical values must not contain a comma or dollar sign.

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19. ABSTRACT

Decision Maker is a prototype software tool developed by Maritime Platforms Division (MPD) of the Defence Science and Technology Organisation (DSTO) that can be applied to most multi-criteria decision-making problems. Decision Maker is a software implementation of the Criteria Importance Through Intercriteria Correlation (CRITIC) decision-making technique. The decision-making problems use a set of criteria and objectives to select the most preferred alternative in a set of alternatives. In most problems there are conflicting criteria/objectives and therefore, complex trade-offs have to be made between competing alternatives. This is where Decision Maker can be used. This user guide will assist and inform users on how they can structure their decision problems in the required format for Decision Maker.