Hiview 3

enabling effective decisions

Starter Guide

catalyze

ENABLING EFFECTIVE DECISIONS

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Welcome to Hiview 3!

Hiview 3 is a Multi-Criteria Decision Analysis (MCDA) tool that supports the appraisal and evaluation of options. Hiview is particularly useful in helping decision makers faced with conflicting objectives to choose the best way forward.

Using Hiview 3, you create a value tree including your decision criteria. You then assess the options against the criteria and weight the criteria. The Hiview model shows you the most preferred option based on the scores and weights you provide. Sensitivity analysis features help you to fine tune your model. Exploring the model provides insights that were not evident from the input data and deepens understanding of the issues.

This starter guide explains how to use Hiview 3 to create and analyse MCDA models. Following the example in the guide, you will complete a partially created model and then analyse the results. The example is designed to support a site selection decision for the placement of a new supermarket. This is a typical use of Hiview, where one option from a range of possibilities must be chosen. Hiview can also be used to rank options where one or more can be chosen.

1.1 What is MCDA?

MCDA is a way of looking at complex problems that are characterised by any mixture of objectives, to present a coherent overall picture to decision makers. The purpose is to serve as an aid to thinking and decision-making, but not to make the decision. As a set of techniques, MCDA provides different ways of measuring the extent to which options achieve objectives. Publications on MCDA techniques can provide more theoretical detail for those who want to gain a greater understanding. Some of the most useful are listed in Chapter 6 of this guide.

1.2 The MCDA Process

This brief process diagram highlights the key stages in MCDA. It will be used throughout this guide to provide navigation. In practice, it is usually necessary to cycle back to previous stages to make changes as new ideas and insights develop. The serial order below is a guide to MCDA, not a strict agenda. For example, options can be identified after criteria are proposed.
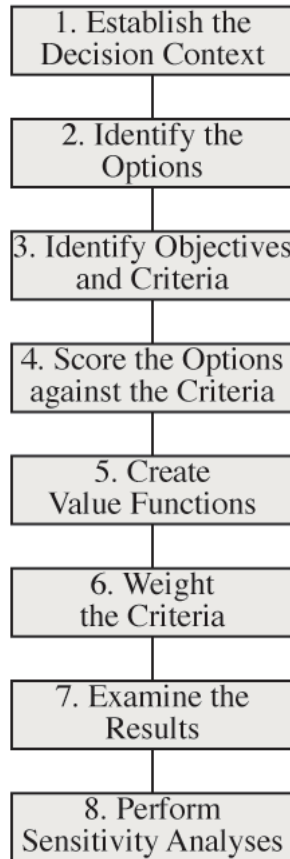
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┌─────────────────────┐
│ 1. Establish the    │
│ Decision Context    │
└─────────────────────┘
┌─────────────────────┐
│ 2. Identify the     │
│ Options             │
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Figure 1. The MCDA Process.

Getting Started with Hiview 3

In this chapter...

- Installing Hiview 3

2.1 Installing Hiview 3

To prepare for installation:

- Close all programs and turn off virus protection software to prevent installation conflicts.
- Check you have at least 20Mb of available disk space.
- When you run Hiview 3 for the first time you will be asked to enter a serial number. You can find this number on the CD envelope or on the email that confirmed your order.
- If you are installing Hiview3 on Windows NT 4.0, 2000 or XP you will need administrator rights.
- For the latest information about Hiview 3, please review the release notes found in the Catalyze folder in the Start menu.

You must be running Microsoft Windows 98SE, NT4 with service pack 6a, 2000, or XP. Note: if you are using Windows ME, Hiview 3 may run but is not supported by Catalyze. On most Windows systems, installation starts when you insert the Hiview 3 CD into your CD-ROM drive. The Install program guides you through the installation procedure.

If installation does not start automatically, you can install Hiview 3 using the following procedure:

1. Insert Hiview 3 CD into your CD-ROM drive.
2. From the Start menu choose Run.
3. Type d:\setup, where d is the drive letter of your CD-ROM drive.
4. Click OK. The Setup program guides you through the installation procedure.

If you have any further questions on Hiview 3 installation, contact Catalyze at support@catalyze.co.uk.

Building the Decision Model

In this chapter...

- Constructing the Model
- Scoring
- Value Functions
- Weighting

3.1 Constructing the Model
In this section, you will be introduced to the basics of building a Hiview 3 model, including work on the example model that accompanies this guide.

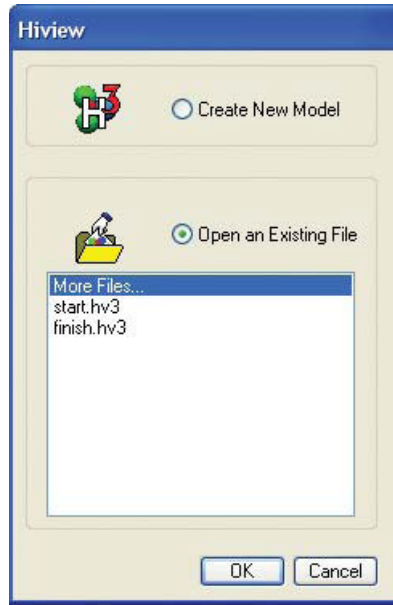- Double-click the 🄷³ icon on the desktop to launch Hiview 3.

Figure 2. The Startup Dialog.

- Double-click ***start.hv3*** in the list to open the example file. Now save it with a new name so that you can return to it later.

The example file start.hv3 is a model to support the decision of where to build a new supermarket. We will use this example throughout the Hiview 3 starter guide to demonstrate MCDA modelling. There is a second file called finish.hv3 which is the completed model so you can check your results when you have finished working through the guide.

3.1.1 The Tree: Nodes and Criteria
The first objective is to build a value tree of the criteria you wish to use to appraise your various decision options.

At the top of the tree is the **Root Node**. This acts as the focus for the final decision, where all the data in the model are collated. The root node branches to nodes representing objectives which group the criteria. In our example, these are structured under nodes called "Costs" and "Benefits". These high level nodes should represent the main trade-off facing the decision makers.

At the right of the tree are the **Criteria** in the model. You should be able to differentiate between the options for each criterion. A criterion such as cost may be important in its own right, but if all options cost the same then it is redundant in the evaluation of the options. The criteria should be complete, not double counted and be mutually preference independent i.e. you do not need to know the scores on one criterion to assess the scores on another.
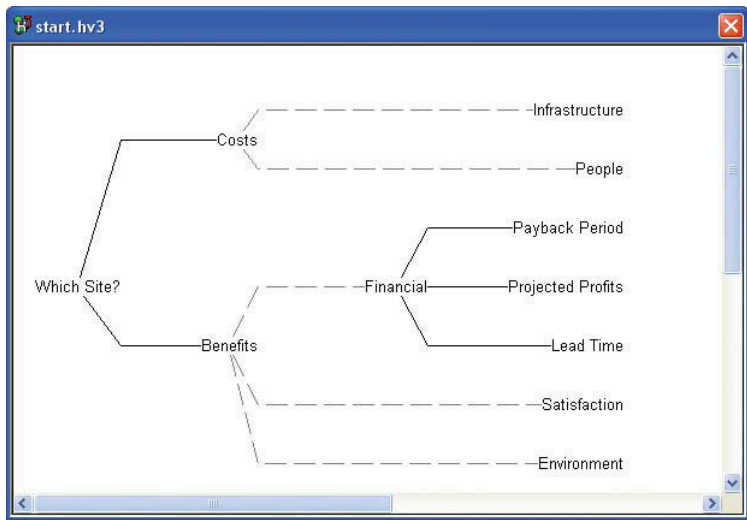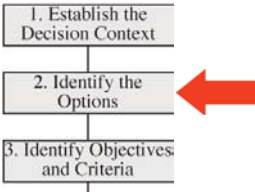

Figure 3. The Value Tree.

3.1.2 Decision Options

An **Option** is a single item in the collection of possibilities that are under consideration.

- Click the ![icon] button on the toolbar.

This window is where options are added and deleted using the buttons to the right of the list. The Up and Down buttons move the options to the order that you choose. In our example, there is one option that requires editing.
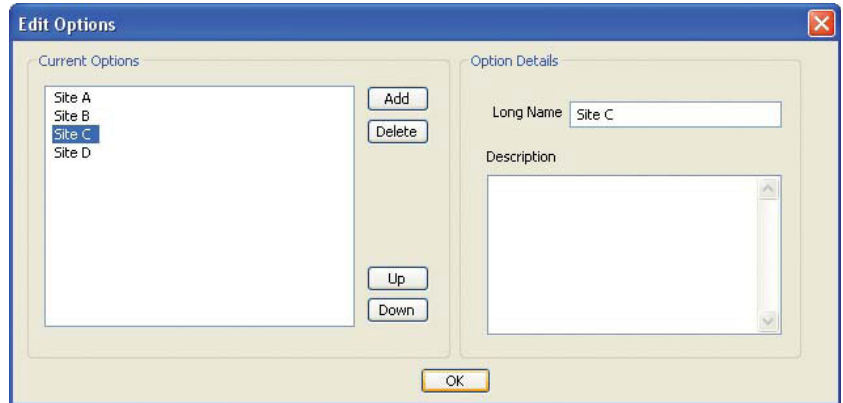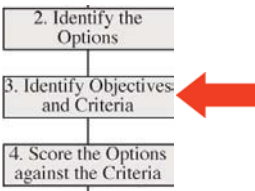

Figure 4. The Options window.

- Click **Site C** in the options list.
- In the description field, enter **Excellent central site, has some expansion capability, but the local government require a dual carriageway built as part of the deal**.
- Click the **OK** button to confirm the new description of Site C.

3.1.3 Creating and Editing Criteria

Criteria can be added and edited directly on the tree. They can be dragged to new nodes or to re-arrange the tree. In a new Hiview 3 model, the tree structure is freeform. You can automatically arrange the tree either vertically or horizontally. In our example, the tree is partially complete and is arranged horizontally. There are two criteria that must be added.

- Click on the ![icon] button and click anywhere within the tree window. A new criterion is created.
- Enter the name **Building** and hit **Enter**.

At this point the criterion is grey because it has no data. It is not attached to the tree.

- Click on the 🕯 button again and click in the tree window. A second new criterion is created.
- Enter the name *Attractiveness* and hit *Enter*.
- If you mistype the name of the criteria you just entered, you can edit by clicking once on the criterion, then again after a short pause.

The next step is to link the new criteria to the correct nodes in the tree. The Building criterion will link to the costs node. Attractiveness is a benefit, but it is not directly measurable.

- Using the mouse, drag *Building* and drop it onto the *Costs* node. The link is made and the tree is automatically arranged with the new criterion. Notice that the line linking Building to Costs is grey and dashed. This is because no weights have yet been input for Building costs.
- Now click on the ⬚ button on the toolbar. The mouse cursor changes to an arrow and a circle. Click on the *Benefits* node and then on *Attractiveness*. A link is made between the two tree items and the tree is automatically arranged with the new criterion.
- If the criteria are not in the order you wish to see them, drag them to the correct place using the mouse. Dragging works in steps as criteria pass by each other.

The next step is to define the details of the criteria you have just created. All criteria details are defined and edited within one window.
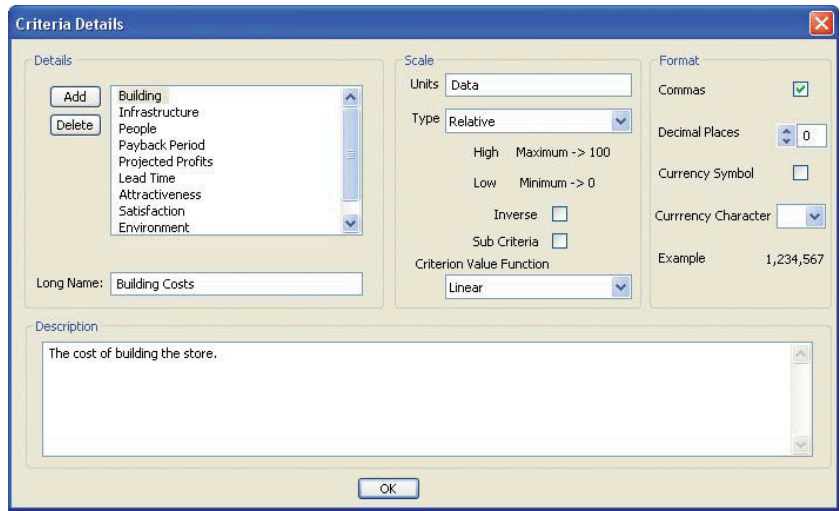

Figure 5. The Criteria Details window.

- Click on the ✏️ button to launch the Criteria Details window.
- Click on the **Building** criterion in the list on the left.
- Edit the long name of the criterion to be **Building Costs** and the short name to be **Building**. Double-click the short name in the list to edit. Note that the names may already be this way, depending on the **User Options** set in the **Tools** menu.
- Enter the following description for Building Costs: **The cost of building the store.**

There are many other options for criteria in this window which will be explored throughout this guide. You can edit details of criteria in this window anytime, so if, as the model develops, you want to add or modify the description, then this can be done in the same way as the initial entry. To complete the entry of new criteria:

- Click once on the **Attractiveness** criterion to select it.
- Enter the following description for Attractiveness: **Attractiveness includes the aesthetics of the site, the proximity to competition and distance from store customers. These are all elements of the decision that marketing people will care about. Consequences for brand values can be included here. Can the site be expanded over time? Can it be used for different purposes? Can adjacent land be purchased easily?**
- Click the **OK** button to confirm your entries.

3.1.4 Sub-Criteria
By creating sub-criteria you can input more detail for your criterion scores. In our example, we have created sub-criteria for **Infrastructure** to allow the separate costs for **Roads** and **Services** to be recognised. By defining Infrastructure as the sum of these sub-criteria, we can give the model more detail and flexibility. For more information on sub-criteria, please see the online help.

- Double-click on **Infrastructure** on the tree to see its sub-criteria. The formula to process sub-criteria can include most simple functions.

3.1.5 Scale Types
Hiview 3 converts input scores into value scales, which are subsequently weighted so that a unit of value on one scale will equal a unit of value on the scales for all the other criteria. To facilitate this conversion, three types of scale are used.

Relative Scale - This is the default scale and is the easiest to use. Input scores are automatically converted to scales extending from 0 to 100. Hiview assigns a value of 100 to the option given the highest score and 0 to the lowest score. All other options are scaled 0-100 in proportion to their input scores, a direct linear conversion.

Fixed Scale - The user defines what input values are to be associated with values of 0 and 100. This is most useful when weighting of criteria is to be done first, as might be the case where not all of the input data are available.

Identity Scale - Used where the conversion of scores into values is not required. In this case, the weighting process applies directly to the input data. Identity scales are usually used when a fixed scoring system, such as points out of 10, is used for all criteria.

Relative and fixed scales can be defined as inverse. This assigns a value of 100 to the lowest score and 0 to the highest. Costs and time-to-completion are examples of this as, very often, low costs and short completion times are more preferred.
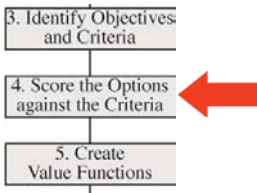
In our example, the new criteria you created must have scale types assigned.

- In the Criteria Details window, select *Building* from the list.
- Set scale type to *Relative*.
- Enter *£millions* in the units field.
- Check the box for *Inverse*.
- Select to display *1 decimal place*. That is all the changes for *Building*.
- Select *Attractiveness* in the list. Enter *Judgement* in the units field and click the *OK* button to confirm.

Figure 6. The Criteria Details window showing completed details of Attractiveness.

3.2 Scoring

When the model has been constructed, each of the options has to be scored against each of the criteria. The score records the performance of each of the options against the criteria. A score of zero on a relative scale does not mean that an option has no value, it is least preferred. The collection of scores on a criterion constitutes a scale.

There are two types of scale, natural and constructed. Natural scales reflect directly measurable aspects of an option e.g. Euros, square metres, completion times or pollution levels. When direct measures are unavailable or do not adequately capture the aspect of concern, scales are constructed. Examples of constructed scales include rating scales, performance indices and effectiveness measures.

Hiview converts scores into preference values which express the extent to which the options achieve the objectives represented by the criteria. The conversion is accomplished by a value function chosen by the user. By default, Hiview uses a linear value function.

3.2.1 Direct Scoring for Constructed Scales

The simplest way to create a constructed scale is by direct scoring. The decision makers identify the best option on a criterion and assign it a score of 100. Next, the least preferred option on the criterion is assigned a score of 0. The remaining options are given a score between 100 and 0 such that differences in the scores represent differences in strength of preference. Consistency checks help to ensure realism in the numbers.

For example, options A, B and C have been given scores of 100, 75 and 0. The decision makers then ask, "Is the difference between B and C really three times the difference between A and B?" Consistency checks often result in revisions of the scores.

3.2.2 Scoring Using a Natural Scale

In section 3.1, two new criteria were created in the example model. These two criteria must now be scored. Building costs are directly measurable and thereforeare scored using a natural scale.

- Double-click on the ***Building*** criterion in the tree window. The criterion scores window (Figure 7) is launched.

This window is where you can input score data for your options against the specific criterion. Also available through the options pane is a bar chart view of the scores.

- Enter the building costs as in the screenshot Figure 7. This can be done by typing in the spreadsheet cells or by dragging the options on the scale.
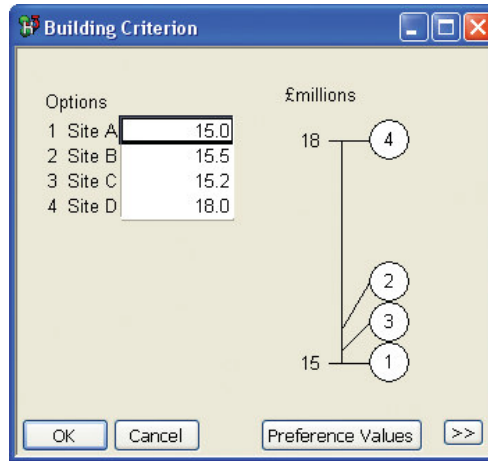
Figure 7. The Criterion Scores window for Building Costs.

- You can also use a bar chart for scoring. Click on the >> button in the right hand corner of the screen. In the options pane, choose **Graph**.
- Click the << button to return to the main form.

The scores being entered here are numeric and monetary. They are the costs in £millions of building the four optional stores. You can see the conversion to preference values by clicking on the **Preference Values** button.

3.2.3 Scoring Using a Constructed Scale

Scores are not always monetary, or even numeric. Hiview 3 can incorporate many types of judgement or measurement of the differences between options. The second new criterion from Section 3.1 was **Attractiveness**. This was defined as an aggregation of many criteria that are especially important for marketing and branding.

These qualities of a site cannot easily be quantified for scoring. There is no standard unit of value. However, it is possible for a team of decision makers to agree a relative value of attractiveness for each site. This value is subjective and is made using the experience of the decision makers themselves. In Section 3.2.1 above, the MCDA concept of constructed scales is explained. A qualitative version of this method will be used to score the Attractiveness criterion.

Although it may be possible to agree numeric values and input them directly, Hiview 3 also has a useful component that facilitates qualitative judgements. This component is called Measuring Attractiveness by a Categorical Based Evaluation TecHnique or MACBETH. This new feature in Hiview generates numeric values from verbal judgements. It also helps to ensure the consistency of those judgements. We will now score the Attractiveness criterion using MACBETH.

- Select the ***Attractiveness*** criterion on the tree.
- Click the [M] button on the toolbar to launch MACBETH. You will see a matrix like Figure 8 where the column and row headers are the names of the options in the Hiview model.
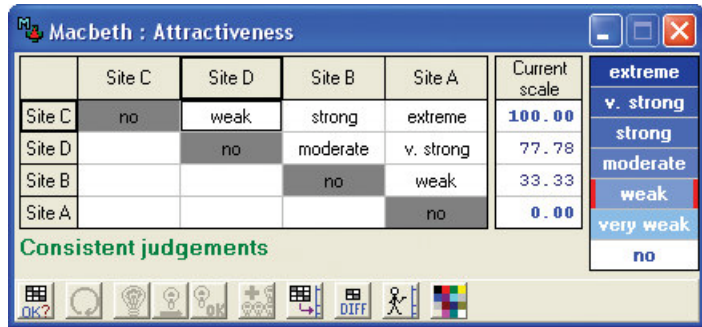

Figure 8. The MACBETH matrix for Attractiveness.

The first step to scoring in MACBETH is to rank the options in order of value. The first question to answer is **Which is the most attractive site?** In our example, Site C is the most attractive. It is a brand new site, with new purpose-built roads. It is not too near the competition but it is near the customers.

- Use the mouse to drag ***Site C*** to the top of the list on the left-hand side of the matrix.

With the most attractive site identified, other sites can now be ranked using this guide.

- Use the mouse to drag the sites into the rank order in the screenshot Figure 8. Both row and column labels can be dragged.

The second step to scoring using MACBETH is to complete the judgements matrix with verbal judgements. First, consider the relative attractiveness of Site C to Site A. The question to answer is **How strong is the difference in value between Site C and Site A for the Attractiveness criterion?** In our example, the difference in attractiveness is **Extreme**.

- Click on the matrix cell in the top right corner where the row for ***Site C*** meets the column for ***Site A***.
- Click on the word ***Extreme*** in the scale list on the far right of the matrix. The matrix cell will now have the word Extreme inside it. Note that you can change judgements by clicking off the word in the list on the right or by double-clicking the matrix cell and using the check boxes in the dialog that appears.

One way to populate the MACBETH matrix is to first judge every option against the worst. This will complete the column for Site A. Next, complete the row for Site C. Thirdly, complete the diagonal from top left to bottom right and lastly fill in the gaps.

- Complete the matrix of judgements as in the screenshot Figure 8.

MACBETH constantly checks the matrix for consistency of judgements.

- Change the value in the cell where the row for *Site D* meets the column for *Site B* to *Very Strong*. MACBETH tells you that the judgements in your matrix are not consistent. Confirm the judgement by clicking the *Yes* button in the dialog that appears.

MACBETH now actively searches for ways to correct the judgements in the matrix. In this case, it finds two methods of correction and displays the message in Figure 9.
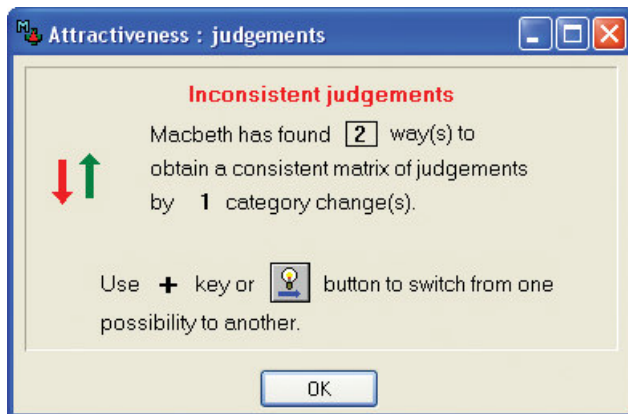

Figure 9. The MACBETH consistency warning.

- Click *OK* to accept the message.

The user must now decide which of the MACBETH corrections to accept. The corrections are shown as coloured arrows on the matrix.

- To cycle through these corrections, click the 💡 button.
- Click the 💡 button to accept a change. The matrix is now consistent.
- Change the matrix values back to those in the screenshot in Figure 8 before proceeding to the next stage.

When the matrix of judgements has been completed, MACBETH can generate the numeric values for each of the options.

- Click on the ⊞ button to generate the MACBETH scale. The MACBETH thermometer appears with numeric values for the options.

The verbal judgements made in the matrix have been converted to numeric values consistent with the verbal judgements. However, these values are not fixed, they have a range of possibilities.

- Click on the label for **Site B** in the MACBETH thermometer window. The thermometer now displays the valid range of values for Site B.
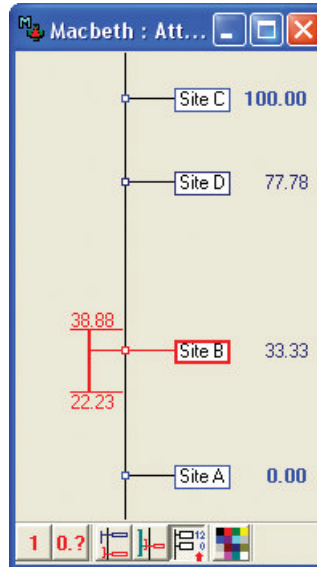

Figure 10. The MACBETH Thermometer for Attractiveness.

- Drag the label for **Site B** up and down within this range for fine tuning.
- Click the ⊞ button below the matrix to restore the original values for the options.
- On the upper MACBETH toolbar, click **Return to Hiview**. Click **Yes** to confirm the value transfer.
- Double-click on **Attractiveness** on the tree and see that your MACBETH scores have been transferred to Hiview.

Hiview remembers the judgements you made in MACBETH and saves them in your model. If you want to review or change your MACBETH judgements, simply return to MACBETH and the matrix will be populated with your previous judgements. For more information on MACBETH, see http://www.m-macbeth.com.
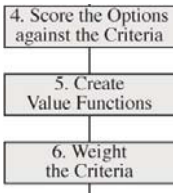
3.3 Value Functions

MCDA allows comparisons of value to be made between criteria with different units. The first step is to normalise the scores that have been input. Value Functions define how this normalisation is achieved.

Consider an example of a woman looking for a new job. She is concerned about the length of time she will have to travel to get to her new place of work. It is quite acceptable to travel for 10-20 minutes each way. More than 30 minutes though is a real effort and very undesirable. Clearly, 30 minutes is more than twice as bad as 15 minutes, implying a non-linear value function.

As time is continuous data (as opposed to discrete), we can consider the value function to be a graph where travel time is plotted on the x-axis and value on the y-axis. This is a piecewise value function, which is described in more detail on the next page. By asking several questions about the value of travel time, a value function can be constructed which might look like Figure 11.
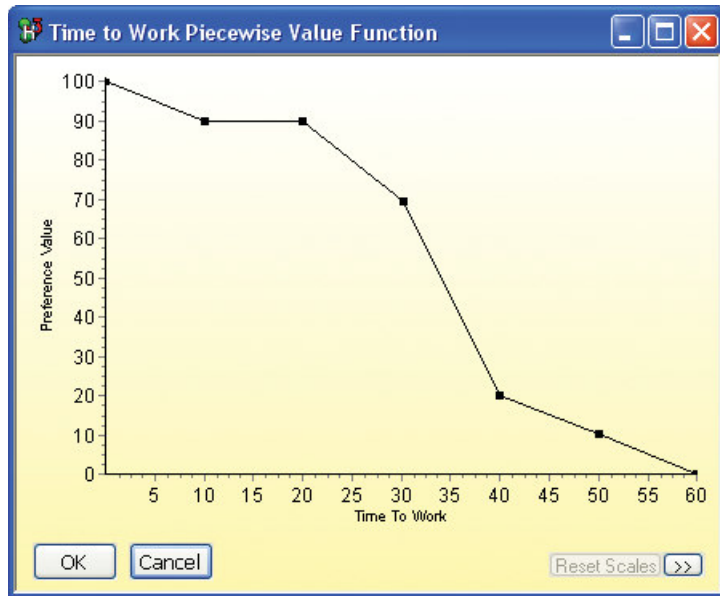

Figure 11. A Piecewise Value Function for Time to Work.

3.3.1 Linear Value Functions

A linear value function is the default in Hiview 3, as it was in Hiview 2. The scores input for a criterion are normalised across the 0-100 scale proportionally to their values. This is the same as if the graph in Figure 11 was a single straight line.

3.3.2 Piecewise Value Functions

Piecewise value functions are useful approximations for normalising continuous data. Time to Work is an example of continuous data, as are effectiveness measures, numbers of lives saved and reduction in CO_2 emissions.

- Select **Lead Time** on the tree and click the f button on the toolbar to edit the value function of the criterion. Figure 12 will appear.
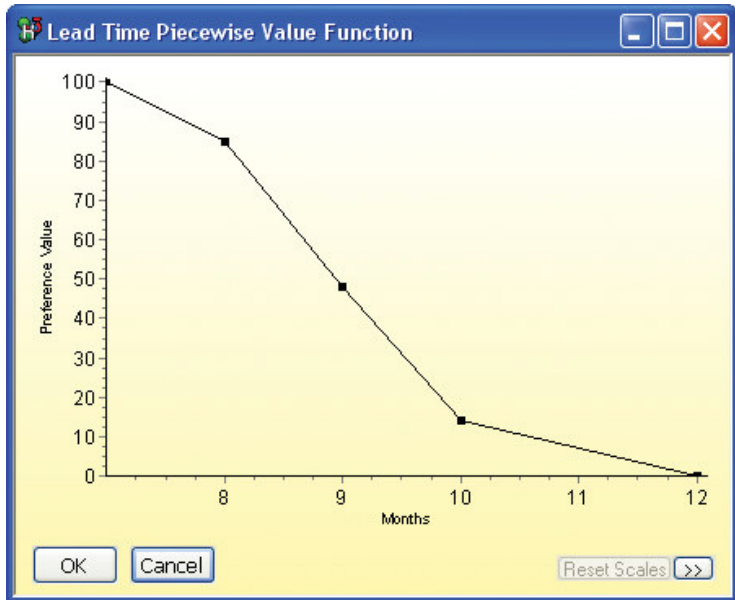

Figure 12. The piecewise Value Function for Lead Time.

This window shows the value function for the Lead Time criterion. Lead Time has already been scored. Each option is in the range 7-12 months so the value function represents this scale on the x-axis of the graph. The supermarket organisation prefers lead times to be shorter so has assigned shorter times the highest values.

- Move the mouse cursor over a point on the graph. It changes to a crosshair.
- Click on the point and drag it around the graph to edit the value function.
- Right-click on a point and choose **Delete Graph Point** from the pop-up menu to delete a point.
- Right-click on the graph and choose **Add Graph Point** to add a point.
- Exit the window by clicking **Cancel** so as not to save changes.

3.3.3 Discrete Value Functions

Discrete value functions are used for the same purpose as piecewise value functions, to assign values to input scores. They differ in that they normalise discrete data. This means that, for criteria that use a discrete value function, you have to define the value function before scoring the options.

- Select *Satisfaction* on the tree. Choose *Value Function* from the *Data* menu. Figure 13 is displayed.
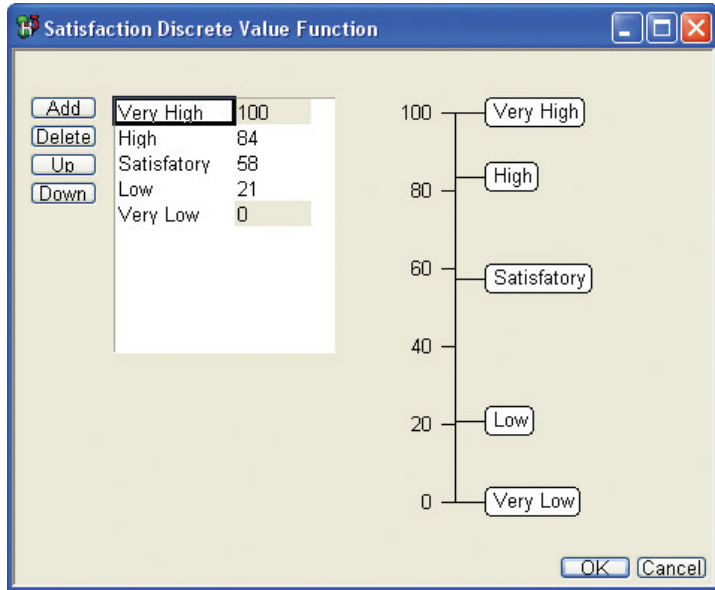

Figure 13. The Discrete Value Function for Satisfaction.

This window allows you to create and edit discrete value functions. In our example, this criterion is a measure of staff satisfaction at each of the potential sites for a new store. Staff satisfaction is affected by the facilities at each site, the access to local amenities and the time it takes staff to travel to work.

This is a subjective judgement and each site will be scored on a five-point scale from Very High satisfaction down to Very Low. The value function has been created to assign numeric values to each of the points on our discrete scale.

- Select a name from the list. Type to edit the name.
- Select a value for an item in the list. Type over the value to change it. Note that the 0 and 100 values are fixed and cannot be edited as they are the top and bottom of the scale.

- Use the mouse cursor to click and drag the thermometer labels to set values for the list items.
- Click *Cancel* to exit so as not to save changes to the model.

When creating a discrete value function, you can score the options on that criterion.

- Double-click on *Satisfaction* on the tree. The criterion scores window appears but has a different method of input.
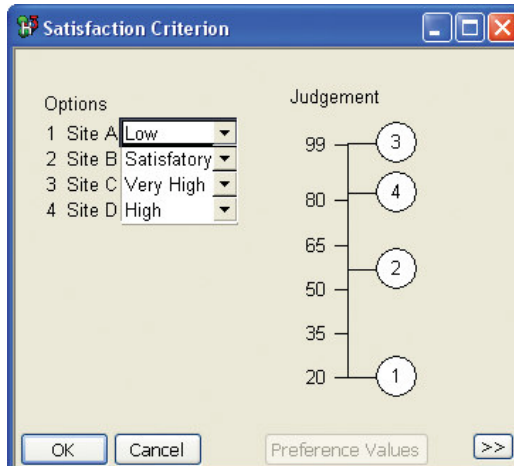

Figure 14. The Criterion Scores for Satisfaction.

Instead of allowing numeric input, you now choose a value from a drop-down list box. These values are the discrete data points defined in the value function. The thermometer reflects the numeric values associated with the discrete data points.

- Click *Cancel* to exit so as not to save changes to the model.

3.3.4 Probability to Preference
This is a special type of value function that allows Hiview 3 to reflect risk adjustments to options. MCDA benefits should always be risk-adjusted if there is any uncertainty about achieving the benefits. In such cases, you can create a criterion with a fixed scale that reflects risk with this value function.

The input scores for this criterion are the probability of success for each option. This is entered as a number in the range 1-100. A 0.65 or 65% probability of success will be input as *65*. Hiview converts these probabilities into penalty scores, then normalises them on the standard 0-100 scale.

Hiview uses a logarithmic rule for converting probabilities to preferences. This expresses the judgement that increasing the probability of success from 0.3 to 0.4 is more valued than increasing it from 0.8 to 0.9. The logarithmic rule is one of a class known as "proper" scoring rules.

3.3.5 Using MACBETH to Derive Value Functions

If you have not read section 3.2.3 about MACBETH scoring, please read that before this section.

It is possible to use MACBETH to derive value functions. The process for using MACBETH is the same as that for scoring. A matrix is created, qualitative judgements are made and MACBETH generates numeric values.

For piecewise value functions MACBETH generates the y-values on the value function graph. The matrix is created from the input scores of the criterion and it is these that are judged. Note that the input scores should not be ranked in MACBETH as they are numeric and therefore already ranked. The resulting value function graph plots input scores on the x-axis against MACBETH derived values on the y-axis.

For discrete value functions, MACBETH generates the numeric values associated with the defined data points. The matrix is created from the names of the data points. These are then ranked and judged as with MACBETH scoring. The numeric values are returned to the value function window.

- To create or edit value functions using MACBETH, open the value function window for your criterion and then click on the ⟨M⟩ toolbar button.

3.3.6 If in doubt…

Value functions add a further element of accuracy to your MCDA models. This will be very important for some users, especially where models are sensitive to the non-linearity between input scores and values. However, the default linear value function is very often a satisfactory approximation to a non-linear function. In addition, the overall results of MCDA models can be insensitive to non-linearities in the value function. If you are in any doubt which value function to use, leave the default linear function in place.
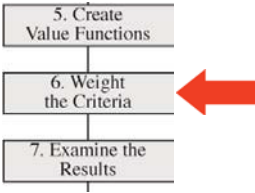
3.4 Weighting

Weighting is the process by which MCDA allows the comparison of criteria with different units. Rather than comparing "apples" with "oranges", MCDA compares the value of a change in the number of apples with the value of a change in the number of oranges. At this stage in the modelling, options have already been scored and these scores have been converted to values. Now the changes or "swings" on these scales will be considered to derive weights.

Imagine that you wish to buy a new car. You have £20,000. This is a lot of money and therefore cost is very important to you. You have made a short list of 5 cars and are using a Hiview model to help you make the final decision. You consider at first that the "Purchase Cost" criterion should have a high weighting. However, you have chosen 5 cars in the range of £19,500-£20,000. The swing in cost is only £500. You realise that, because of this, purchase cost is not so important.

If the range of difference had been £2,000, you might have cared more - unless you are very wealthy. So, the swing weight represents both the range of difference between the option and how much you care about that difference.

The key to swing weighting is to formulate the correct question. When weighting a group of criteria, you should ask **Of all the swings within these criteria, which represents the biggest difference that you care about?** The criterion swing that is most important is weighted 100. Then the swing on each of the criteria is compared to this and assigned a weight proportionally. Thus if a criterion swing has half the importance of the standard, it is assigned a weight of 50.

3.4.1 Weighting All Base Criteria

Hiview 3 provides a new, flexible swing weighting system that ensures consistency in weighting. All criteria under any node at any level can be compared. If criteria under lower level nodes have already been compared, Hiview shows only the most important swing from that group and adjusts weights proportionally.

> • Select *Costs* on the tree. Choose *Weight Criteria Below Selected Node* from the *Data* menu. Figure 15 is displayed.

This window displays all the base criteria below the Costs node. In our example, there are three base criteria and no nodes between them and Costs. You can choose any node in the tree and weight all base criteria below it, even if there are other nodes below as well. With smaller models, it is good practice to call this window from the root node and weight the whole model in one piece.

> • Enter the weights as in the screenshot Figure 15. Click the *OK* button to confirm. Be sure to input weights in the correct criteria.
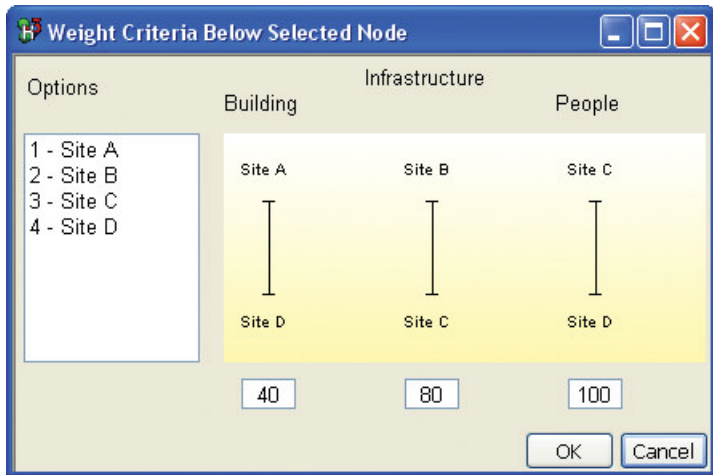
Figure 15. Weighting All Base Criteria below Costs.

Note that costs, because they have the same unit, can often be weighted proportional to their input scores. However, in our example, the costs are realised over different time frames and the weights reflect the timing of expenditure.

3.4.2 Weight Most Important Criteria Swings

With larger models, weighting all the criteria at once may be very difficult. This is especially true in group work where weighting is the subject of much debate before the relative importance of swings can be agreed. When this difficulty arises, it is necessary to break the task down into smaller sections, weighting small groups of criteria separately.

The problem with weighting small groups of criteria is ensuring consistency when you make judgements about the relative importance of criteria swings. Hiview 3 provides a method for ensuring this consistency.

> ● Double-click the node *Financial* on the tree to open the Node Data window. Notice that the weights of the criteria below this node are *30*, *70*, *100*.

These criteria have already been weighted as a small group. Now we are going to weight the rest of the criteria under the Benefits node in a way that maintains consistency of judgement.

- Select **Benefits** on the tree and click the 🦅 button on the toolbar to show the Weight Most Important Swings window.
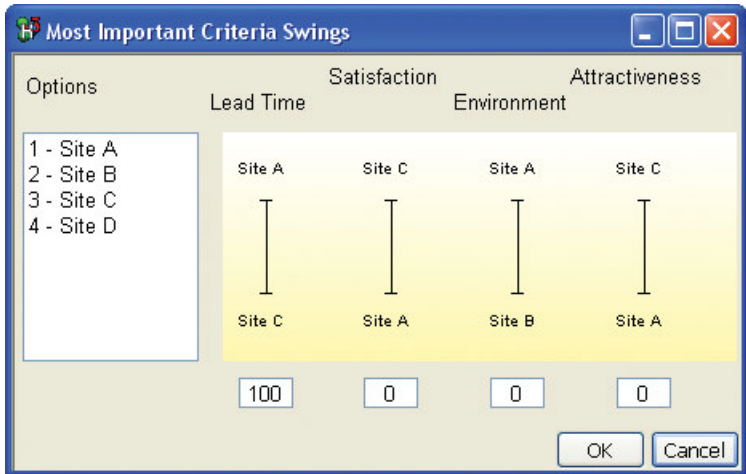

Figure 16. Weighting the Most Important Swings below Benefits.

The window shows scales for four criteria, even though there are six criteria beneath Benefits. This is because Hiview recognises that weights have already been input for a smaller group. Lead Time was judged to have the most important swing of all the criteria in this smaller group so its swing will now be compared to the others.

The four criteria displayed should be weighted in the usual way. The first question to ask is **Of all the swings within these criteria, which represents the biggest difference that you care about?** In our example, Attractiveness is the most important criterion.

- Enter **100** as the weight for **Attractiveness**.

Now the other criteria swings can be weighted relative to Attractiveness. This includes changing the weight already assigned to Lead Time if necessary.

- Enter **40** as the weight for **Environment**. Enter **80** as the weight for **Lead Time**. Enter **60** as the weight for **Satisfaction**.
- Click the **OK** button to confirm your weights.
- If you previously shut the node data window for **Financial**, double-click the node on the tree to re-open it.

Notice that the weights for the three criteria below Financial benefits have been changed. When Lead Time was changed to 80, the other criteria in the small group were automatically adjusted so as to retain the proportion of weights within the group. This is the mechanism by which Hiview maintains consistency of judgements when small groups of criteria are weighted separately.

- Double-Click *Benefits* on the tree to launch the node data window.

Figure 17. The Node Data window for Benefits.

Notice that the weight on Financial is 160. This is the sum of the weights of the criteria below this node. The other children of Benefits are criteria so have maintained the values input on the previous page. Although the weight on Financial benefits seems high, it represents three criteria and, technically, is a sound judgement.

3.4.3 Using MACBETH to Derive Weights*
If you have not read section 3.2.3 about MACBETH scoring, please read that before this section.

It is possible to use MACBETH to derive weights for your model. The process for using MACBETH is the same as that for scoring. A matrix is created, verbal judgements are made and MACBETH generates numeric values. In this case though, MACBETH adds a baseline option to the matrix as weights are relative but do not get normalised as with scores. MACBETH creates an All Zero option in the matrix to be the bottom of the relative scale. This option must be judged in the normal way as part of the matrix.

- To derive or edit weights using MACBETH, select a node on the tree and click on the ![M] button on the toolbar.
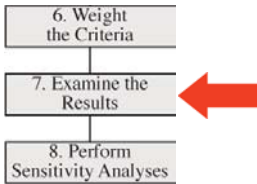
* Note: MACBETH weighting is an optional module of Hiview 3 and you may not have access to this functionality.

Analysing the Model

In this chapter...

- Reviewing the Results
- Sensitivity Analysis

4.1 Reviewing the Results

Hiview 3 has many tools for analysing the MCDA model and presenting the results back to the decision makers. The tools provide various high-level perspectives, enabling the decision makers to compare the results with their holistic judgements. Sensitivity analysis makes visible the effect on results of vagueness of inputs or differences of opinion. New insights are fed back into the model, which develops with the new understanding of the group. When no new insights emerge the model is considered to be sufficiently complete and the analysis phase moves into the documentation, planning and implementation phases.

4.1.1 Node Data Windows

The Node Data window provides several views for reviewing the model results.

- Double-click the root node *Which Site?* on the tree to launch the Node Data window.

The **Total** row in the table gives the final weighted scores for each of the options in the model. We can see that **Site B** is the most preferred option, having the highest score of **65**. The weighted scores are comprised of costs and benefits. The contribution made by costs and benefits is expressed numerically but can also be viewed as a graph.

- From the drop down box in the *Which Site?* node data window, choose *Criteria Contribution*. Figure 18 is displayed. You may need to resize the window to see all your criteria.

This view of the root node shows how the total weighted scores for each option are built up from individual criteria.
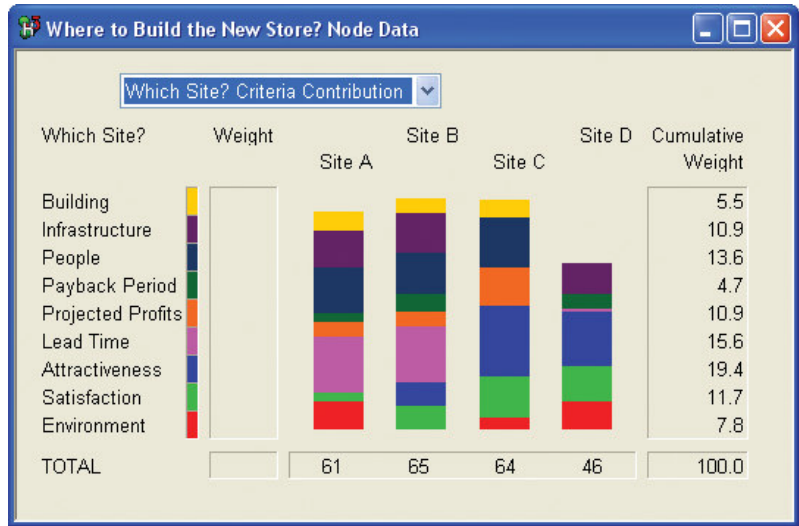
Figure 18. Criteria Contribution for Which Site?

There are six views of the Node Data window. These are:

Data Breakdown - This view shows the weighted scores as calculated at the immediate child nodes. If the child is a criterion, an asterisk is shown next to the name and the unweighted preference values for that criterion are displayed.

Weighted Scores - This view shows the data breakdown values after they have been multiplied by the normalised input weights. It is these numbers that add up to the total weighted score in the **Total** row.

Weights - This chart shows the weights for child nodes and criteria. You can drag the horizontal bars on the graph to input weights graphically.

Results - This chart shows the total weighted preference values for each option graphically as a vertical bar.

Contribution - This chart shows how the children of the selected node have contributed to the total weighted value. Because costs are treated as inverse preference scales, long cost bars reflect low costs.

Criteria Contribution - This chart shows how the total weighted scores for each option are built up from individual criteria.

4.1.2 The Map

The overall results of the model can be viewed graphically by using the map facility in Hiview 3. Mapping allows you to plot the values for any node or criterion against any other. The most common map is for Benefits versus Costs, showing which options realise the most benefits for their costs.

- Click on the 🖼 button on the toolbar. The mouse cursor changes to a horizontal graded line symbolising the x-axis of the Map. Click **Costs** on the tree. The mouse cursor now changes to a vertical graded line symbolising the y-axis of the Map. Click **Benefits** on the tree. The Map graph is now displayed.
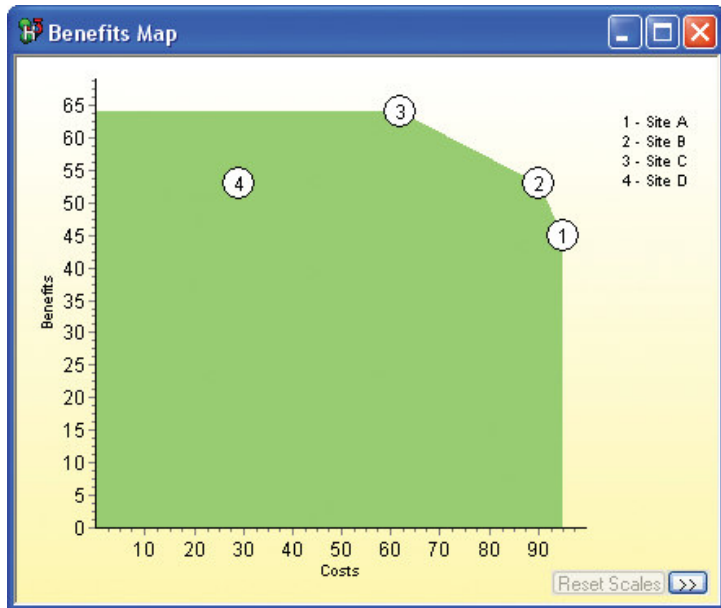

Figure 19. The Map of Benefits versus Costs.

The graph shows the four options plotting weighted preference values at the **Costs** node against those at the **Benefits** node. Remember that input scores have now been normalised and weighted. This means that the x-axis is showing preferences for cost, with lower costs to the right. An ideal option would lie at (100,100) on the graph, so options in the top right hand corner of the graph are preferred. This agrees with the numerical scores showing that **Site B** is the most preferred, followed by **Site C**.

The edge of the shaded area represents the efficient frontier, where for a particular cost, the maximum benefit is achieved. Site D is dominated by Site B and Site C, both of which show lower costs and greater benefits.

4.1.3 Sorts

The Sorts window allows you to compare the performance of two options against each of the criteria and to examine the strengths and weaknesses of any option. All sorts are based on differences. It is the exploration of the differences that can stimulate creative thinking about possible new options that are better than those under consideration.

In our example, **Site B** and **Site C** have nearly identical total scores. The Sorts window allows us to compare them at every stage in the model.

- Click on the ⬇ button on the toolbar.
- In the drop down box in the top left corner, choose *Site B*.
- In the drop down box for the comparison option, choose *Site C*.
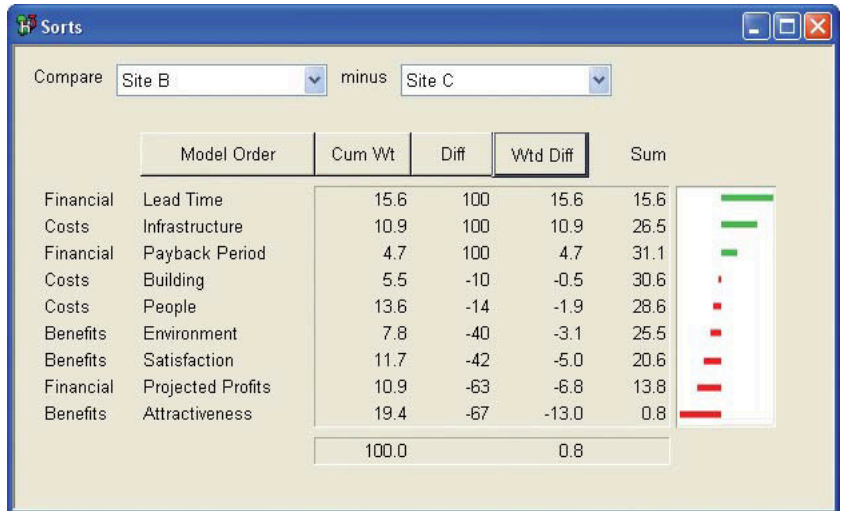- Click on the *Wtd Diff* button to sort by *Weighted Difference*.

Figure 20. Sorts comparing Site B and Site C, sorted by Weighted Difference.

This shows us that Site B performs much better than Site C in Lead Time and Infrastructure costs. Site C performs better in Attractiveness and Projected Profits. As the total weighted scores for these two options are very close, the decision makers can now trade off using strengths and weaknesses displayed on the graph. This is a good example of how Hiview informs a decision but does not make it for you.

The sorts window displays four main types of data:

Cumulative Weight (Cum Wt) displays the cumulative weight of the criteria. This is the proportion of the weight of the entire model that each criterion takes.

Unweighted Difference (Diff) displays the difference between the unweighted preference values of the two options. These numbers appear at the parent node in the data breakdown view.

Weighted Difference (Wtd Diff) displays the unweighted difference multiplied by the cumulative weight after cumulative weight is normalised on a 0 to 1 scale. These weighted numbers show the contribution of each of the criteria to the overall difference between the options.

The **Difference Graph** displays the values in the sorted column graphically, using horizontal bars.

Sorts can also be used to identify strengths and weaknesses of any option.

- Select *Site B* in the left drop-down box and select *All at 0* in the right drop-down box. Sort by weighted difference.
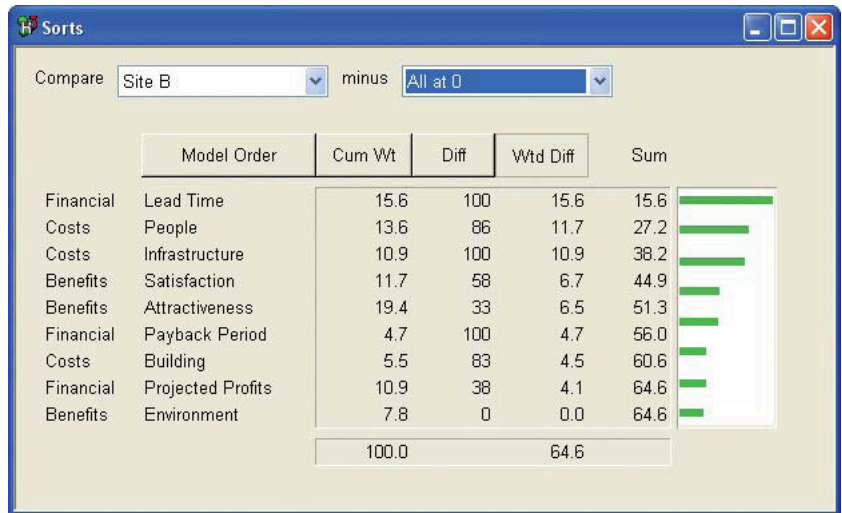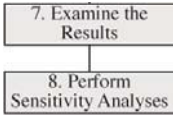

Figure 21. Finding strengths of Site B by comparing with All at 0.

Strengths are high preference values on heavily weighted criteria, indicated by the longer bars. To identify weaknesses, select *All at 100* in the left drop-down box and the option in the right drop-down box.

4.2 Sensitivity Analysis

During the creation of an MCDA model, especially in a group setting, there is often debate about scores and weights. It can be helpful for disagreements at these early stages to be put aside and considered later. When the model is complete, it is relatively easy to see how important these disagreements truly are by conducting sensitivity analyses.

Sensitivity analysis highlights areas in the model that influence the overall preference ordering. It is frequently used to examine the extent to which differences of opinion and vagueness in scoring and weighting leave the overall ordering of the options unchanged.

Hiview 3 has two main approaches to sensitivity analysis. the first is to summarise the whole model or areas of the model. Using the Sensitivity Down function, you can display a summary of sensitivity for the whole model. This highlights areas which require further investigation. The Sensitivity Up function allows each criterion or node to be examined in detail.

4.2.1 Sensitivity Down

The sensitivity down window displays a summary of weight sensitivity for all criteria below the selected node. It is most useful to display this window for the root node and get a summary of sensitivity throughout the whole model.

- Click the 🔀 button on the toolbar and select *Which Site?*. Figure 22 is displayed.

The sensitivity summary shows that the most preferred option at the root node, given current scores and weights, is **Site B**. This can be changed by changing the weights.

Rather than manually change weights to test for sensitivity, the sensitivity down window calculates which criteria weights are sensitive. The criteria are listed down the middle of the screen. Where a change to the cumulative weight of a criterion can result in a new most preferred option, a bar is drawn on the graph.

The bars are colour coded. A red bar is very sensitive, a yellow bar is less sensitive and a green bar would require a large weight change to change the most preferred option.

The thresholds for colour coding are as follows:

Red - Cumulative weight would have to change by less than 5 points in order to change the most preferred option.
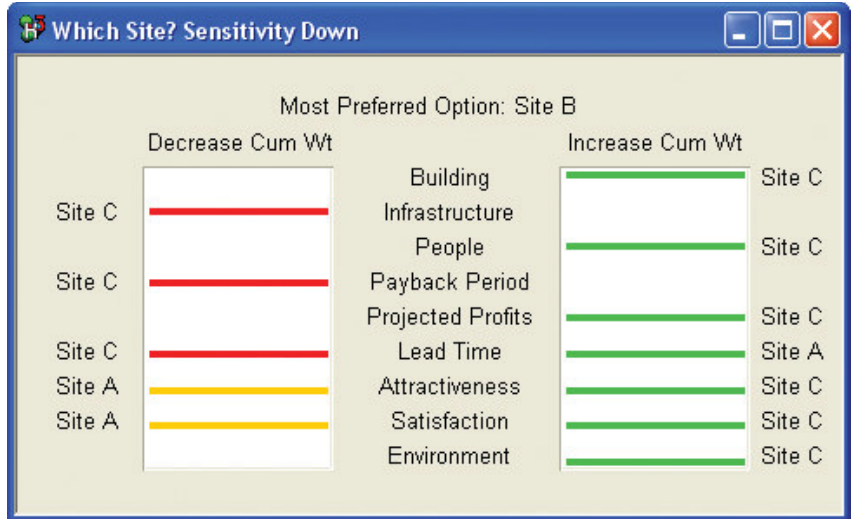
Figure 22. Sensitivity Down for the Root Node.

Yellow - Cumulative weight would have to change by between >5 to 15 points in order to change the most preferred option.

Green - Cumulative weight would have to change by more than 15 points in order to change the most preferred option.

The bars drawn to the left of the criteria list represent a decrease in cumulative weight, whilst the bars drawn to the right represent an increase. For each instance of a bar being drawn, the new most preferred option is displayed at the end of the bar. Where there is no bar, no amount of weight change will change the most preferred option.

The sensitivity down window is used to direct further analysis of the model. Where criteria have a red bar, further analysis is a high priority. In our example, three criteria have a red bar to the left. This means that they are sensitive to a drop in their cumulative weights. Only a small drop in cumulative weight on any of them would cause Site C to become the most preferred option.

4.2.2 Sensitivity Up

The sensitivity up graph displays the sensitivity of the overall results to a change in the weight of a selected criterion or node over the entire range of 0 to 100. When used to show the sensitivity of a criterion, it shows more detail than the sensitivity down screen, providing information about how the most preferred option at the top of the tree will change over the 0-100 weight range.

In our example, the sensitivity down window shows a red bar to the left of criterion **Lead Time**. It also shows a green bar to the right of this criterion. We will investigate this further.

- Click the ![button] button on the toolbar and select *Lead Time* on the tree to open the *Sensitivity Up* graph.

Figure 23. Sensitivity Up Graph for Lead Time.

This graph demonstrates how the overall weighted preference values for all the options vary with the cumulative weight on **Lead Time**. The x-axis represents the cumulative weight on the criterion. The y-axis shows the total weighted values, at the root node, of each of the options.

The vertical red line shows the current cumulative weight of **Lead Time**. The y-values for each option at the intersection with the vertical red line are the same as the total weighted scores in the node data window for the root node. The sloping lines for the options show how the total weighted scores change as the cumulative weight on the criterion changes.

The most preferred option at any cumulative weight has the highest y-value. The upper surface of the graph always shows the most preferred option for a given cumulative weight. At the vertical red line, **Site B** has the highest y-value. It is currently the most preferred option. However, the cumulative weight does not have to decrease by much before **Site C** takes over as the most preferred. This change is marked by the edge of the green shaded area.

This graph shows that only a small change in the weight on **Lead Time** will cause the most preferred option at the top of the tree to change. It also tells us that **Site D** is fully dominated and will never be preferred at this level of the analysis.

Now that we know that **Lead Time** is a sensitive criterion, scores and weights can be further investigated.

4.2.3 A Further Use for Sensitivity
As mentioned earlier, it is common for debate to arise regarding scores and weights when building an MCDA model. These differences can be noted and put aside until the model is complete.

Sensitivity analysis is a powerful tool for dealing with differences in judgements. Experience shows that hotly debated criteria scores and weights can often turn out to be very insensitive. Hiview 3 sensitivity analysis tools can demonstrate this easily, allowing individuals to agree about the overall best option while still preserving their differences in judgements. The same principle applies to vague judgements. The overall most preferred option may not change over the range of vagueness for a particular score or weight.

Reporting

In this chapter...

- Report Options
- Reporting Sorts

Hiview 3 provides a report of your model. The report is a formatted HTML file to give most flexibility. Graphics in the report are saved separately. The report can be used immediately as a web page or imported into a word processing package such as Microsoft Word.

5.1 Report Options
There are several options for what you can include in your report.
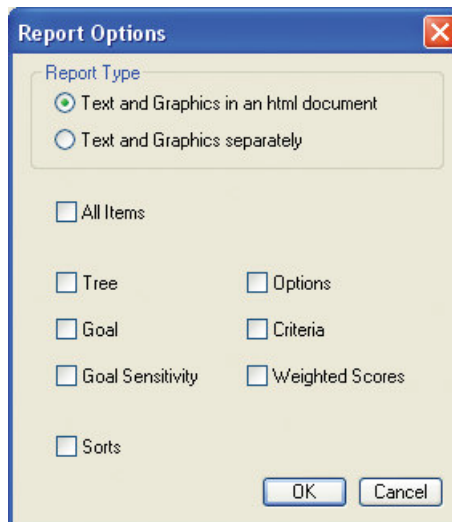
- Choose **Report** from the **File** menu.

Figure 24. Report Options.

You can set options for your report in this dialog box.

- Check the box for *All Items*. All the check boxes will now be checked. Click the *OK* button. The *Report Sorts* dialog opens.
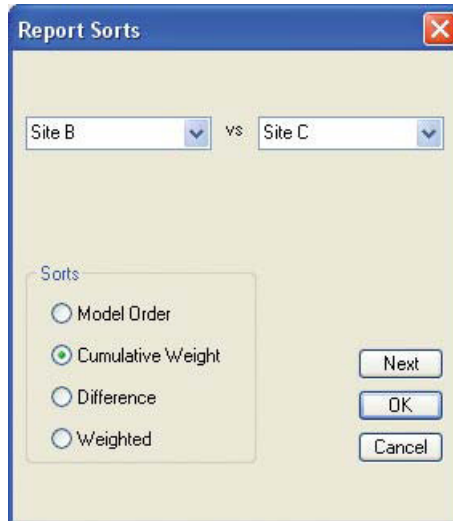
5.2 Reporting Sorts

Figure 25. Reporting Sorts.

This dialog is used to specify any number of sorts that you would like appended to your report. There is no restriction on the number of sorts you can request.

- Using the list boxes, choose to compare *Site B* with *Site C*.
- Choose to sort the data by *Cumulative Weight*.
- Click the *Next* button. The form clears and you can enter more sorts to report. When you have finished requesting sorts, click the *OK* button to prepare your report.

When the report is prepared, you will be asked to specify where it should be saved. If you have chosen graphical items in the report, there will be more than one file created so you may wish to create a new folder for the report on your disk.

- To view the saved report open the file you saved in either a web browser or a word-processing package.

References

For further reading on Decision Analysis:

Belton, V. and Stewart, T.J. (2002) Multiple Criteria Decision Analysis: An Integrated Approach. Kluwer Academic Publishers. ISBN: 079237505X. Explains all the various schools of multi-criteria analysis, sufficiently to aid practitioners in applying the theories.

Clemen, R. (1996) Making Hard Decisions: An Introduction to Decision Analysis (2nd Edition). Boston: Duxbury Press. A solid and comprehensive introduction to decision analysis, much used as a textbook.

DETR (2000) Multi-Criteria Analysis: A Manual. London: Department of the Environment, Transport and the Regions. A review of multi-criteria analysis techniques, and a guide explaining how to apply multi-criteria decision analysis. Written by a team of two economists, John Dodgson and Michael Spackman of NERA, and two academics, Professors Alan Pearman (Leeds) and Larry Phillips (London School of Economics). Download free from www.odpm.gov.uk/about/multicriteria/index.htm, which also gives hardcopy ordering instructions.

Hammond, J.S, Keeney, R.L. and Raiffa, H. (1999) Smart Choices: A Practical Guide to Making Better Decisions, Boston, MA: Harvard Business School Press. A layman's guide that minimises the mathematics and emphasises the practical considerations.

Keeney, R. and Raiffa, H. (1976) Decisions with Multiple Objectives, New York: John Wiley. The classic text that elaborated decision analysis to include multiple objectives.

Phillips, L.D. (1984) A theory of requisite decision models. Acta Psychologica, 56, 29-47.
Elaborates a theory of models that are just sufficient to resolve the issues at hand.

Raiffa, H. (1968) Decision Analysis. Reading, Mass.: Addison-Wesley.
The classic introduction to decision analysis. Still worth reading.

Note: There will be updated material via the Catalyze and LSE Websites.
http://www.catalyze.co.uk

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