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Conducting a Multi-Criteria Analysis Using Web-HIPRE
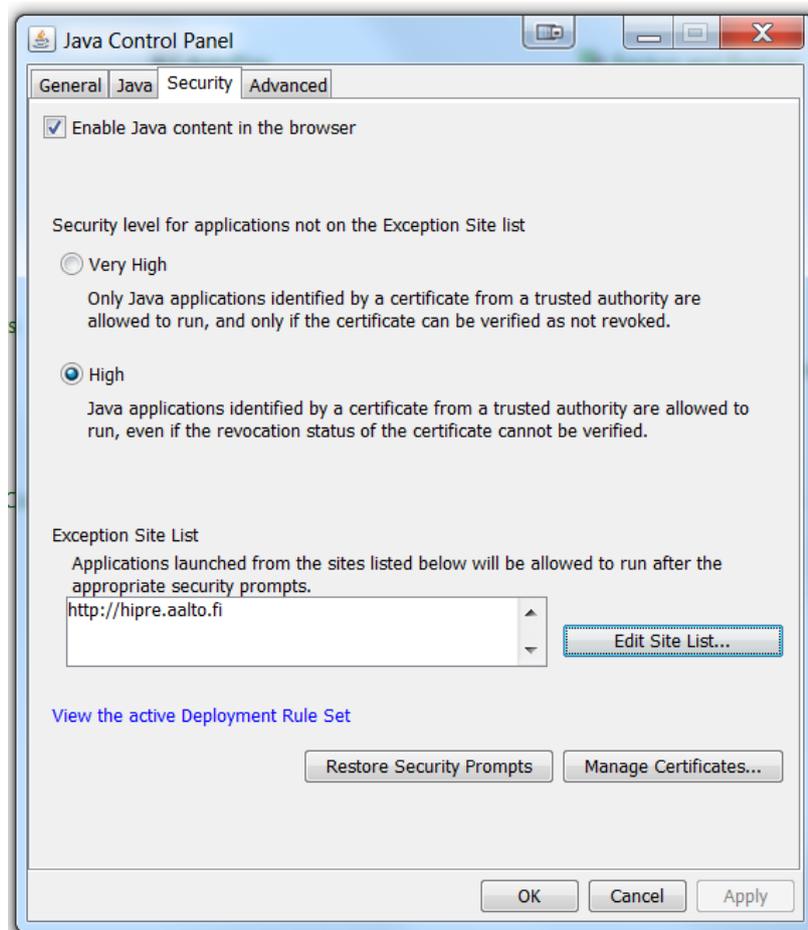# Practical session

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Starting the software

Go to **http://hipre.aalto.fi**. Make sure that pop-ups are allowed for the site, and that Java is enabled. To enable Java, go to the Control Panel, and click on "Programs" on the left side of the screen, then "Java" followed by the "Security" tab. Click "Edit Site List…" and add http://hipre.aalto.fi to the list.

Once it is configured correctly, click the "Start Web-HIPRE" button on the pop-up window to start the programme.

Step 1: Establish the decision context

The decision context is the whole range of administrative, political, and social structures that surround the decision being made. It is important to identify a single high-level goal (e.g. improve transportation in Leeds), for which there will usually be sub-objectives (e.g. shorten commuting time, reduce air pollution). To determine objectives, we need to know who both the key players and stakeholders are. A *key player* is anyone who can make a useful and significant contribution to the MCA (including outside experts). A *stakeholder* is anyone who has an investment, financial or otherwise, in the decision taken.

Step 2: Identify the alternatives (a.k.a. options)

These are the options you are trying to decide between (e.g. building a tramway, widening the road, implementing a congestion charge, etc.) The status quo (i.e. no change) is an options that is generally worth including.

**Step 3: Identify the criteria**

The criteria are the measures against which the alternatives will be judged. For our transportation example these might include cost, safety, and environmental impact. Typically there are between six and twenty criteria, which may be organised within a *value tree.* The most important trade-off between objectives appears at the top of the value tree hierarchy.

It is important that each alternative can be evaluated against each criterion. Moreover, the criteria must be "preference independent" of one another (you must be able to assign preference scores on one criterion without knowing preference scores on another criterion).

In Web-HIPRE: Enter "GOAL", "CRITERIA", and "ALTERNATIVES" in the boxes across the top. These boxes do not affect the results, but are simply to help you organise the model elements. To edit a box, left click on it, and then press Enter.

Add elements to the model by double-clicking within the area below the named boxes. Start with the goal, then do the alternatives, and finally the criteria (as per Steps 1-3 above). To edit or delete an element after you have created it, left click on it and use the "Model" menu. Elements can be moved from left to right or up and down.
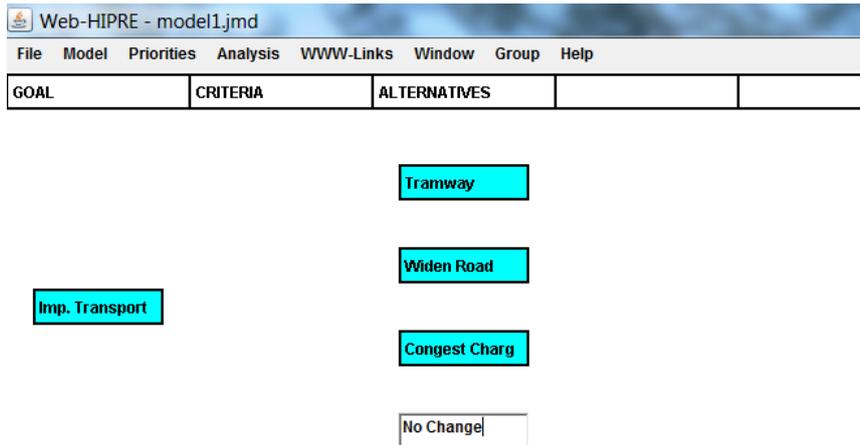
Once all elements have been added you need to connect them. All criteria should be connected to the goal, and all alternatives should be connected to the criteria. First, select an element by left-clicking on it. Then right-click on the element you want to connect it to. You can save time by using SHIFT plus left-click to select multiple elements, and then right-clicking on the element you want to connect them to.
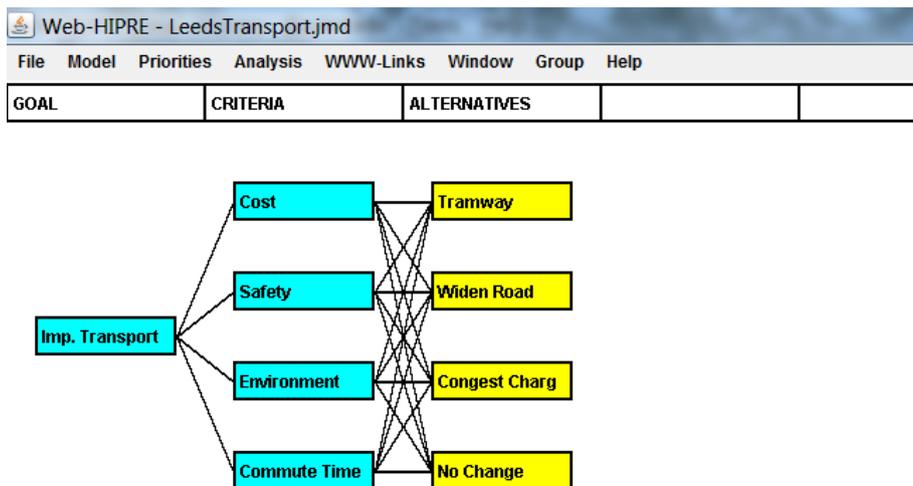
Save your model with a memorable name, and write it down. The class account is called *soee5095*, and the password is *mca*. You can also create your own user account.

Step 4: Score each alternative against the criteria (i.e. generate the performance matrix)

- It is important to set up consistent numerical scales for the criteria to ensure that the direction is the same in all cases (e.g. higher scores indicate better performance on all criteria). It is conventional to normalise values for each criterion so that they are on a 0 to 100 scale.   Web-HIPRE will do this normalisation procedure for you.
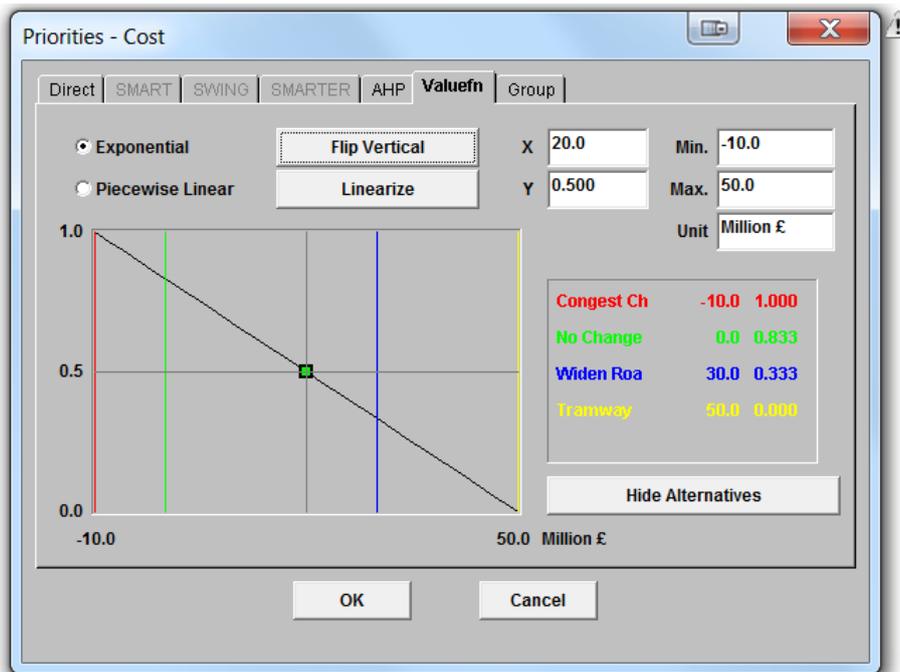
- Establish what the 0 and 100 values mean. With "local scaling", 0 and 100 would represent the worst and best values within the available options. With "global scaling", they would represent the worst and best levels that are possible in general.
- There are three ways to generate scores for the alternatives against each criterion:
    - Value functions: mathematically translate a measured quantity into a value on a 0-100 scale. Generally a linear relationship is used, but not always.
    - Direct rating: uses the judgement of an expert to associate a number on a 0-100 scale with each alternative's performance on the criterion.
    - Pairwise assessments: ask decision-makers to express their opinion on the performance of each alternative with respect to the others. The analytic hierarchy process (AHP) can then transform this information in 0-100 scores.

In Web-HIPRE: Double-click on any of the alternative elements. This will bring up a blank performance matrix for the MCA. The alternatives are on the left, and the criteria are at the top. Fill in scores for each alternative against each criterion. Also include a minimum and maximum value for each criterion (either for local or global scaling) and include units if these exist. Click OK to close the window.

Ratings

	Cost	Safety	Environment	Commute Time
Min Rating	-10.0	1.0	0.0	0.0
Tramway	50.0	5.0	200.0	15.0
Widen Road	30.0	3.0	400.0	30.0
Congest Char	-10.0	3.0	300.0	20.0
No Change	0.0	1.0	600.0	40.0
Max Rating	50.0	5.0	600.0	60.0
Unit	Million £	Expert Opinion	kt of CO2	Minutes

Clear Ratings   OK   Cancel   Import...

Note that in the example above, I have used local scaling for Cost and Safety, but global scaling for Environment and Commute Time.

To determine how scores are calculated for the criteria, click on each criterion individually. Select the "Valuefn" tab. The graph shows how the real values (e.g. the **cost** of each alternative) are normalised to a 0 to 1 scale (Web-HIPRE uses 0 to 1 rather than 0 to 100). In cases where a smaller real value is better (i.e. for **Cost**, **Environment**, and **Commute Time** in our example) **click on "Flip Vertical"** to assign the lowest value to 1 and the highest value to 0. Click "OK" to keep the changes.

Priorities - Cost

Direct | SMART | SWING | SMARTER | AHP | **Valuefn** | Group

- ○ Exponential
- ○ Piecewise Linear

Flip Vertical
Linearize

X 20.0   Min. -10.0
Y 0.500   Max. 50.0
          Unit Million £

1.0

0.5

0.0

-10.0   50.0 Million £

Congest Ch	-10.0	1.000
No Change	0.0	0.833
Widen Roa	30.0	0.333
Tramway	50.0	0.000

Hide Alternatives

OK   Cancel

Step 5: Choose the decision model

The most common method is the *linear additive model*, which multiplies the value score on each criterion by the weight of that criterion, and adds all the weighted scores together. This is the model that Web-HIPRE uses by default.

Step 6: Assign relative weights to each of the criteria

In practice, the method of *swing weighting* is often used. The method evaluates how the "swing" from 0 to 100 on one criterion compares to the swing from 0 to 100 on another criterion. Thus the weight assigned to a criterion reflects both the range of difference and how much that difference matters.

In Web-HIPRE: Double-click on the goal element (e.g. "Imp. Transport"). Weights may be assigned directly by clicking on the "Direct" tab and entering values from 0 to 1 for each criterion. Click "Normalize" to ensure all values add to 1, and then "OK" to keep changes.

Alternatively, we can use swing weighting by clicking on the "SWING" tab. Choose which of the criteria is most important and assign 100 points to it. Now, assign a smaller number of points to each of the other criteria. The values assigned should reflect how a swing from 0 to 1 on the other criteria would compare to a swing from 0 to 1 on the first criterion. Click "OK" when done.
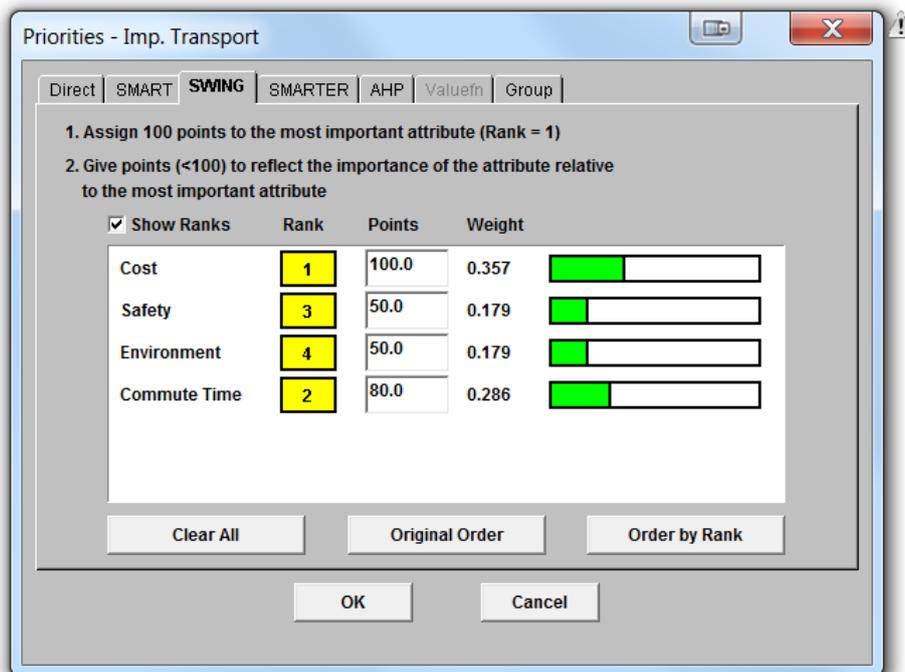
Note that whichever of the tabs you leave selected (in the above example it is "SWING") determines the weights that are applied.

At this point you should probably save the model again.

Step 7: Combine the weights and scores for each of the alternatives to arrive at rankings

You are now ready to generate some results using the software.

In Web-HIPRE: Click on "Analysis" in the menu, and then "Composite Priorities…". The software will show you a graphical depiction of how each alternative scores, and the contribution that each criterion makes to the score. In our example, the Congestion Charge option is ranked highest, largely due to its strong score on Cost. The Congestion Charge has the lowest Cost, and Cost is also the most highly-weighted criterion.
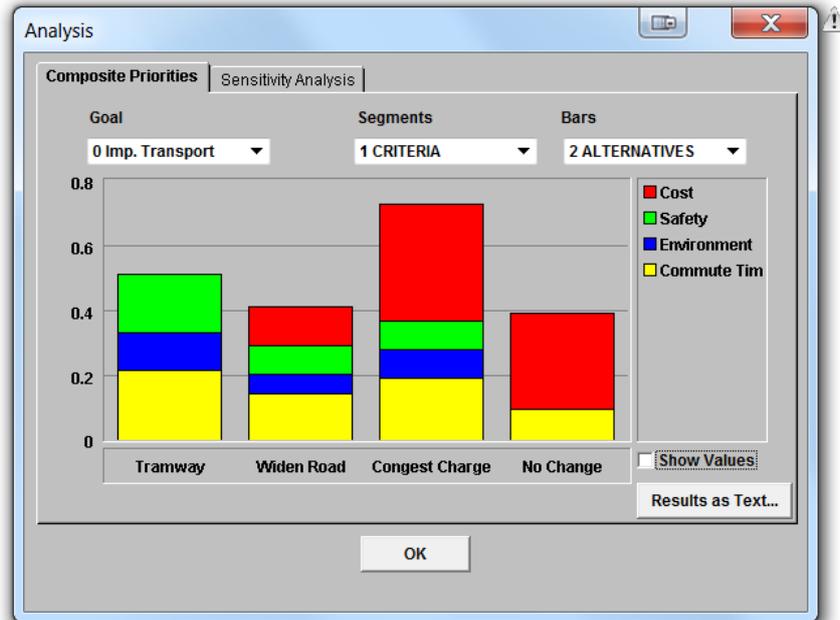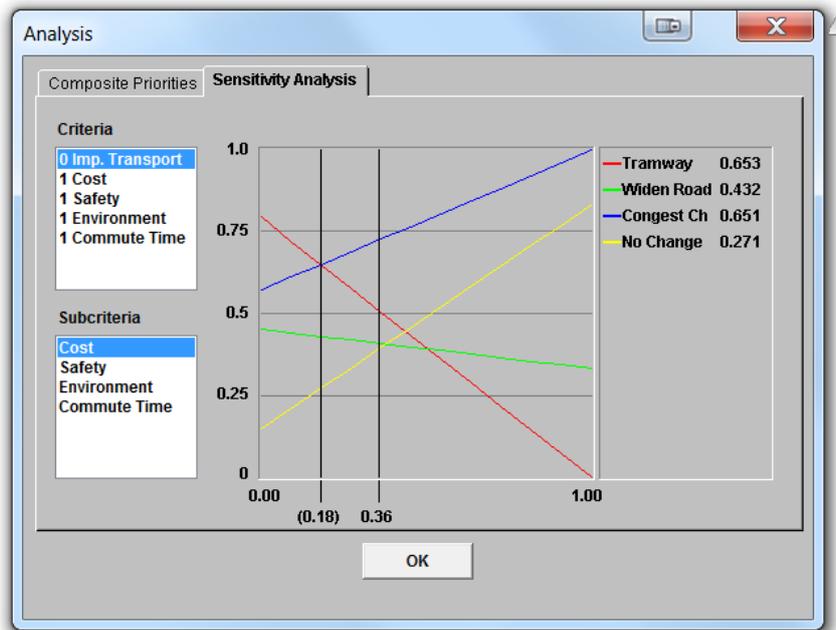
Step 8: Perform a sensitivity analysis

Use the software to examine how the ranking of alternatives might change under different weighting or scoring systems. An advantage (a high score on a heavily-weighted criterion) or a disadvantage (a low score on a heavily-weighted criterion) may be identified.

In Web-HIPRE: Click on the "Sensitivity Analysis" tab (or go back to the "Analysis" menu item and click "Sensitivity Analysis…").

To do a sensitivity analysis on the **weights** that were applied, select the overall goal in the upper left-hand box (i.e. "Imp. Transport"). The criteria should appear in the lower left-hand box (i.e. "Subcriteria). You can now select each criterion and see how changing its weight (by clicking a new value on the graph) would change the result. In the example below I have selected Cost, and then a new weight of 0.18 (compared to the weight assigned by SWING which was 0.36). The graph shows me that if Cost were weighted less than 0.18, the Tramway would become the preferred option.

To do a sensitivity analysis on the **scores** that were assigned in the performance matrix, select one of the criteria in the upper left-hand box, followed by one of the alternatives in the lower left-hand box. You can now see how changing the value assigned to this alternative–criteria pair (by clicking a new value on the graph) would change the result. In the example below, I have selected the Commute Time criterion and Congestion Charge alternative. The value on the x-axis represents the assigned score for the alternative (in this case commuting time in minutes). The graph shows that the Congestion Charge would still have the highest score even if its Commute Time were increased to 60 minutes!