The process of bag manufacturing

- The figure outlines the macro processes of bag manufacturing in a workshop. First, cutting and preparing components, where semi-finished products originate; then, assembling and checking against quality. If products are good, they are packed and shipped out. Otherwise corrective actions are triggered to handle error (not modeled).

- In the two exclusive gateways, the make-or-buy business decision is made, by comparing the costs and benefits of carrying out internal or external manufacturing of product components, via outsourcing to a third party specialist.
1. Select each task, and insert duration and cost per execution.
2. Data concerning all the activities of the model.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Average Duration</th>
<th>Average Cost (EUR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutting</td>
<td>25</td>
<td>16</td>
</tr>
<tr>
<td>Preparing Components (internal)</td>
<td>28</td>
<td>31</td>
</tr>
<tr>
<td>Preparing Components (external)</td>
<td>24</td>
<td>48</td>
</tr>
<tr>
<td>Assembling (internal)</td>
<td>93</td>
<td>67</td>
</tr>
<tr>
<td>Assembling (external)</td>
<td>68</td>
<td>93</td>
</tr>
<tr>
<td>Quality check and packing</td>
<td>42</td>
<td>26</td>
</tr>
<tr>
<td>Outsourcing Management *</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>

* Interfacing with the third party

3. Define number of available instances (pools)$^1$, time scale $^2$ and currency$^3$. 
4. Create a scenario: left-click on the diagram background and press *add*;
5. Insert the name (Internal production) and the number of cases;
6. Create the path of the scenario.
7. Two scenarios: internal production and (partially) external production.
8. Click the *Play/Stop/Pause* buttons to simulate;
9. Look at the red inverted triangles (tokens queues) and at the the green gears (processing tokens);
10. Look at the final duration and cost;
11. The two scenarios are executed considering the related number of tokens, e.g., 30% and 70%;
12. Click on the logo for plotting important duration and cost parameters;
13. **Completion** against time: to be processed, processing, and processed tokens:
14. **Resource usage** against time:
15. Queue time
16. Cost per flow object (cost per use)
17. Other costs

<table>
<thead>
<tr>
<th>Input Name</th>
<th>Number Of Instance</th>
<th>Cost Per Instance (EUR)</th>
<th>Total (EUR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 External Production</td>
<td>28</td>
<td>191</td>
<td>5,348</td>
</tr>
<tr>
<td>2 Internal Production</td>
<td>12</td>
<td>140</td>
<td>1,680</td>
</tr>
</tbody>
</table>

18. Time Cost

![Time Cost Graph]
19. **Exercise**

Suppose to aim at producing 40 bags, by combining internal and external production scenarios, with a single bag workshop and a single third party specialist.

Simulate:

a) a scenario of totally internal production; analyze results/plots;
b) a scenario of partially external production; analyze results/plots;
c) find a combination of the two scenarios so as to carry out the process in both less time and cost, with respect to (a) and (b).
**Solution**

Let $x_1$ be the percentage of bags that are produced internally, and $y(x)$ the total duration of the production process of 40 bags.

a) $x_1=100\% \rightarrow 5\,\text{g} \, 5\,\text{h} \, 20' \, 5600\,\text{€}$, with maximum queues on the last phases, due to the sequential character of the workflow;

b) $x_1=0\% \rightarrow 3\,\text{g} \, 6\,\text{h} \, 52' \, 7640\,\text{€}$, with maximum queues on the assembling stage, which is a process with larger duration, with respect to the other processes;

c) by carrying out internally some units, the assembling is parallelized, thus reducing queuing effects, and then saving total time and cost; e.g., $x_1=20\% \rightarrow 3\,\text{g} \, 2\,\text{h} \, 38' \, 7232\,\text{€}$;

d) In the context of luxury handbags production, for a given quality level that is guaranteed by the control quality process, the *total duration* of the process is the main Key Performance Indicator (KPI), rather than the total production cost;

e) Is 20\% the best solution in terms of total duration? Assuming that there is a unique minimum, it can be efficiently found by using a *binary search*;

f) Given $x_1$ and $x_3$, calculate the total duration of the process for $x_1$, $x_3$, and for the center $x_2=(x_1+x_3)/2$, as well as for a value very close ($dx$) to each of these points. On the basis of the *descent direction* we can establish the position of the optimum with respect to the center.
g) e.g. if the total duration goes down on the right side of $x_1$, and on the left sides of $x_2$ and $x_3$, then the minimum is between $x_1$ and $x_2$.

h) By carrying out 8 simulations, it can be determined that the optimum is located at $x=12\text{-}13\%$, i.e., 5 bags produced internally and 35 externally, with a total duration of 3d 16m, and a total cost of 7385€.