**Cost report presentation**

**Cost model**

The aim of this document is to show the process and philosophy behind the costing method used for the Formula Student Cost Event.

***Context and hypothesis***

*Company description*

The simulated company is sized to be a prototyping shop, able to manufacture and assemble most of the components of a Formula Student car. Therefore, it will not have in-house specific expensive machinery used for a unique or only few parts of the car. For instance, 3D stereolithography printer used for the air intake, water-jet cutter, …

Of course, the machinery will not be used all the year to build only one Formula Student car. Thus, we assume that the remaining time where the equipment is not allocated for the Formula Student project is used for other customers to build another car, small/medium series of components, prototypes, …

The same hypothesis is used for manpower.

Therefore, the shop is built around:

* Administrative department for marketing, production support (materials orders, invoice, …), finance, …
* Several shop floor workstations:
  + A 3 axis Haas CNC Mill VF-3SSYT
  + A CNC mill with Y axis Haas ST35-Y
  + A CNC laser table FL510HD-1000 from Baileigh
  + An assembly station
  + A welding station
  + A Reflow oven (for PCBs)
  + A conventional machining area with a mill and a lathe
  + A metrological lab
  + FAO workstations

*Hypothesis*

The following assumptions are used in the cost model:

* The shop is running 35 hours a week, 46 week per year.
* During the opening time, machines are considered to have an OPE reflecting downtime, preventive maintenance, lack of orders, …
* Manpower of the shop floor are considered to work 95% of the time

Items are assumed to have a linear depreciation between 3 to 10 years regarding equipment type.

In this simulation is not included:

* Building expense: rent, security, insurance
* VAT for the purchased and sold products
* Governmental taxes
* Worker’s health insurance
* Margin applied on sold products

*Cost model division*

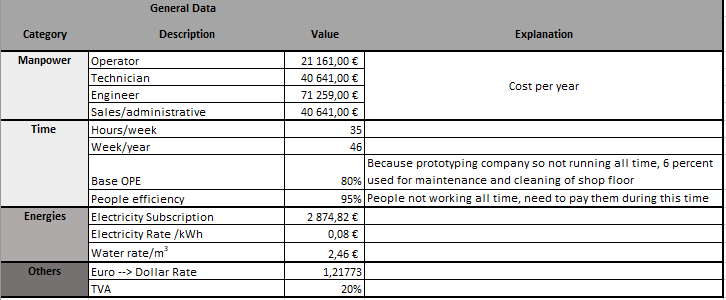
It has been chosen to divide the model in several parts.

* Overhead costs: Include all the equipment and expenses required to run the company.
* Manufacturing cost:
  + Machining cost: Equipment like CNC mill and lathe cost are detailed. This cost is added to manpower and overhead cost.
  + Assembly cost: This section uses cycle time for operation, mix to overhead and manpower cost to reflect the price of assembly.
* Bought parts:
  + Materials
  + Fasteners

*Sources*

The cost is built on reliable sources to ensure the quality of the model. Machine prices come from Baileigh industrial, Haas machining and informatic equipment are from Lenovo. Metrology equipment are sourced from Mitutoyo, Starrett and Orexad. Fasteners and materials prices come from our suppliers.

*General data*



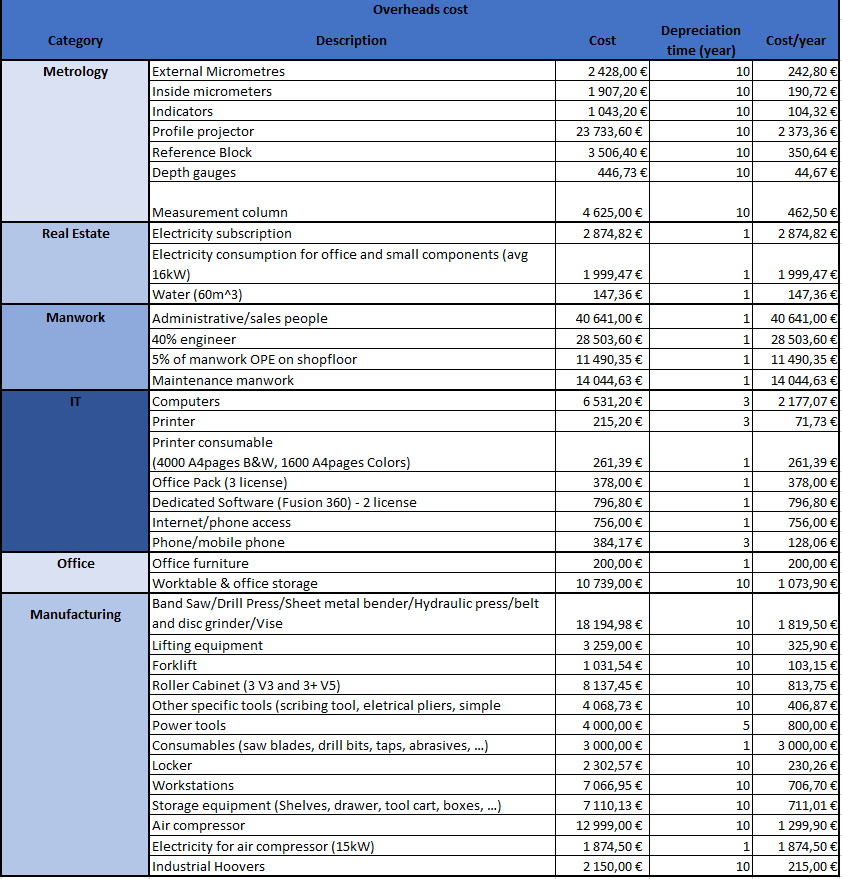
Operators are assumed to be skilled machinists. Thus, they can manage a CNC machine and program simple parts.

***Overhead cost***

The overhead cost includes all the equipment and expenses required to run the company.

Therefore, it takes into account office furniture, items used for different workstations, administrative wages, manpower time used for maintenance purpose, energies cost for small machinery and offices…

This overhead is then distributed equally between each workstation production in order to annually compensate the overhead expense of the company.



***Manufacturing cost***

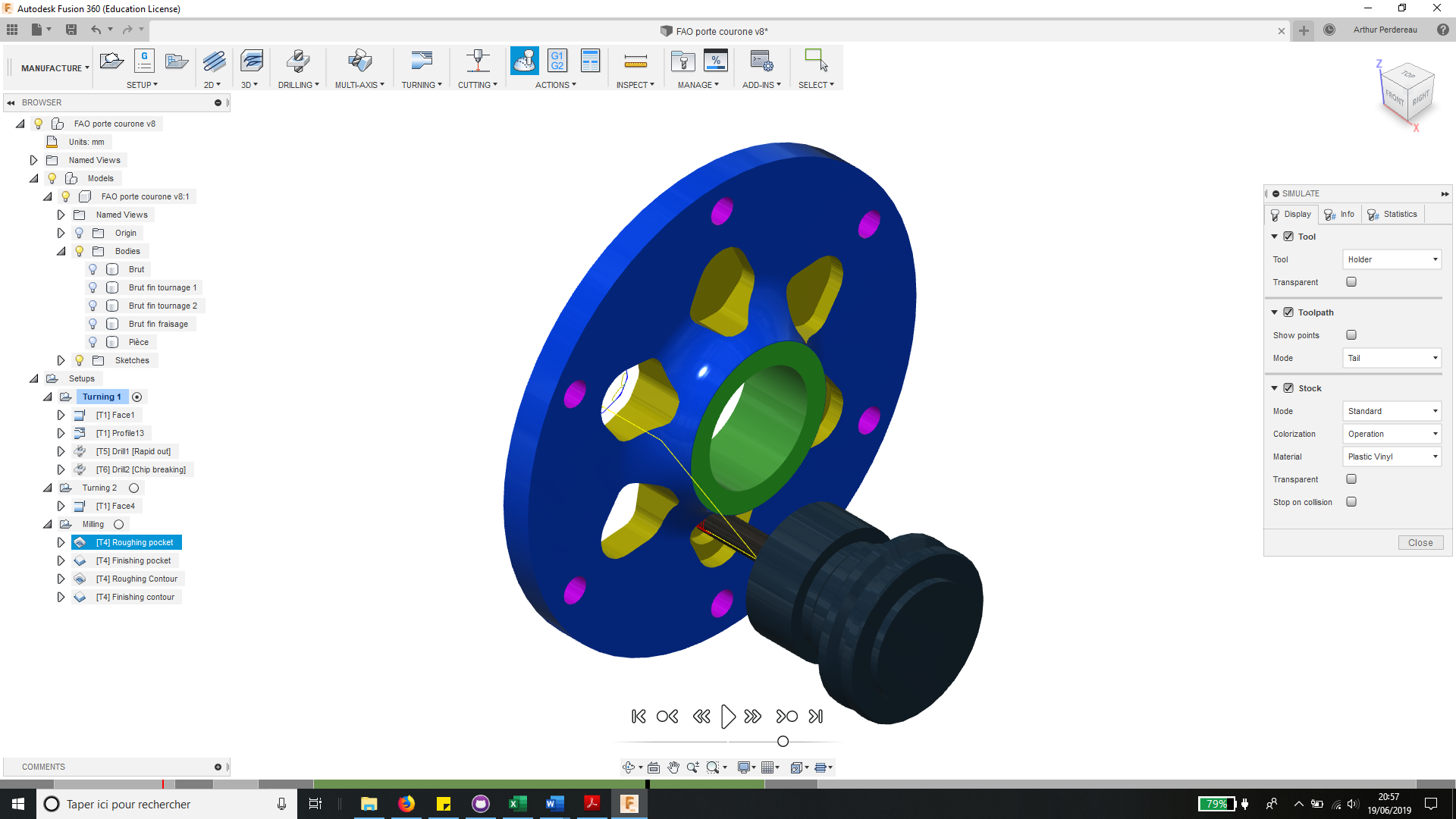
For each equipment, a fixed cost is built around machine, tooling, fixture prices and maintenance cost dedicated to the workstation. It is depreciated as the overhead is. Then is added the variable costs such as electricity, cutting fluid, filler and tools. A ratio is determined to link a machining data (volume, length) to execution time. Finally, it is possible to associate a cost on each operation.

*Milling and turning*

For both milling and turning, a machine has been selected from Haas catalogue to fulfil most of the production need for the Formula Student prototype. A Y axis lathe with live tooling has been preferred to a classic CNC lathe as it allows more versatile machining like sprocket machining and reduce the number of setups.

The company expect to keep its equipment in a proper condition. Therefore, 5 min of operator preventive maintenance (OPM) is included for each job.

The removal rate and programming time has been determined through a CAM analysis of one of our parts with Fusion 360. It allows to include machine non-cutting time to obtain an estimation of volume removed per minute.

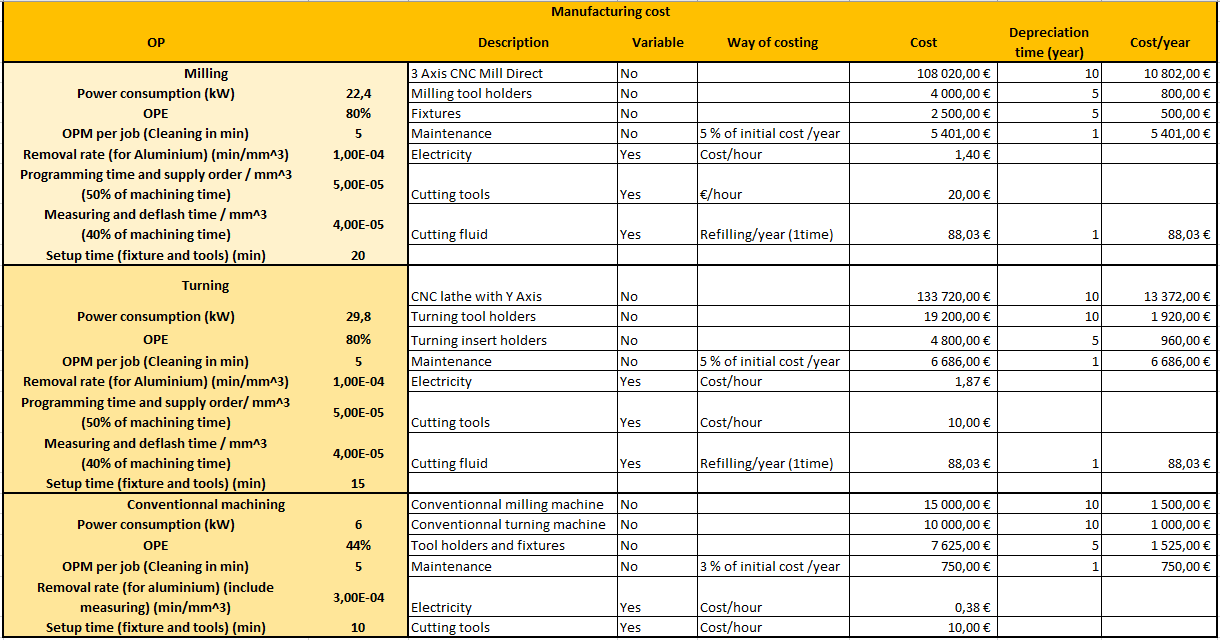


Programming and metrology operations are added separately to the process to show the allocation in the part cost. It is also indexed on volume removed.

The machine is considered to be managed by an operator. During a first part run in the machine, the operator ensures the program do not have any issue. Coefficients are used for multiple parts as the programming is not needed anymore, and the program is validated through the first run.

The programming of the part could be allocated to an operator, a technician, or an engineer regarding part complexity. In this case, the metrology of the part is allocated to the same employee.

For conventional machining, the measurements are included in the machining process.



*Laser cutting*

Laser cutting removal rate has been chosen from manufacturer spec sheet of the laser cutter.

As this kind of machine is really efficient, it is difficult to index a programming time on the cut length. Therefore, we assume a constant programming time of 1.5 min per part. It is also applicable for measuring operation, that consist of measuring basic part dimensions like holes diameter.

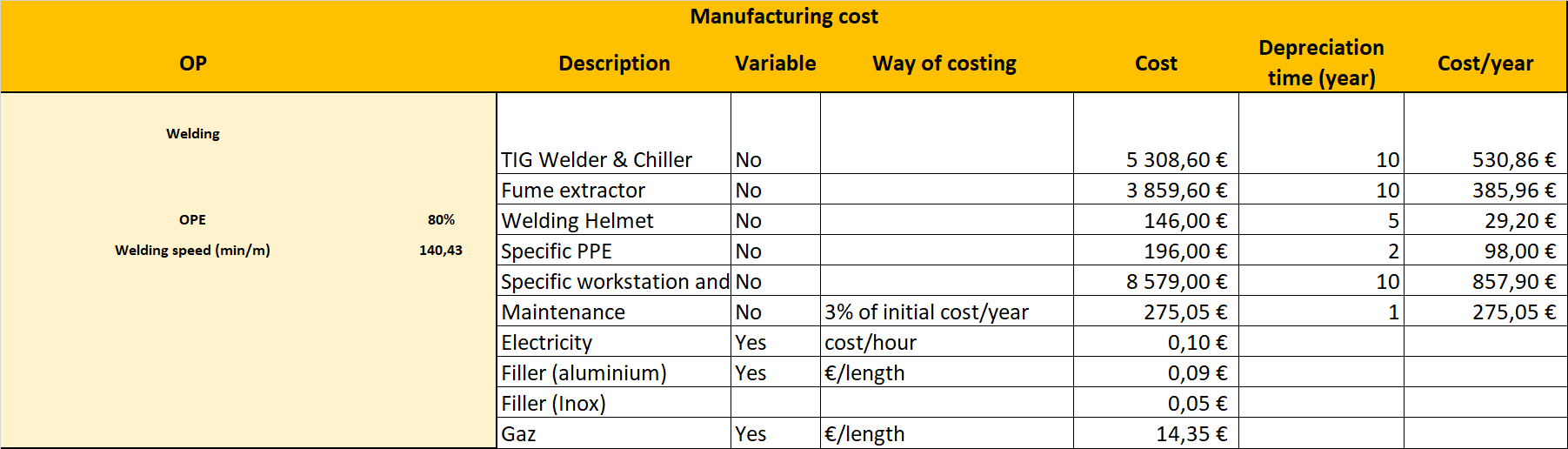
The setup time is related to a full metal sheet with coefficients as it is more realistic.



*Welding*

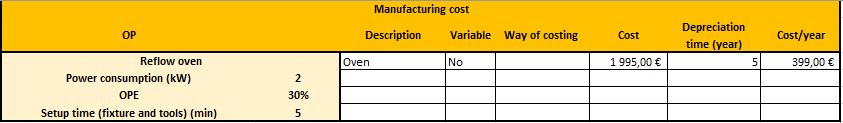
The welding rate was estimated thanks to a precise timing of the different steps required to weld the exhaust system, anti-roll bar and all the aluminium parts. The welding rate includes the time of putting in position the parts to be welded, the time of tack welding, the time of welding of course and also the time of metrology.

All the cost of the different welding machines were found at professional suppliers (Orexad, promeca).



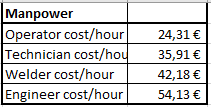
*Reflow oven*

The job duration for the cycle is given by the manufacturer, and there are no other expenses. We considered a low OPE because it represents a small part of the overall production time for a card.



***Processes cost***

Thanks to the established cost model, a cost / hour for each employee, fixing cost included, was calculated.



To find out the rest of the processes cost, the different time for each process were methodically measured during vehicle assembly. All the details of the processes cost can be found on the summary.

***Fasteners cost***

All the fasteners cost used are the one of the team suppliers (TDI visserie, k-Nut, Oreca, …). The price indicated by unit is always the one with taxes (TTC). The one calculated in the column Price, when a quantity is entered, is without taxes (HT).

All the details of the fasteners cost can be found on the summary.

***Materials cost***

Concerning the materials cost, prices between our suppliers have been compared to obtain a right price.

Concerning the raw materials, a study was realised to see the influence of the dimensions on the price by mm^3. As the differences of price observed for the dimensions of materials used the vehicle were very low, it was decided to keep a unique price (€/mm^3) for each material. Same conclusions for the metal sheet materials.

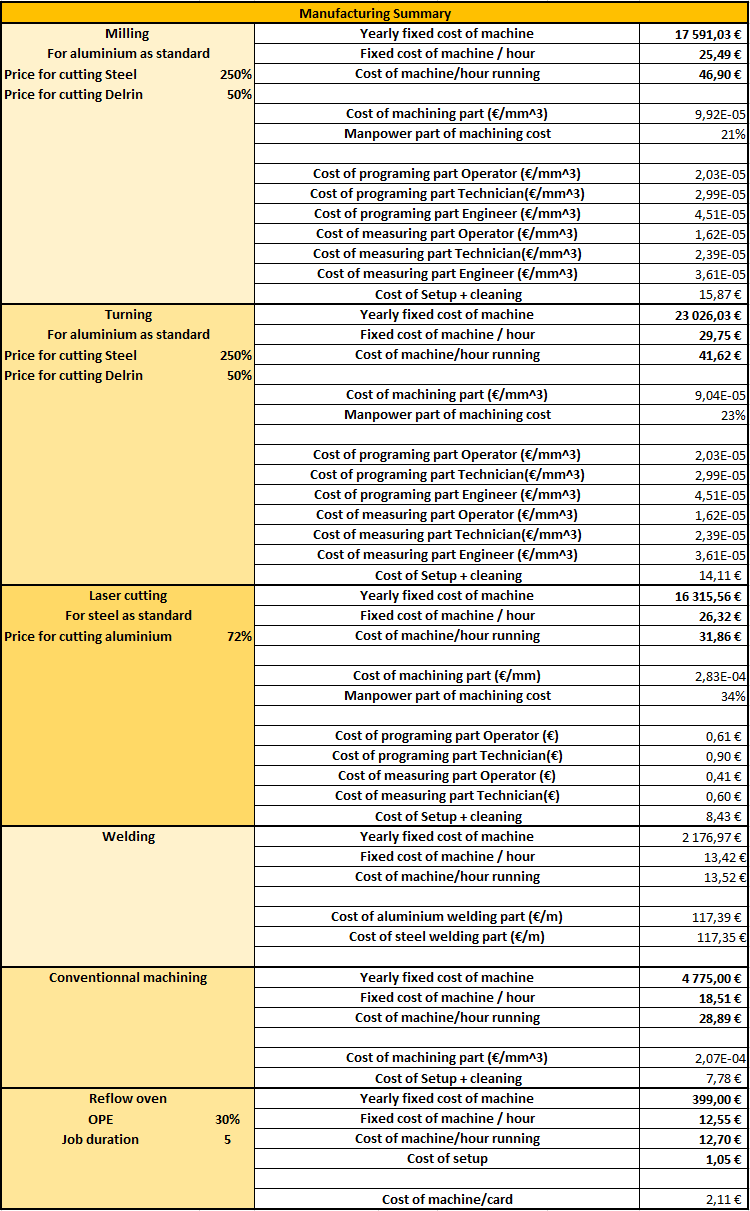
|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Materials | Steel S235 | Steel S355 | Steel S700 | Steel 25CD4 | Alu 2017A | Alu 7075 T6 |
| Chemical composition | S235 | S355 | S700 | 24CrMo 5 | AlCu4MgSi | AlZn6MgCu |
| Tensile Strength: Yield (MPa) | 235 | 355 | 700 | 350 | 120 | 480 |

All the details of the materials cost can be found on the summary.

***Summary***

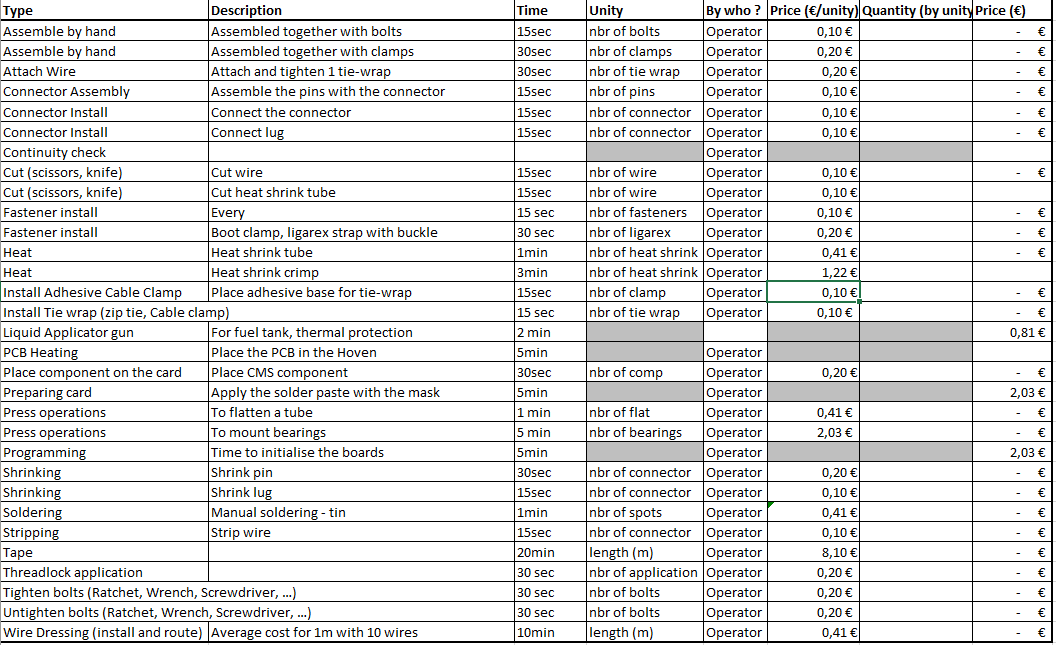


*Overhead summary*

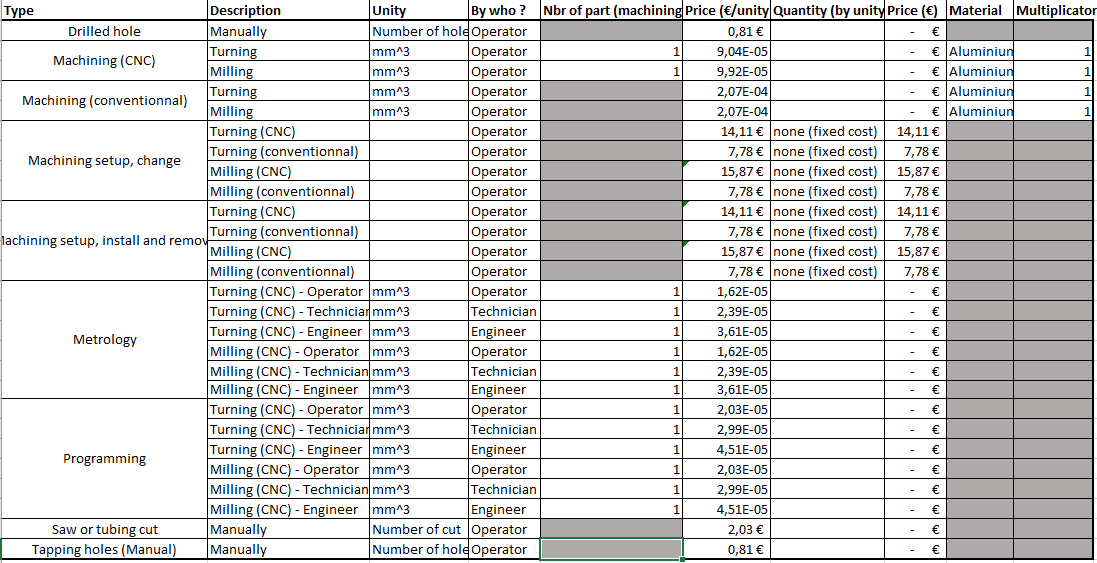


*Manufacturing summary*

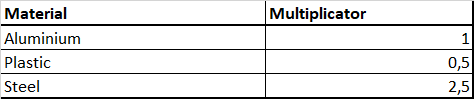
***Processes cost summary***



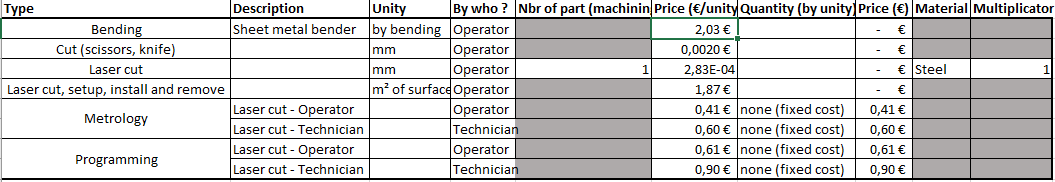
*Assembly cost summary*



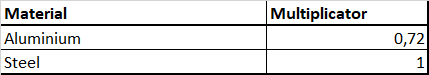
*Material removal processes cost summary*



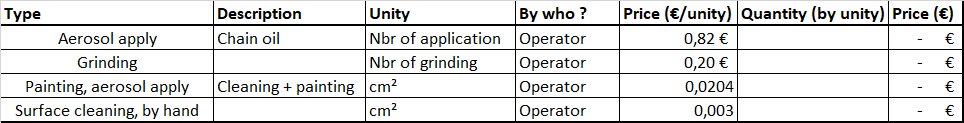
*Multiplicator for machining operation summary*



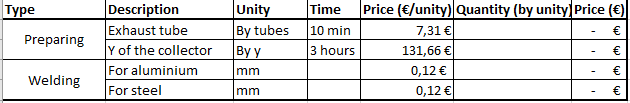
*Sheet materials processes cost summary*



*Multiplicator for laser cut operation summary*

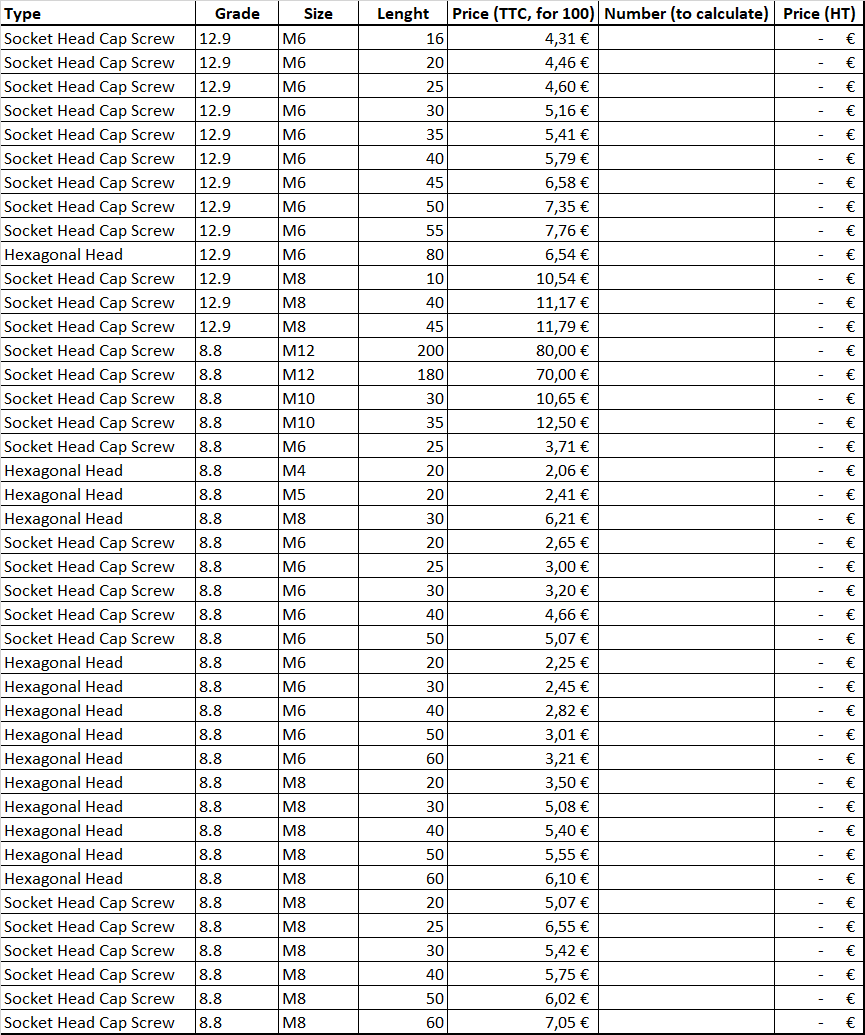


*Surface processes cost summary*

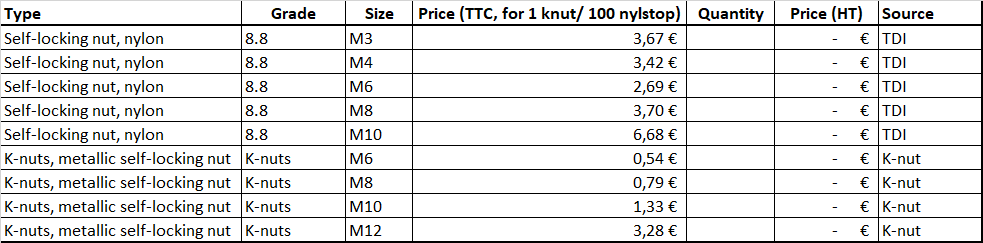


*Welding operation cost summary*

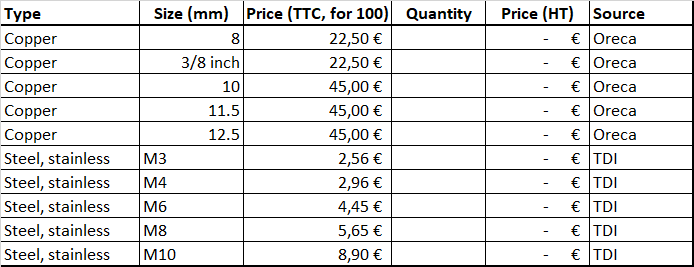
***Fasteners cost summary***



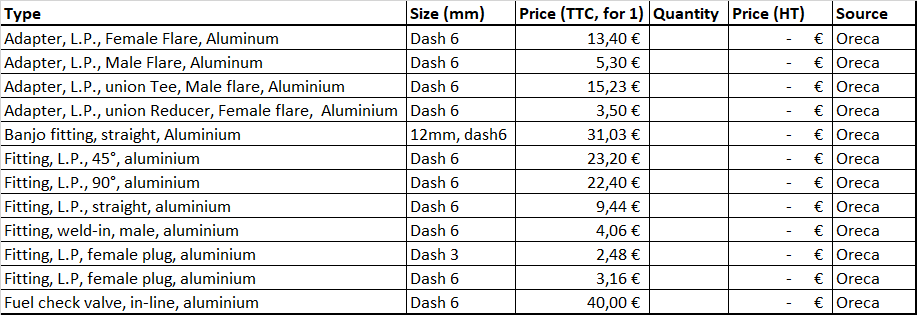
*Bolts cost summary (source: TDI)*



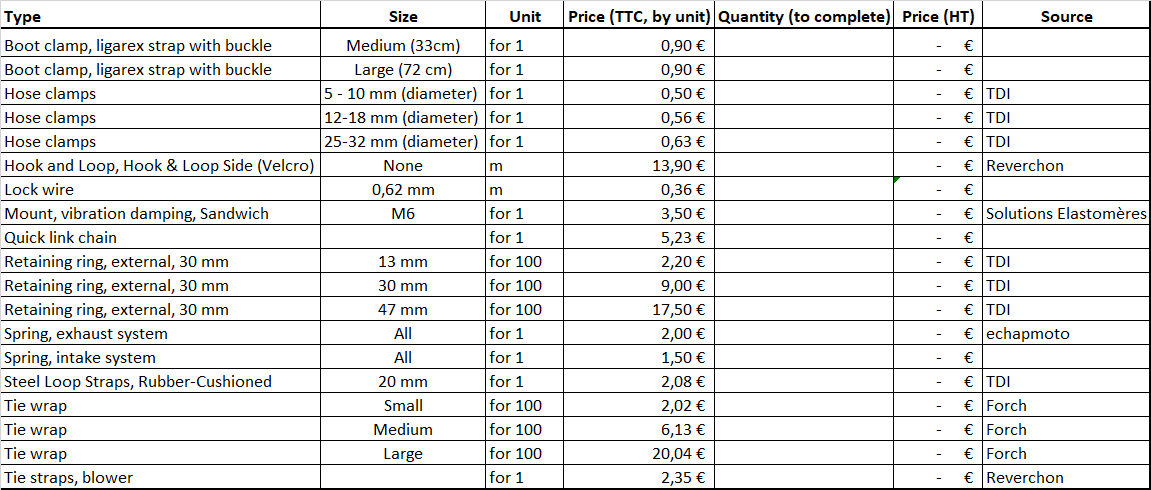
*Nuts cost summary*



*Washers cost summary*

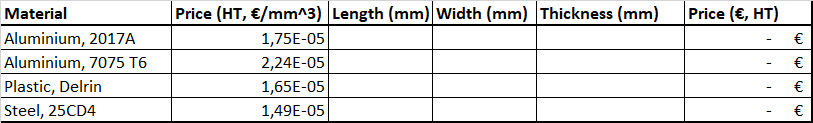


*Plumbing fasteners cost summary*

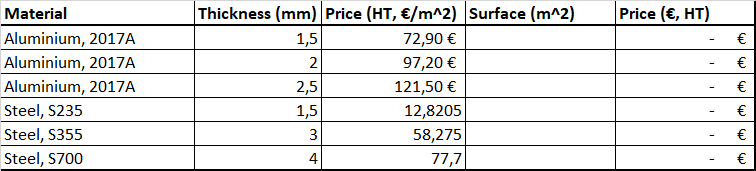


*Miscellaneous fasteners cost summary*

***Materials cost summary***



*Raw materials cost summary*



*Sheet materials cost summary*



*Tubing materials cost summary*