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

General Data			
Category	**Description**	**Value**	**Explanation**
Manpower	Operator	21 161,00 €	Cost per year
	Technician	40 641,00 €	
	Engineer	71 259,00 €	
	Sales/administrative	40 641,00 €	
Time	Hours/week	35	
	Week/year	46	
	Base OPE	80%	Because prototyping company so not running all time, 6 percent used for maintenance and cleaning of shop floor
	People efficiency	95%	People not working all time, need to pay them during this time
Energies	Electricity Subscription	2 874,82 €	
	Electricity Rate /kWh	0,08 €	
	Water rate/m^3	2,46 €	
Others	Euro --> Dollar Rate	1,21773	
	TVA	20%	

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.

Overheads cost				
Category	Description	Cost	Depreciation time (year)	Cost/year
Metrology	External Micrometres	2 428,00 €	10	242,80 €
	Inside micrometers	1 907,20 €	10	190,72 €
	Indicators	1 043,20 €	10	104,32 €
	Profile projector	23 733,60 €	10	2 373,36 €
	Reference Block	3 506,40 €	10	350,64 €
	Depth gauges	446,73 €	10	44,67 €
	Measurement column	4 625,00 €	10	462,50 €
Real Estate	Electricity subscription	2 874,82 €	1	2 874,82 €
	Electricity consumption for office and small components (avg 16kW)	1 999,47 €	1	1 999,47 €
	Water (60m^3)	147,36 €	1	147,36 €
Manwork	Administrative/sales people	40 641,00 €	1	40 641,00 €
	40% engineer	28 503,60 €	1	28 503,60 €
	5% of manwork OPE on shopfloor	11 490,35 €	1	11 490,35 €
	Maintenance manwork	14 044,63 €	1	14 044,63 €
IT	Computers	6 531,20 €	3	2 177,07 €
	Printer	215,20 €	3	71,73 €
	Printer consumable (4000 A4pages B&W, 1600 A4pages Colors)	261,39 €	1	261,39 €
	Office Pack (3 license)	378,00 €	1	378,00 €
	Dedicated Software (Fusion 360) - 2 license	796,80 €	1	796,80 €
	Internet/phone access	756,00 €	1	756,00 €
	Phone/mobile phone	384,17 €	3	128,06 €
Office	Office furniture	200,00 €	1	200,00 €
	Worktable & office storage	10 739,00 €	10	1 073,90 €
Manufacturing	Band Saw/Drill Press/Sheet metal bender/Hydraulic press/belt and disc grinder/Vise	18 194,98 €	10	1 819,50 €
	Lifting equipment	3 259,00 €	10	325,90 €
	Forklift	1 031,54 €	10	103,15 €
	Roller Cabinet (3 V3 and 3+ V5)	8 137,45 €	10	813,75 €
	Other specific tools (scribing tool, eletrical pliers, simple	4 068,73 €	10	406,87 €
	Power tools	4 000,00 €	5	800,00 €
	Consumables (saw blades, drill bits, taps, abrasives, …)	3 000,00 €	1	3 000,00 €
	Locker	2 302,57 €	10	230,26 €
	Workstations	7 066,95 €	10	706,70 €
	Storage equipment (Shelves, drawer, tool cart, boxes, …)	7 110,13 €	10	711,01 €
	Air compressor	12 999,00 €	10	1 299,90 €
	Electricity for air compressor (15kW)	1 874,50 €	1	1 874,50 €
	Industrial Hoovers	2 150,00 €	10	215,00 €

Manufacturing cost

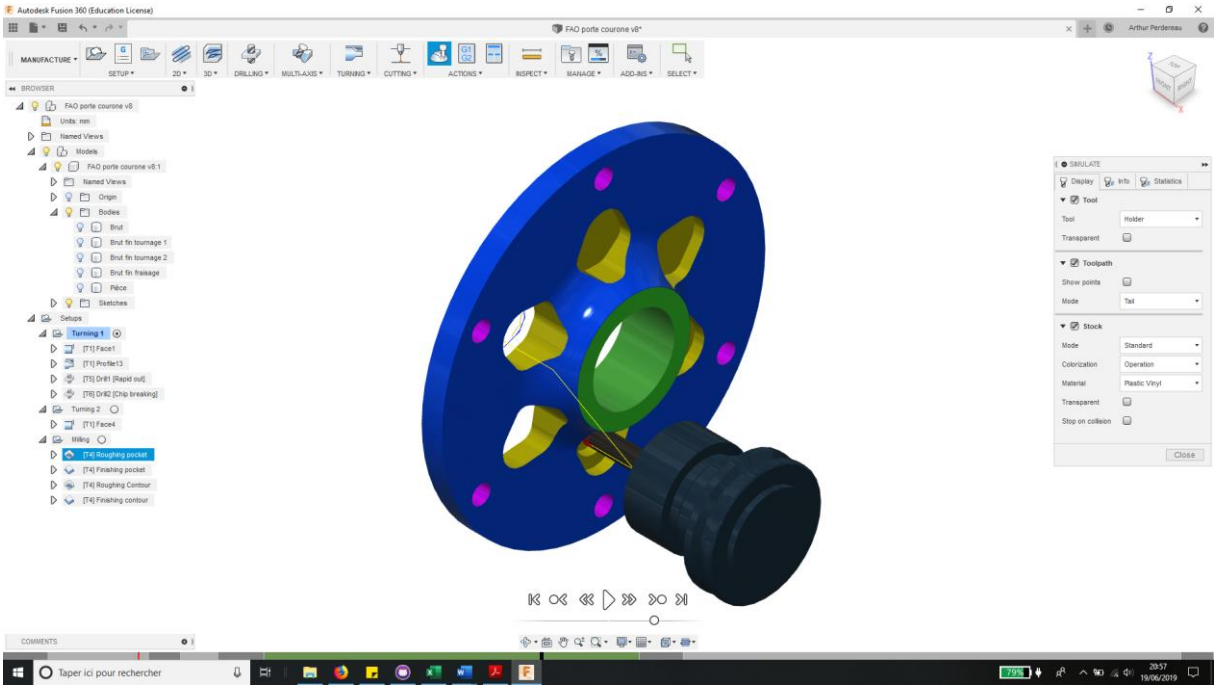
For each equipment, a fixed cost is built around machine, tooling, fixture prices and maintenance cost dedicated to the workstation. It is depreciated as the overhead is. Then is added the variable costs such as electricity, cutting fluid, filler and tools. A ratio is determined to link a machining data (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.

OP		Manufacturing cost					
		Description	Variable	Way of costing	Cost	Depreciation time (year)	Cost/year
Milling		3 Axis CNC Mill Direct	No		108 020,00 €	10	10 802,00 €
Power consumption (kW)	**22,4**	Milling tool holders	No		4 000,00 €	5	800,00 €
OPE	**80%**	Fixtures	No		2 500,00 €	5	500,00 €
OPM per job (Cleaning in min)	**5**	Maintenance	No	5 % of initial cost /year	5 401,00 €	1	5 401,00 €
Removal rate (for Aluminium) (min/mm^3)	**1,00E-04**	Electricity	Yes	Cost/hour	1,40 €		
Programming time and supply order / mm^3 (50% of machining time)	**5,00E-05**	Cutting tools	Yes	€/hour	20,00 €		
Measuring and deflash time / mm^3 (40% of machining time)	**4,00E-05**	Cutting fluid	Yes	Refilling/year (1time)	88,03 €	1	88,03 €
Setup time (fixture and tools) (min)	**20**						
Turning		CNC lathe with Y Axis	No		133 720,00 €	10	13 372,00 €
Power consumption (kW)	**29,8**	Turning tool holders	No		19 200,00 €	10	1 920,00 €
OPE	**80%**	Turning insert holders	No		4 800,00 €	5	960,00 €
OPM per job (Cleaning in min)	**5**	Maintenance	No	5 % of initial cost /year	6 686,00 €	1	6 686,00 €
Removal rate (for Aluminium) (min/mm^3)	**1,00E-04**	Electricity	Yes	Cost/hour	1,87 €		
Programming time and supply order/ mm^3 (50% of machining time)	**5,00E-05**	Cutting tools	Yes	Cost/hour	10,00 €		
Measuring and deflash time / mm^3 (40% of machining time)	**4,00E-05**	Cutting fluid	Yes	Refilling/year (1time)	88,03 €	1	88,03 €
Setup time (fixture and tools) (min)	**15**						
Conventionnal machining		Conventionnal milling machine	No		15 000,00 €	10	1 500,00 €
Power consumption (kW)	**6**	Conventionnal turning machine	No		10 000,00 €	10	1 000,00 €
OPE	**44%**	Tool holders and fixtures	No		7 625,00 €	5	1 525,00 €
OPM per job (Cleaning in min)	**5**	Maintenance	No	3 % of initial cost /year	750,00 €	1	750,00 €
Removal rate (for aluminium) (include measuring) (min/mm^3)	**3,00E-04**	Electricity	Yes	Cost/hour	0,38 €		
Setup time (fixture and tools) (min)	**10**	Cutting tools	Yes	Cost/hour	10,00 €		

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.

OP		Manufacturing cost					
		Description	Variable	Way of costing	Cost	Depreciation time (year)	Cost/year
Laser Cutting		2D Laser cut	No		185 010.27 €	10	18 501.03 €
Power consumption (kW)	**7.5**	Maintenance	No	5 % of initial cost /year	9 250.51 €	1	9 250.51 €
OPE	**70%**	Electricity	Yes	Cost/hour	0.47 €		
OPM per job (Cleaning in min)	**5**	Assist Gas O2 or air	Yes	Cost/hour	5.07 €		
Removal rate (for steel) (min/mm)	**4.60E-04**						
Programation time (min)	**1.5**						
Measuring time (min)	**1**						
Setup time (min)	**8**						

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).

OP		Manufacturing cost					
		Description	Variable	Way of costing	Cost	Depreciation time (year)	Cost/year
Welding							
		TIG Welder & Chiller	No		5 308,60 €	10	530,86 €
		Fume extractor	No		3 859,60 €	10	385,96 €
OPE	**80%**	Welding Helmet	No		146,00 €	5	29,20 €
Welding speed (min/m)	**140,43**	Specific PPE	No		196,00 €	2	98,00 €
		Specific workstation and	No		8 579,00 €	10	857,90 €
		Maintenance	No	3% of initial cost/year	275,05 €	1	275,05 €
		Electricity	Yes	cost/hour	0,10 €		
		Filler (aluminium)	Yes	€/length	0,09 €		
		Filler (Inox)			0,05 €		
		Gaz	Yes	€/length	14,35 €		

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.

OP		Manufacturing cost					
		Description	Variable	Way of costing	Cost	Depreciation time (year)	Cost/year
Reflow oven		Oven	No		1 995,00 €	5	399,00 €
Power consumption (kW)	**2**						
OPE	**30%**						
Setup time (fixture and tools) (min)	**5**						

Processes cost

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

Manpower	
Operator cost/hour	24,31 €
Technician cost/hou	35,91 €
Welder cost/hour	42,18 €
Engineer cost/hour	54,13 €

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		
Fixed Cost	Sum of fixed cost/year (+5% extra equipment integrated)	128 441.42 €
	Fixed cost/hour to charge on operation (machine/station/programing/metrology)	11.78 €
Manpower cost	Operator cost/hour	12.69 €
	Technician cost/hour	23.63 €
	Welder cost/hour	29.77 €
	Engineer cost/hour	41.46 €

Overhead summary

Manufacturing Summary			
Milling		**Yearly fixed cost of machine**	**17 591,03 €**
For aluminium as standard		**Fixed cost of machine / hour**	**25,49 €**
Price for cutting Steel	**250%**	**Cost of machine/hour running**	**46,90 €**
Price for cutting Delrin	**50%**		
		Cost of machining part (€/mm^3)	9,92E-05
		Manpower part of machining cost	21%
		Cost of programing part Operator (€/mm^3)	2,03E-05
		Cost of programing part Technician(€/mm^3)	2,99E-05
		Cost of programing part Engineer (€/mm^3)	4,51E-05
		Cost of measuring part Operator (€/mm^3)	1,62E-05
		Cost of measuring part Technician(€/mm^3)	2,39E-05
		Cost of measuring part Engineer (€/mm^3)	3,61E-05
		Cost of Setup + cleaning	15,87 €
Turning		**Yearly fixed cost of machine**	**23 026,03 €**
For aluminium as standard		**Fixed cost of machine / hour**	**29,75 €**
Price for cutting Steel	**250%**	**Cost of machine/hour running**	**41,62 €**
Price for cutting Delrin	**50%**		
		Cost of machining part (€/mm^3)	9,04E-05
		Manpower part of machining cost	23%
		Cost of programing part Operator (€/mm^3)	2,03E-05
		Cost of programing part Technician(€/mm^3)	2,99E-05
		Cost of programing part Engineer (€/mm^3)	4,51E-05
		Cost of measuring part Operator (€/mm^3)	1,62E-05
		Cost of measuring part Technician(€/mm^3)	2,39E-05
		Cost of measuring part Engineer (€/mm^3)	3,61E-05
		Cost of Setup + cleaning	14,11 €
Laser cutting		**Yearly fixed cost of machine**	**16 315,56 €**
For steel as standard		**Fixed cost of machine / hour**	**26,32 €**
Price for cutting aluminium	**72%**	**Cost of machine/hour running**	**31,86 €**
		Cost of machining part (€/mm)	2,83E-04
		Manpower part of machining cost	34%
		Cost of programing part Operator (€)	0,61 €
		Cost of programing part Technician(€)	0,90 €
		Cost of measuring part Operator (€)	0,41 €
		Cost of measuring part Technician(€)	0,60 €
		Cost of Setup + cleaning	8,43 €
Welding		**Yearly fixed cost of machine**	2 176,97 €
		Fixed cost of machine / hour	13,42 €
		Cost of machine/hour running	13,52 €
		Cost of aluminium welding part (€/m)	117,39 €
		Cost of steel welding part (€/m)	117,35 €
Conventionnal machining		**Yearly fixed cost of machine**	**4 775,00 €**
		Fixed cost of machine / hour	**18,51 €**
		Cost of machine/hour running	**28,89 €**
		Cost of machining part (€/mm^3)	2,07E-04
		Cost of Setup + cleaning	7,78 €
Reflow oven		**Yearly fixed cost of machine**	**399,00 €**
OPE	**30%**	**Fixed cost of machine / hour**	**12,55 €**
Job duration	**5**	**Cost of machine/hour running**	**12,70 €**
		Cost of setup	**1,05 €**
		Cost of machine/card	2,11 €

Manufacturing summary

Processes cost summary

Type	Description	Time	Unity	By who ?	Price (€/unity)	Quantity (by unity	Price (€)
Assemble by hand	Assembled together with bolts	15sec	nbr of bolts	Operator	0,10 €		- €
Assemble by hand	Assembled together with clamps	30sec	nbr of clamps	Operator	0,20 €		- €
Attach Wire	Attach and tighten 1 tie-wrap	30sec	nbr of tie wrap	Operator	0,20 €		- €
Connector Assembly	Assemble the pins with the connector	15sec	nbr of pins	Operator	0,10 €		- €
Connector Install	Connect the connector	15sec	nbr of connector	Operator	0,10 €		- €
Connector Install	Connect lug	15sec	nbr of connector	Operator	0,10 €		- €
Continuity check				Operator			
Cut (scissors, knife)	Cut wire	15sec	nbr of wire	Operator	0,10 €		- €
Cut (scissors, knife)	Cut heat shrink tube	15sec	nbr of wire	Operator	0,10 €		
Fastener install	Every	15 sec	nbr of fasteners	Operator	0,10 €		- €
Fastener install	Boot clamp, ligarex strap with buckle	30 sec	nbr of ligarex	Operator	0,20 €		- €
Heat	Heat shrink tube	1min	nbr of heat shrink	Operator	0,41 €		- €
Heat	Heat shrink crimp	3min	nbr of heat shrink	Operator	1,22 €		
Install Adhesive Cable Clamp	Place adhesive base for tie-wrap	15sec	nbr of clamp	Operator	0,10 €		- €
Install Tie wrap (zip tie, Cable clamp)		15 sec	nbr of tie wrap	Operator	0,10 €		- €
Liquid Applicator gun	For fuel tank, thermal protection	2 min					0,81 €
PCB Heating	Place the PCB in the Hoven	5min		Operator			
Place component on the card	Place CMS component	30sec	nbr of comp	Operator	0,20 €		- €
Preparing card	Apply the solder paste with the mask	5min		Operator			2,03 €
Press operations	To flatten a tube	1 min	nbr of flat	Operator	0,41 €		- €
Press operations	To mount bearings	5 min	nbr of bearings	Operator	2,03 €		- €
Programming	Time to initialise the boards	5min		Operator			2,03 €
Shrinking	Shrink pin	30sec	nbr of connector	Operator	0,20 €		- €
Shrinking	Shrink lug	15sec	nbr of connector	Operator	0,10 €		- €
Soldering	Manual soldering - tin	1min	nbr of spots	Operator	0,41 €		- €
Stripping	Strip wire	15sec	nbr of connector	Operator	0,10 €		- €
Tape		20min	length (m)	Operator	8,10 €		- €
Threadlock application		30 sec	nbr of application	Operator	0,20 €		- €
Tighten bolts (Ratchet, Wrench, Screwdriver, ...)		30 sec	nbr of bolts	Operator	0,20 €		- €
Untighten bolts (Ratchet, Wrench, Screwdriver, ...)		30 sec	nbr of bolts	Operator	0,20 €		- €
Wire Dressing (install and route)	Average cost for 1m with 10 wires	10min	length (m)	Operator	0,41 €		- €

Assembly cost summary

Type	Description	Unity	By who ?	Nbr of part (machining	Price (€/unity	Quantity (by unity	Price (€)	Material	Multiplicator
Drilled hole	Manually	Number of hole	Operator		0,81 €		- €		
Machining (CNC)	Turning	mm^3	Operator	1	9,04E-05		- €	Aluminiun	1
	Milling	mm^3	Operator	1	9,92E-05		- €	Aluminiun	1
Machining (conventionnal)	Turning	mm^3	Operator		2,07E-04		- €	Aluminiun	1
	Milling	mm^3	Operator		2,07E-04		- €	Aluminiun	1
Machining setup, change	Turning (CNC)		Operator		14,11 €	none (fixed cost)	14,11 €		
	Turning (conventionnal)		Operator		7,78 €	none (fixed cost)	7,78 €		
	Milling (CNC)		Operator		15,87 €	none (fixed cost)	15,87 €		
	Milling (conventionnal)		Operator		7,78 €	none (fixed cost)	7,78 €		
lachining setup, install and remov	Turning (CNC)		Operator		14,11 €	none (fixed cost)	14,11 €		
	Turning (conventionnal)		Operator		7,78 €	none (fixed cost)	7,78 €		
	Milling (CNC)		Operator		15,87 €	none (fixed cost)	15,87 €		
	Milling (conventionnal)		Operator		7,78 €	none (fixed cost)	7,78 €		
Metrology	Turning (CNC) - Operator	mm^3	Operator	1	1,62E-05		- €		
	Turning (CNC) - Technician	mm^3	Technician	1	2,39E-05		- €		
	Turning (CNC) - Engineer	mm^3	Engineer	1	3,61E-05		- €		
	Milling (CNC) - Operator	mm^3	Operator	1	1,62E-05		- €		
	Milling (CNC) - Technician	mm^3	Technician	1	2,39E-05		- €		
	Milling (CNC) - Engineer	mm^3	Engineer	1	3,61E-05		- €		
Programming	Turning (CNC) - Operator	mm^3	Operator	1	2,03E-05		- €		
	Turning (CNC) - Technician	mm^3	Technician	1	2,99E-05		- €		
	Turning (CNC) - Engineer	mm^3	Engineer	1	4,51E-05		- €		
	Milling (CNC) - Operator	mm^3	Operator	1	2,03E-05		- €		
	Milling (CNC) - Technician	mm^3	Technician	1	2,99E-05		- €		
	Milling (CNC) - Engineer	mm^3	Engineer	1	4,51E-05		- €		
Saw or tubing cut	Manually	Number of cut	Operator		2,03 €		- €		
Tapping holes (Manual)	Manually	Number of hole	Operator		0,81 €		- €		

Material removal processes cost summary

Material	Multiplicator
Aluminium	1
Plastic	0,5
Steel	2,5

Multiplicator for machining operation summary

Type	Description	Unity	By who ?	Nbr of part (machinin	Price (€/unity	Quantity (by unity	Price (€)	Material	Multiplicator
Bending	Sheet metal bender	by bending	Operator		2,03 €		- €		
Cut (scissors, knife)		mm	Operator		0,0020 €		- €		
Laser cut		mm	Operator	1	2,83E-04		- €	Steel	1
Laser cut, setup, install and remove		m² of surface	Operator		1,87 €		- €		
Metrology	Laser cut - Operator		Operator		0,41 €	none (fixed cost)	0,41 €		
	Laser cut - Technician		Technician		0,60 €	none (fixed cost)	0,60 €		
Programming	Laser cut - Operator		Operator		0,61 €	none (fixed cost)	0,61 €		
	Laser cut - Technician		Technician		0,90 €	none (fixed cost)	0,90 €		

Sheet materials processes cost summary

Material	Multiplicator
Aluminium	0,72
Steel	1

Multiplicator for laser cut operation summary

Type	Description	Unity	By who ?	Price (€/unity)	Quantity (by unity)	Price (€)
Aerosol apply	Chain oil	Nbr of application	Operator	0,82 €		- €
Grinding		Nbr of grinding	Operator	0,20 €		- €
Painting, aerosol apply	Cleaning + painting	cm²	Operator	0,0204		- €
Surface cleaning, by hand		cm²	Operator	0,003		- €

Surface processes cost summary

Type	Description	Unity	Time	Price (€/unity)	Quantity (by unity)	Price (€)
Preparing	Exhaust tube	By tubes	10 min	7,31 €		- €
	Y of the collector	By y	3 hours	131,66 €		- €
Welding	For aluminium	mm		0,12 €		- €
	For steel	mm		0,12 €		- €

Welding operation cost summary

Fasteners cost summary

Type	Grade	Size	Lenght	Price (TTC, for 100)	Number (to calculate)	Price (HT)
Socket Head Cap Screw	12.9	M6	16	4,31 €		- €
Socket Head Cap Screw	12.9	M6	20	4,46 €		- €
Socket Head Cap Screw	12.9	M6	25	4,60 €		- €
Socket Head Cap Screw	12.9	M6	30	5,16 €		- €
Socket Head Cap Screw	12.9	M6	35	5,41 €		- €
Socket Head Cap Screw	12.9	M6	40	5,79 €		- €
Socket Head Cap Screw	12.9	M6	45	6,58 €		- €
Socket Head Cap Screw	12.9	M6	50	7,35 €		- €
Socket Head Cap Screw	12.9	M6	55	7,76 €		- €
Hexagonal Head	12.9	M6	80	6,54 €		- €
Socket Head Cap Screw	12.9	M8	10	10,54 €		- €
Socket Head Cap Screw	12.9	M8	40	11,17 €		- €
Socket Head Cap Screw	12.9	M8	45	11,79 €		- €
Socket Head Cap Screw	8.8	M12	200	80,00 €		- €
Socket Head Cap Screw	8.8	M12	180	70,00 €		- €
Socket Head Cap Screw	8.8	M10	30	10,65 €		- €
Socket Head Cap Screw	8.8	M10	35	12,50 €		- €
Socket Head Cap Screw	8.8	M6	25	3,71 €		- €
Hexagonal Head	8.8	M4	20	2,06 €		- €
Hexagonal Head	8.8	M5	20	2,41 €		- €
Hexagonal Head	8.8	M8	30	6,21 €		- €
Socket Head Cap Screw	8.8	M6	20	2,65 €		- €
Socket Head Cap Screw	8.8	M6	25	3,00 €		- €
Socket Head Cap Screw	8.8	M6	30	3,20 €		- €
Socket Head Cap Screw	8.8	M6	40	4,66 €		- €
Socket Head Cap Screw	8.8	M6	50	5,07 €		- €
Hexagonal Head	8.8	M6	20	2,25 €		- €
Hexagonal Head	8.8	M6	30	2,45 €		- €
Hexagonal Head	8.8	M6	40	2,82 €		- €
Hexagonal Head	8.8	M6	50	3,01 €		- €
Hexagonal Head	8.8	M6	60	3,21 €		- €
Hexagonal Head	8.8	M8	20	3,50 €		- €
Hexagonal Head	8.8	M8	30	5,08 €		- €
Hexagonal Head	8.8	M8	40	5,40 €		- €
Hexagonal Head	8.8	M8	50	5,55 €		- €
Hexagonal Head	8.8	M8	60	6,10 €		- €
Socket Head Cap Screw	8.8	M8	20	5,07 €		- €
Socket Head Cap Screw	8.8	M8	25	6,55 €		- €
Socket Head Cap Screw	8.8	M8	30	5,42 €		- €
Socket Head Cap Screw	8.8	M8	40	5,75 €		- €
Socket Head Cap Screw	8.8	M8	50	6,02 €		- €
Socket Head Cap Screw	8.8	M8	60	7,05 €		- €

Bolts cost summary (source: TDI)

Type	Grade	Size	Price (TTC, for 1 knut/ 100 nylstop)	Quantity	Price (HT)	Source
Self-locking nut, nylon	8.8	M3	3,67 €		- €	TDI
Self-locking nut, nylon	8.8	M4	3,42 €		- €	TDI
Self-locking nut, nylon	8.8	M6	2,69 €		- €	TDI
Self-locking nut, nylon	8.8	M8	3,70 €		- €	TDI
Self-locking nut, nylon	8.8	M10	6,68 €		- €	TDI
K-nuts, metallic self-locking nut	K-nuts	M6	0,54 €		- €	K-nut
K-nuts, metallic self-locking nut	K-nuts	M8	0,79 €		- €	K-nut
K-nuts, metallic self-locking nut	K-nuts	M10	1,33 €		- €	K-nut
K-nuts, metallic self-locking nut	K-nuts	M12	3,28 €		- €	K-nut

Nuts cost summary

Type	Size (mm)	Price (TTC, for 100)	Quantity	Price (HT)	Source
Copper	8	22,50 €		- €	Oreca
Copper	3/8 inch	22,50 €		- €	Oreca
Copper	10	45,00 €		- €	Oreca
Copper	11.5	45,00 €		- €	Oreca
Copper	12.5	45,00 €		- €	Oreca
Steel, stainless	M3	2,56 €		- €	TDI
Steel, stainless	M4	2,96 €		- €	TDI
Steel, stainless	M6	4,45 €		- €	TDI
Steel, stainless	M8	5,65 €		- €	TDI
Steel, stainless	M10	8,90 €		- €	TDI

Washers cost summary

Type	Size (mm)	Price (TTC, for 1)	Quantity	Price (HT)	Source
Adapter, L.P., Female Flare, Aluminum	Dash 6	13,40 €		- €	Oreca
Adapter, L.P., Male Flare, Aluminum	Dash 6	5,30 €		- €	Oreca
Adapter, L.P., union Tee, Male flare, Aluminium	Dash 6	15,23 €		- €	Oreca
Adapter, L.P., union Reducer, Female flare, Aluminium	Dash 6	3,50 €		- €	Oreca
Banjo fitting, straight, Aluminium	12mm, dash6	31,03 €		- €	Oreca
Fitting, L.P., 45°, aluminium	Dash 6	23,20 €		- €	Oreca
Fitting, L.P., 90°, aluminium	Dash 6	22,40 €		- €	Oreca
Fitting, L.P., straight, aluminium	Dash 6	9,44 €		- €	Oreca
Fitting, weld-in, male, aluminium	Dash 6	4,06 €		- €	Oreca
Fitting, L.P, female plug, aluminium	Dash 3	2,48 €		- €	Oreca
Fitting, L.P, female plug, aluminium	Dash 6	3,16 €		- €	Oreca
Fuel check valve, in-line, aluminium	Dash 6	40,00 €		- €	Oreca

Plumbing fasteners cost summary

Type	Size	Unit	Price (TTC, by unit)	Quantity (to complete)	Price (HT)	Source
Boot clamp, ligarex strap with buckle	Medium (33cm)	for 1	0,90 €		- €	
Boot clamp, ligarex strap with buckle	Large (72 cm)	for 1	0,90 €		- €	
Hose clamps	5 - 10 mm (diameter)	for 1	0,50 €		- €	TDI
Hose clamps	12-18 mm (diameter)	for 1	0,56 €		- €	TDI
Hose clamps	25-32 mm (diameter)	for 1	0,63 €		- €	TDI
Hook and Loop, Hook & Loop Side (Velcro)	None	m	13,90 €		- €	Reverchon
Lock wire	0,62 mm	m	0,36 €		- €	
Mount, vibration damping, Sandwich	M6	for 1	3,50 €		- €	Solutions Elastomères
Quick link chain		for 1	5,23 €		- €	
Retaining ring, external, 30 mm	13 mm	for 100	2,20 €		- €	TDI
Retaining ring, external, 30 mm	30 mm	for 100	9,00 €		- €	TDI
Retaining ring, external, 30 mm	47 mm	for 100	17,50 €		- €	TDI
Spring, exhaust system	All	for 1	2,00 €		- €	echapmoto
Spring, intake system	All	for 1	1,50 €		- €	
Steel Loop Straps, Rubber-Cushioned	20 mm	for 1	2,08 €		- €	TDI
Tie wrap	Small	for 100	2,02 €		- €	Forch
Tie wrap	Medium	for 100	6,13 €		- €	Forch
Tie wrap	Large	for 100	20,04 €		- €	Forch
Tie straps, blower		for 1	2,35 €		- €	Reverchon

Miscellaneous fasteners cost summary

Materials cost summary

Material	Price (HT, €/mm^3)	Length (mm)	Width (mm)	Thickness (mm)	Price (€, HT)
Aluminium, 2017A	1,75E-05				- €
Aluminium, 7075 T6	2,24E-05				- €
Plastic, Delrin	1,65E-05				- €
Steel, 25CD4	1,49E-05				- €

Raw materials cost summary

Material	Thickness (mm)	Price (HT, €/m^2)	Surface (m^2)	Price (€, HT)
Aluminium, 2017A	1,5	72,90 €		- €
Aluminium, 2017A	2	97,20 €		- €
Aluminium, 2017A	2,5	121,50 €		- €
Steel, S235	1,5	12,8205		- €
Steel, S355	3	58,275		- €
Steel, S700	4	77,7		- €

Sheet materials cost summary

Type	Size	Price (HT, by m)	Quantity (m)	Price (€, HT)
Tubing, Aluminum, 2017A	Φ 6 * 5 mm	1,85 €		- €
Tubing, Aluminum, 2017A	Φ 10 * 9 mm	3,19 €		- €
Tubing, Aluminum, 2017A	Φ 12 * 11 mm	3,86 €		- €
Tubing, Aluminum, 2017A	Φ 38 * 35 mm	26,25 €		- €

Tubing materials cost summary