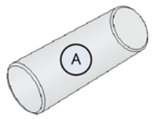
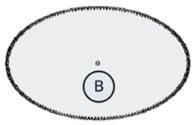
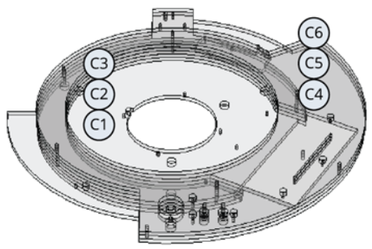
Please Note: The complicated tasks involved in creating this report were made exponentially more complex by having chosen to create a complicated product. A design exercise in itself; systems have been developed and implemented to simplify each task, while still meeting the requirements of the brief. A general balance has also been achieved between 'how it was done' (for producing the single turntable prototype) and 'how it could be done' (for the low volume production of 100 turntables).

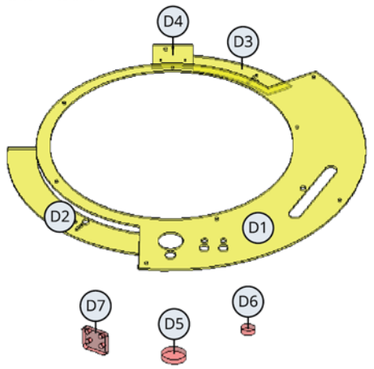
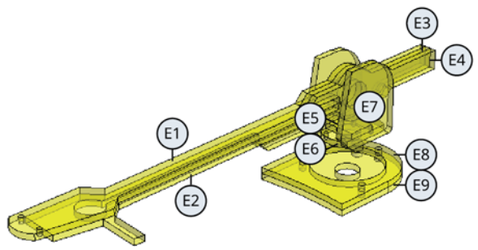
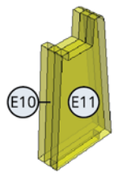
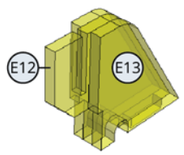
Product Design Studio 4 - Luke Frahn

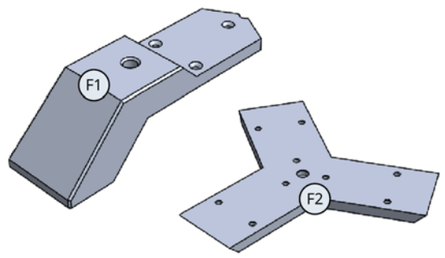
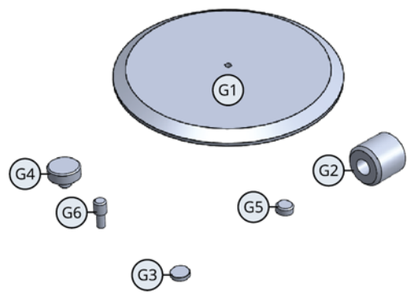
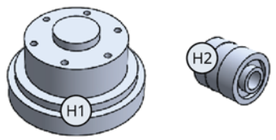
PROJECT 3 - MANUFACTURING REPORT

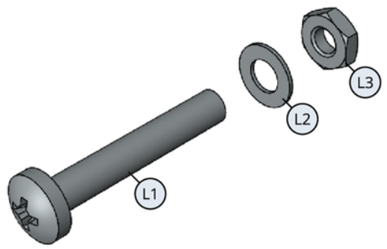
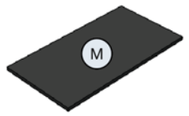
(10th November 2016)

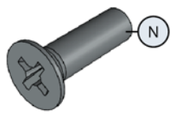
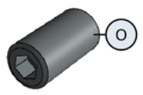
BILL OF MATERIALS
(Material and Manufacturing Costs)

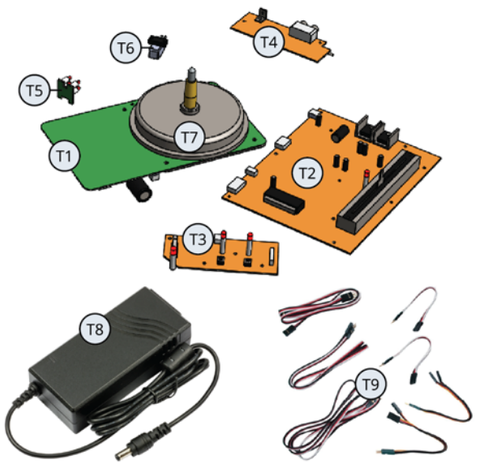
Item Type & Reference Images	Qty.	Ref.	Includes Parts	Material Costs	Manufacturing Costs	Cost /Unit
Acrylic Rod 12.5mm 	**3**	A	Dowel	120x12.5mm Clear Acrylic Rod = **$3** (City Plastics)	Labour - Hand Cutting & Sanding 10min @ $60per/hr = **$10**	**$13.00**
Acrylic Sheet 3mm Clear Laser Cut 	**1**	B	Mat	300x300x3mm Clear Cast Acrylic Sheet = **$4** (City Plastics)	Laser Cutting = **$5** (AAD Workshop)	**$9.00**
Acrylic Sheet 6mm Clear Laser Cut 	1 1 1 1 1 1 **6**	C1 C2 C3 C4 C5 C6	Plinth 6mm Sheet 1 Plinth 6mm Sheet 2 Plinth 6mm Sheet 3 Plinth 6mm Sheet 4 Plinth 6mm Sheet 5 Plinth 6mm Sheet 6	2/1200x600x6mm Clear Cast Acrylic Sheet = **$126** (City Plastics)	Laser Cutting = **$10** (AAD Workshop)	**$136.00**

Item Type & Reference Images	Qty.	Ref.	Includes Parts	Material Costs	Manufacturing Costs	Cost /Unit
Acrylic Sheet 3mm Translucent Colour Laser Cut 	1 1 1 1 1 3 1 **9**	D1 D2 D3 D4 D5 D6 D7	Plinth 3mm Sheet 1 Plinth 3mm Sheet 2 Plinth 3mm Sheet 3 Plinth 3mm Sheet 4 Lens Large Lens Small Lens Strobe	600x300x3mm Translucent Yellow Cast Acrylic Sheet = **$14** (City Plastics) 100x100x3mm Translucent Red Cast Acrylic Sheet = **$2** (City Plastics)	Laser Cutting = **$10** (AAD Workshop)	**$26.00**
Acrylic Sheet 3mm Translucent Colour Laser Cut and Solvent Welded   	1 1 1 1 1 1 2 1 1 2 1 1 2 **17**	E1 E2 E3 E4 E5 E6 E7 E8 E9 E10 E11 E12 E13	Tone Arm Boom Horizontal Upper Tone Arm Boom Horizontal Lower Tone Arm Boom Vertical Inner Tone Arm Boom Vertical Outer Tone Arm Pivot Upper Tone Arm Pivot Lower Tone Arm Pivot Side Tone Arm Base Upper Tone Arm Base Lower Arm Rest Inner Arm Rest Outer Strobe Stand Inner Strobe Stand Outer	600x300x3mm Translucent Yellow Cast Acrylic Sheet = **$14** (City Plastics) 5ml of liquid acrylic welding solvent = **$0.40** (City Plastics)	Laser Cutting = **$20** (AAD Workshop) Labour - Solvent Welding 1hr @ $60 per/hr = **$60**	**$94.40**

Item Type & Reference Images	Qty.	Ref.	Includes Parts	Material Costs	Manufacturing Costs	Cost /Unit
Aluminium Sand Cast and Bead Blast Finished 	1 3 **4**	F1 F2	Base Connector Base Leg	Tooling - Pattern Materials (1 set used 10 times)** 1200x600x12mm MDF = $14.80/10 = **$1.50** 1200x600x16mm MDF = $17.30/10 = **$1.70** 100ml PVA Glue = **$1** (Bunnings)	Tooling - Pattern Creation (1 set used 10 times)** Labour - General Workshop 6hrs @ $60per/hr /10 = **$36** Aluminium Sand Casting (ABC) Part Surcharge = 4 x $20 = **$80** Volume = 2L x $80 per/l = **$160** Labour - Drilling and Tapping Holes and Tidying Surfaces. 2hrs @ $60per/hr = **$120** Glass Bead Blasting = **$50** (GBT)	**$450.20**
Aluminium Sand Cast, Machined and Bead Blast Finished* 	1 1 1 1 1 2 **7**	G1 G2 G3 G4 G5 G6	Platter Counterweight Large Counterweight Small Button Large Button Medium Button Small	Tooling - Pattern Materials (1 set used 10 times)** 1200x600x16mm MDF = $17.30/10 = **$1.70** (Bunnings)	Tooling - Pattern Creation (1 set used 10 times)** Labour - General Workshop 8hrs @ $50per/hr /10 = **$40** Aluminium Sand Casting (ABC) Part Surcharge = 7 x $20 = **$140** Volume = 0.5L x $80per/l = **$40** Machining - 10hrs @ $150per/hr = **$1500** (Drives & Accessories) Glass Bead Blasting = **$50** (GBT)	**$1771.70**
Bearings 	1 1 **2**	H1 H2	Bearing Large Bearing Small	*Assumed to be a similar cost to salvaged fluid bearings from a second hand computer hard drive* = **$5****		**$5.00**
Cable Ties 	**8**	I	(Cable Tie 100x2.5mm)	8 x $0.02 = **$0.16** (per unit price at Bunnings)		**$0.16**
Contact Adhesive 		J	(Contact Adhesive)	10ml Contact Adhesive = **$0.25** (Bunnings)		**$0.25**

Item Type & Reference Images	Qty.	Ref.	Includes Parts	Material Costs	Manufacturing Costs	Cost /Unit
Epoxy Glue 		K	(Epoxy Glue)	1ml Epoxy Glue = **$0.35** (Bunnings)		**$0.35**
Fastener Small, Zinc Plated Steel 	6 5 3 10 4 3 1 4 34 26 17 13 **126**	L1 L1 L1 L1 L1 L1 L1 L1 L2 L2 L3 L3	Screw Metric Cross Pan Head M2 X 5 Screw Metric Cross Pan Head M3 X 12 Screw Metric Cross Pan Head M3 X 16 Screw Metric Cross Pan Head M3 X 25 Screw Metric Cross Pan Head M4 X 16 Screw Metric Cross Pan Head M4 X 25 Screw Metric Cross Pan Head M4 X 35 Screw Metric Cross Pan Head M4 X 45 Washer Metric Small M3 Washer Metric Small M4 Nut Metric Hex Thin M3 Nut Metric Hex Thin M4	126 x $0.15 = **$18.90** (average per unit price at Bunnings)		**$18.90**
Pad, Rubber 	**3**	M	Rubber Pad	100x75x1.5mm Strip Neoprene = **$0.80** (Clark Rubber)	Labour - Hand Cutting 10min @ $60per/hr = **$10**	**$10.80**

Item Type & Reference Images	Qty.	Ref.	Includes Parts	Material Costs	Manufacturing Costs	Cost /Unit
Screw, Zinc Plated Steel 	**9**	N	Screw Metric Cross Countersunk Head M6 X 20	9 x $0.30 = **$2.70** (per unit price at Bunnings)		**$2.70**
Set Screw 	**1**	O	Set Screw Socket Flat Point M5 X 10	**$0.30** (per unit price at Bunnings)		**$0.30**
Spacer 	1 1 **2**	P1 P2	Spacer M3X8 Spacer M3X14	6 x $0.40 = **$2.40** (estimated per unit price at Bunnings)		**$2.40**
Spring 	**1**	Q	Spring	**$2.50** (estimated per unit price at Bunnings)		**$2.50**
Ring, Rubber 	2 1 **3**	R1 R2	Ring 8mm Ring 12mm	3 x $0.70 = **$2.10** (estimated per unit price at Bunnings)		**$2.10**
Tape 		S	(Double Sided Tape)	500x3mm Double Sided Tape = **$0.22** (online purchase)		**$0.22**

Item Type & Reference Images	Qty.	Ref.	Includes Parts	Material Costs	Manufacturing Costs	Cost /Unit
Technical Package 		T1	PCB Motor	*Assumed to be 1/4th the value of the $400RRP turntable used for parts in this project* = **$100*****		**$100.00**
		T2	PCB Pitch			
		T3	PCB Control			
		T4	PCB Tone Arm			
		T5	PCB Strobe			
		T6	Cartridge			
		T7	(Motor)			
		T8	(Transformer)			
		T9	(Cables)			

Total Material & Manufacturing Cost Per Unit:	2645.98
Total Material & Manufacturing Cost Per 100 Units:	**26459.80**

End Notes

***** - For the original prototype, Aluminium parts were machined from extruded stock and billet material. For low volume manufacture, these are to be sand cast over-sized and then machined. This is a far more efficient and less wasteful process for the platter in particular.

****** - As per the original prototype, multiple patterns of identical parts allows the metal casting business to work more efficiently. The resulting benefits are a quicker turnaround time and a lower negotiated cost.

******* - Specialist and product specific technical components were difficult to cost. The amounts paid for salvaged and second hand parts used in the prototype, were therefore used to provide a realistic estimate.

ASSEMBLY SEQUENCE (Assembly Labour Cost)

STAGE A
Assemble the 'Body' parts

Step 1 Line up all six 'Plinth 6mm Sheets' together with 'Plinth 3mm Sheet 1' on the top.

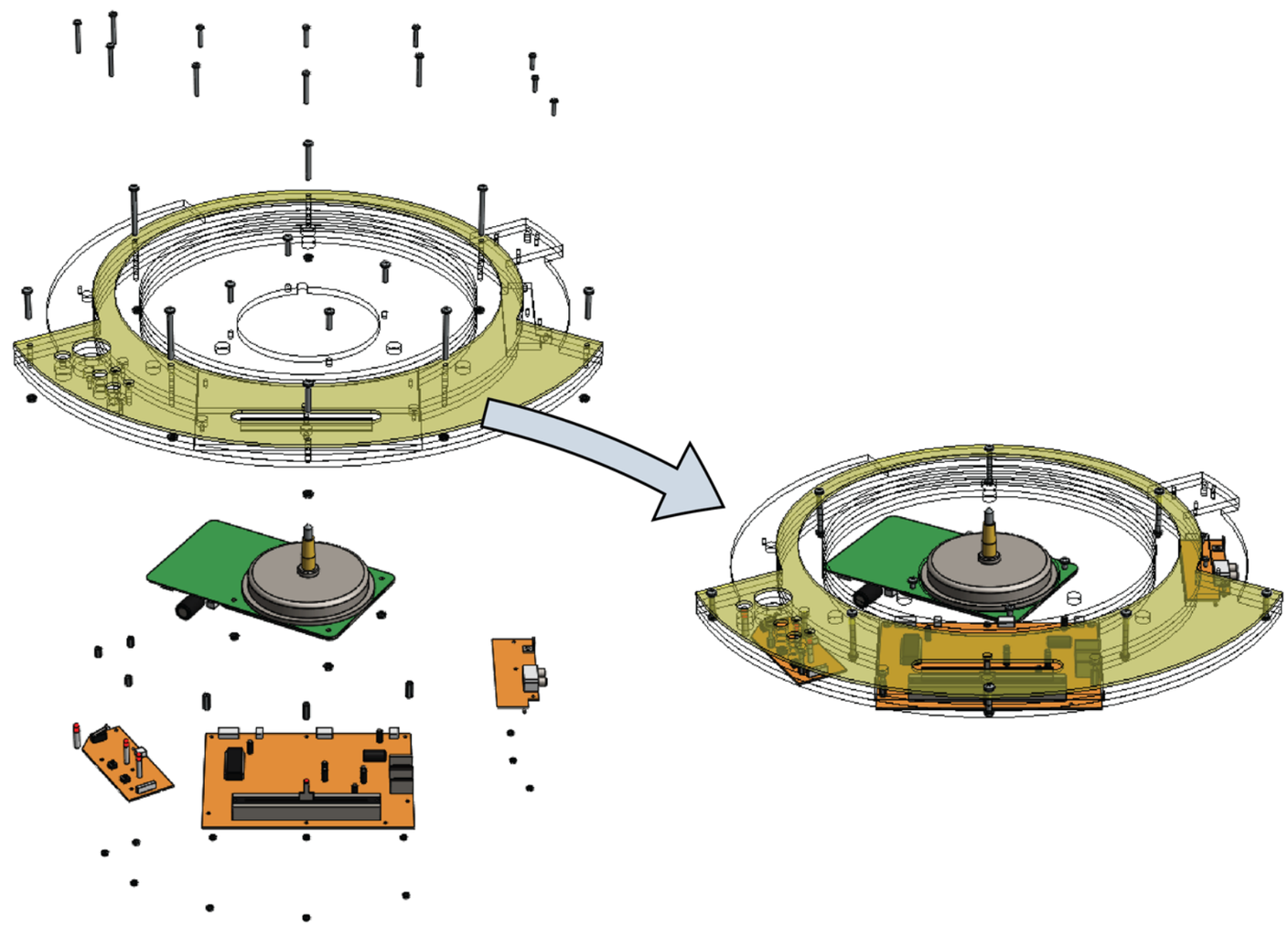
Step 2 Loosely fasten these seven sheets together using eight sets of M4 fasteners.

Step 3 Install the 'Motor PCB' to 'Plinth 6mm Sheet 1' using four sets of M4 fasteners.

Step 4 Install the 'Tone Arm PCB' to 'Plinth 6mm Sheet 2' using three sets of M3 fasteners.

Step 5 Install the 'Control' and 'Pitch' PCBs using nine sets of M3 fasteners and six 'Spacers'.

Step 6 Tighten the M4 fasteners connecting the 'Plinth Sheets'.



STAGE A (continued)
Assemble the 'Body' parts

Step 7 Attach the remaining 'Plinth 3mm Sheets' using double sided adhesive tape on the edges.

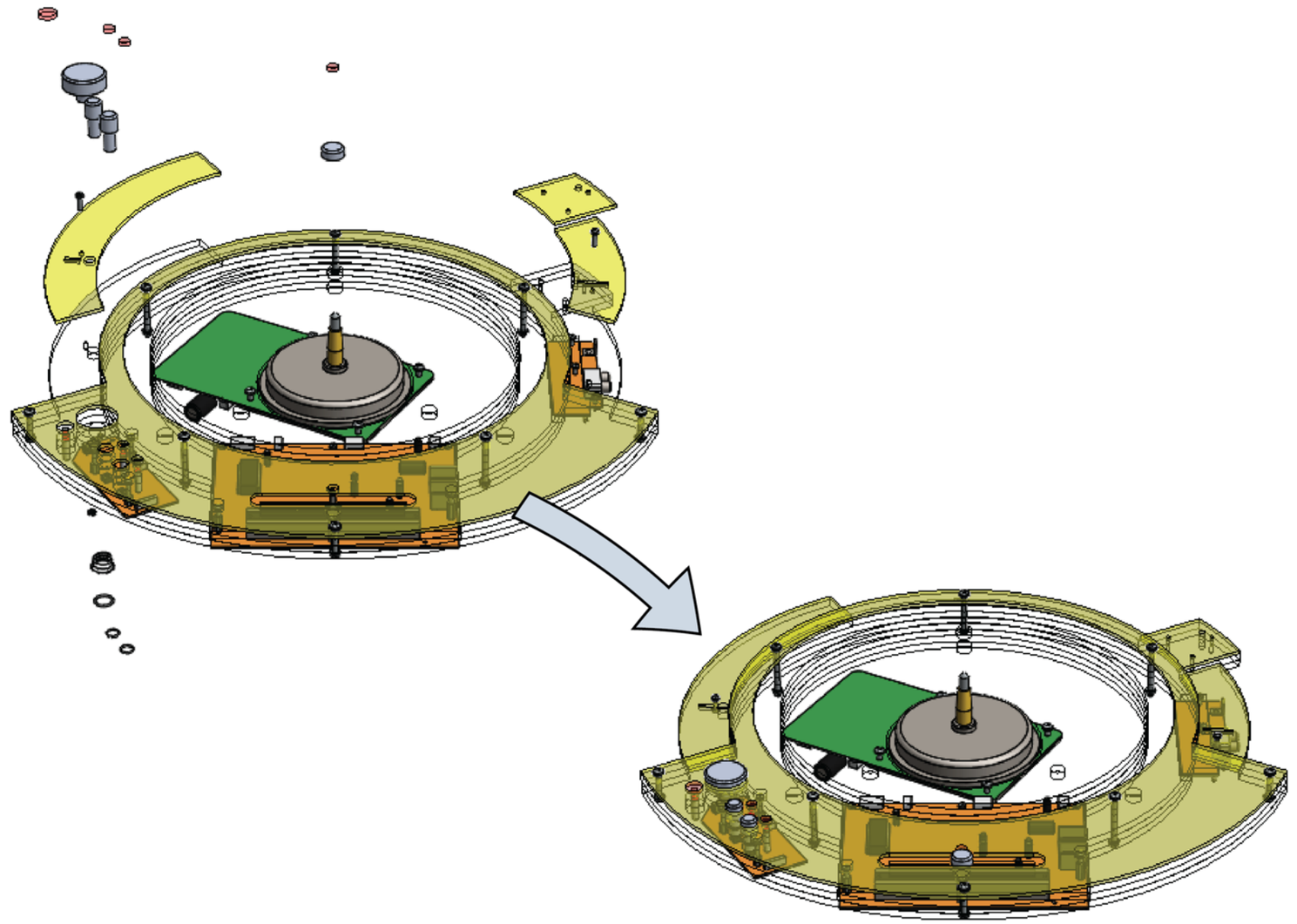
Step 8 Fasten 'Plinth 3mm Sheets' 2 and 3 to 'Plinth 6mm Sheet 4' using sets of M3 fasteners.

Step 9 Place the four 'Buttons' in their respective positions above the 'Control' and 'Pitch' PCBs.

Step 10 Insert the 'Spring' underneath the 'Large' button.

Step 11 Add 'Rings' to secure the three 'Control Buttons'.

Step 12 Install the four 'Lenses' into the top sheet using double sided tape.



Estimated Time = 2 Hours

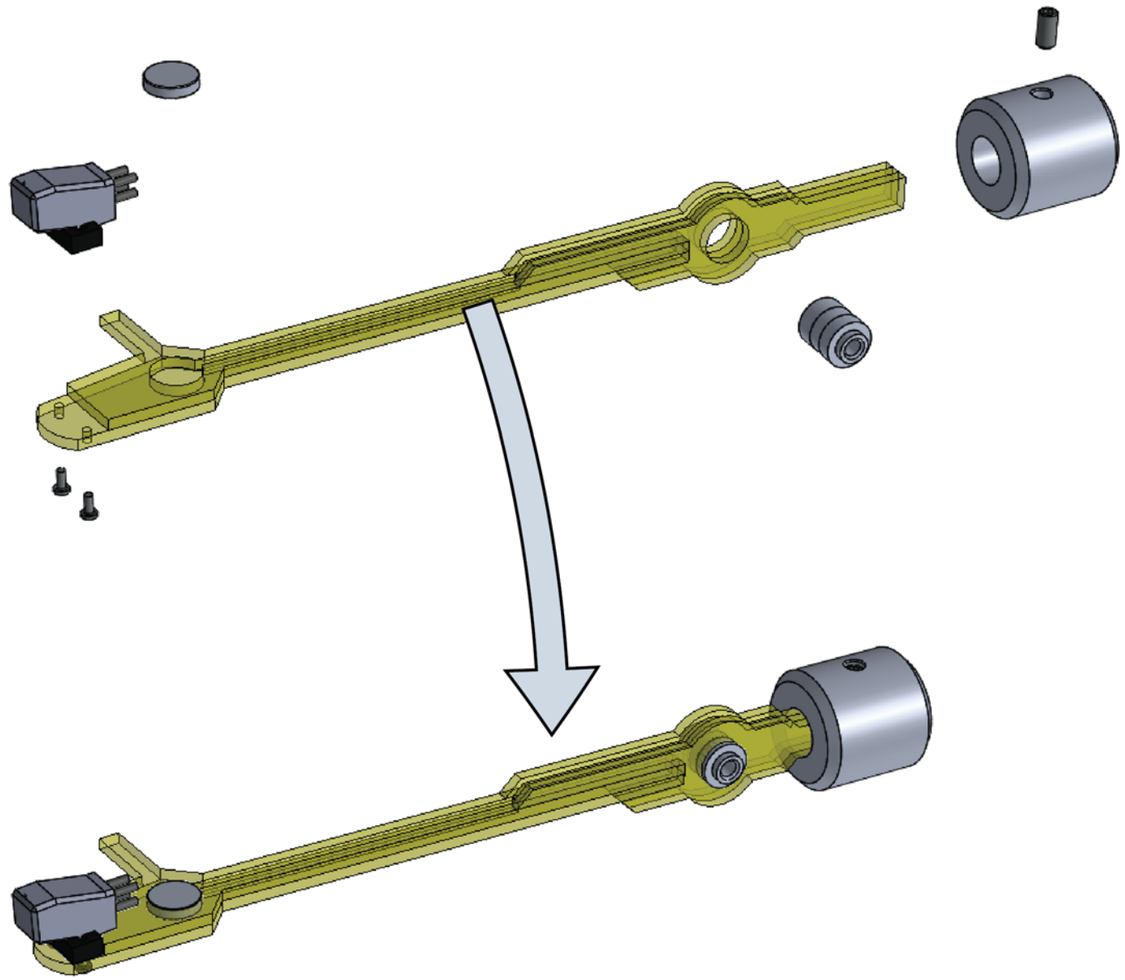
STAGE B
Assemble the ‘Tone Arm’

Step 1 Attach the 'Cartridge' to the end of the 'Boom' using M2 bolts.

Step 2 Install the 'Small Counterweight' into the 'Boom' using double sided tape.

Step 3 Press Fit the 'Small Bearing' into the hole in the 'Boom'.

Step 4 Attach the 'Counterweight' to the 'Boom' using the 'Set Screw'.

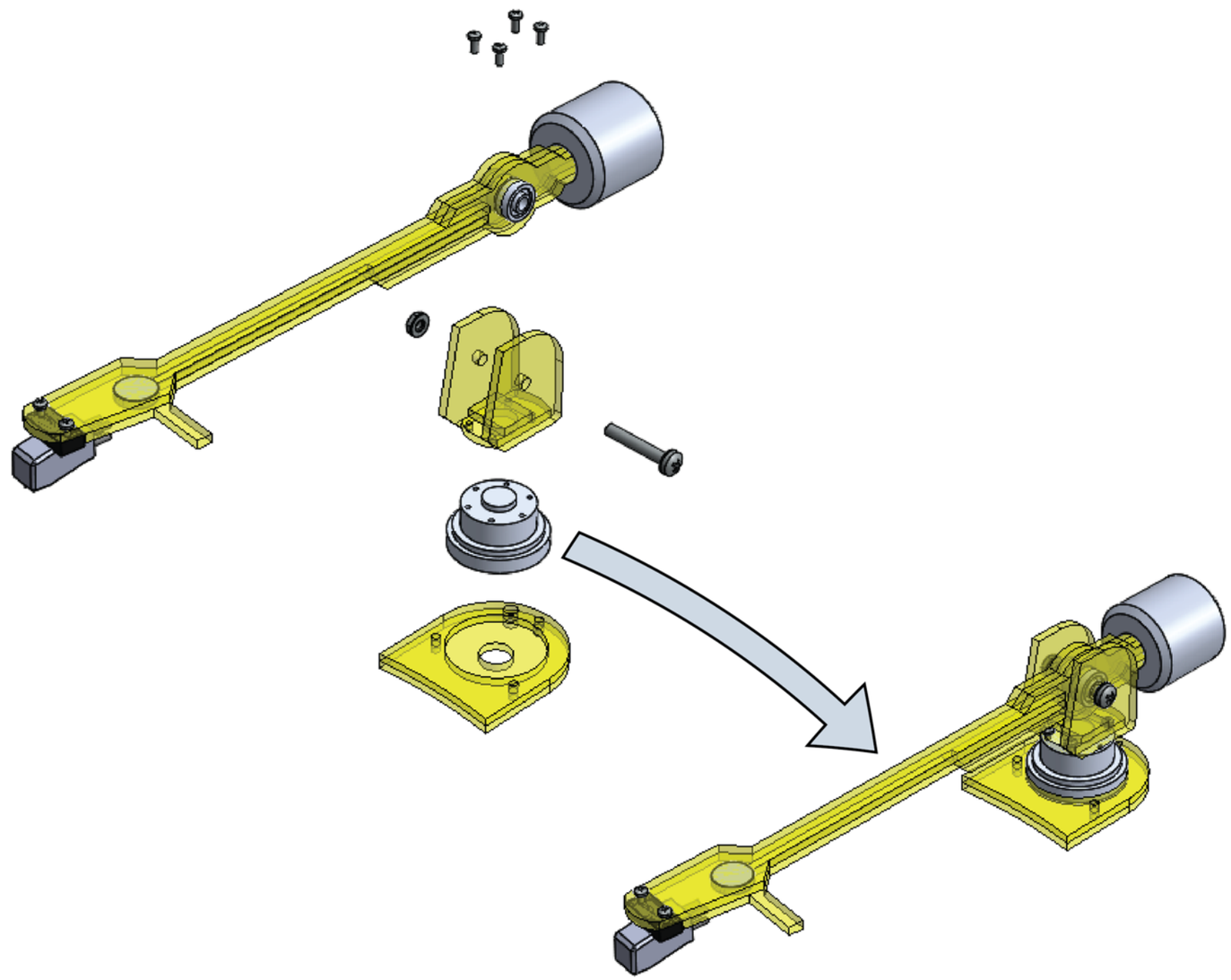


STAGE B (continued)
Assemble the 'Tone Arm'

Step 5 Slide the bearing end of the 'Boom' into the 'Pivot' and secure with M4 fasteners.

Step 6 Attach 'Boom' and 'Pivot' to the 'Large Bearing' using M2 bolts.

Step 7 Press fit and epoxy glue the 'Large Bearing' shaft into the inner hole in the 'Base'.

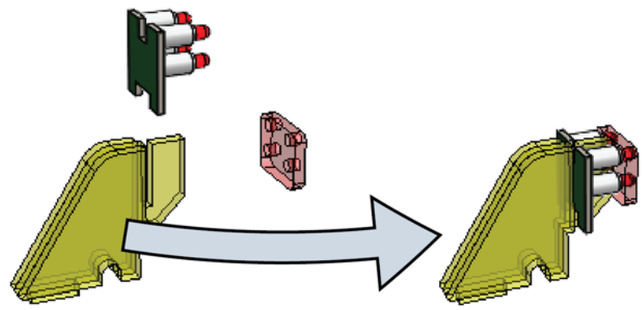


Estimated Time = 0.75 Hours

STAGE C
Assemble the ‘Strobe Light’

Step 1 Insert the 'PCB' into the 'Stand'.

Step 2 Attach the 'Lens' to 'PCB'.

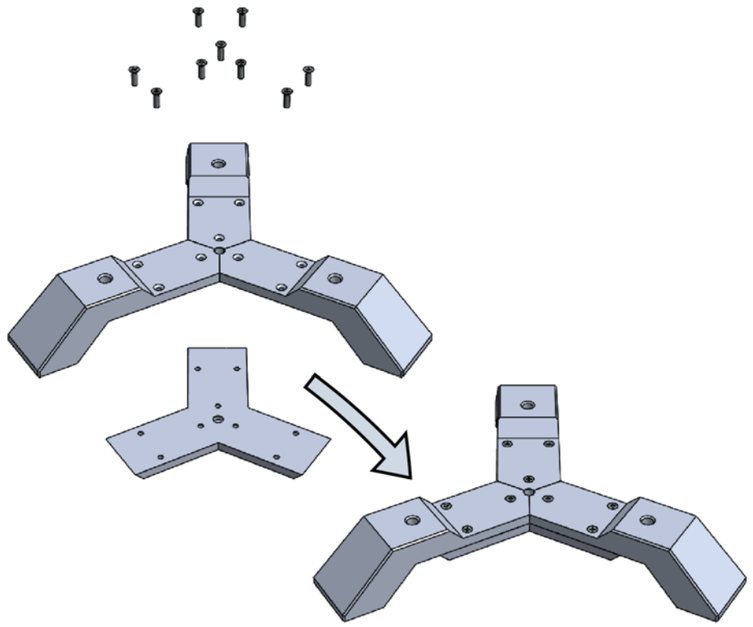


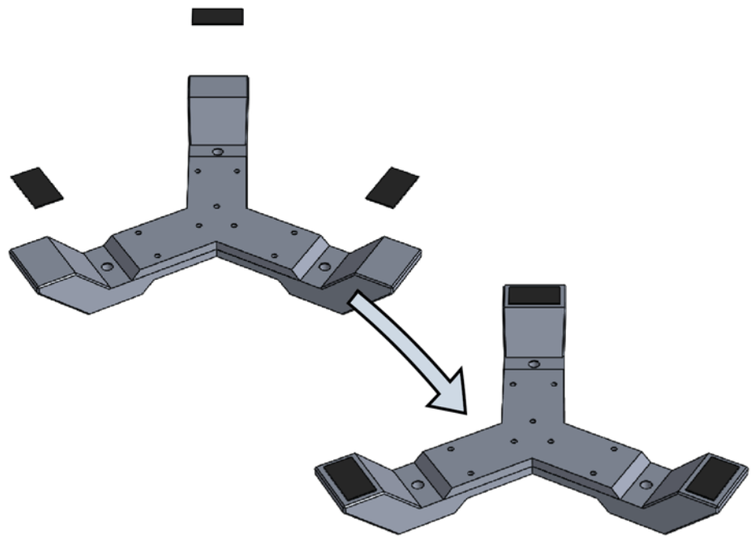
Estimated Time = 5 Minutes

STAGE D
Assemble the ‘Base’ parts

Step 1 Connect the three 'Legs' to the 'Connector' using nine M6 bolts.

Step 2 Adhere the three 'Pads' to the 'Leg' feet using contact adhesive.





Estimated Time = 0.75 Hours

STAGE E

Assemble the main components

Stage 1 Press fit the three 'Dowels' into the blind holes in the bottom of the 'Base'.

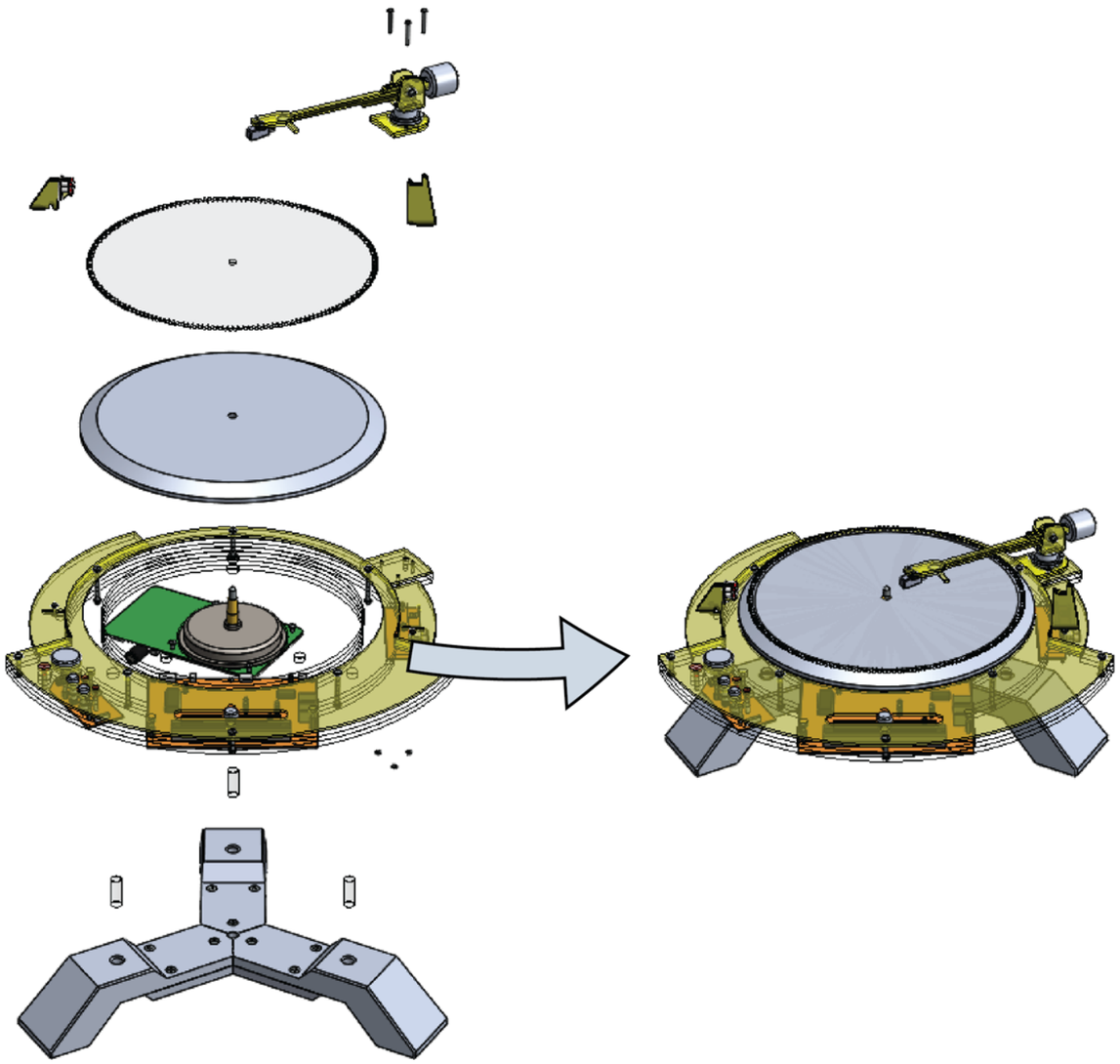
Stage 2 Connect the 'Body' to the 'Base' using the 'Dowels' to locate them.

Stage 3 Install the 'Strobe Light' and 'Arm Rest' into the slots at the top of the 'Base' using double sided tape.

Stage 4 Attach the 'Tone Arm' to the 'Body' using M3 fasteners.

Stage 5 Connect the cables and wiring between the technical components.

Stage 6 Place the 'Platter' on the 'Motor' shaft. Place the 'Mat' on the 'Platter'.



Estimated Time = 1 Hour

End Note: The process described is for one person assembling one unit. The overall cost could be significantly reduced by utilising additional people and/or assembling multiple units simultaneously.

Total Estimated Time:	**4.6 Hours**
Cost @ $60per/hr:	**$276.00**

ECO-FOOTPRINT ASSESSMENT (Human and Environmental Cost)

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Add a Part + | Add Sub-Assembly + | Import BOM +

Name	Material/Process	Qty	Amt	Unit	mPts	CO_2 eq. kg	MS	Part ID	
Aluminium Part Cas		7	200	g	3.35	39.1	E		Process +
Averaged across product.									
Material	Aluminum, cast, precision sa		200	g	0.150	3.47	E		
Process	Turning, aluminum		200	g	0.329	2.11	E		
Welding Solvent	Dichloromethane	1	5	g	0.00120	0.0170	E		No Processes available
For welding acrylic parts.									
MDF	Medium density fibreboard	1	2400	g	0.175	2.60	E		No Processes available
Material for pattern creation. 1/10 of one set.									
Aluminium Part Cas	Aluminum, cast, precision sa	4	1350	g	4.04	93.7	E		Process +
Averaged across product.									
Acrylic Part	Methyl methacrylate	36	330	g	4.21	79.1	E		No Processes available
Averaged across product. Includes waste.									
Fastener	Steel, low-alloyed, market av	142	2	g	0.315	0.493	E		Process +
Averaged between different fastener types.									
Rubber Part	Synthetic rubber, at plant	5	10	g	0.00138	0.00773	E		Process +
Averaged between different parts.									
Technical Package		1			9.05	89.7	E		Part + S.-Asmbly. +
Estimated components and materials.									
Part	Light emitting diode, LED	8	0.5	g	0.0676	1.25	E		No Processes available
Part	Resistor, metal film type, thro	34	0.5	g	0.0858	0.750	E		No Processes available
Part	Transformer, low voltage us	1	750	g	0.414	3.37	E		No Processes available
Part	Transistor, wired, small size	6	1	g	0.0825	1.21	E		No Processes available
Part	Printed wiring board, througl	5	40	g	1.42	15.6	E		No Processes available
Part	Inductor, ring core choke typ	14	1	g	0.0724	0.798	E		No Processes available
Part	Integrated circuit, IC, logic ty	8	3	g	2.69	30.6	E		No Processes available
Part	HDD, desktop computer	1	1000	g	3.17	26.3	E		No Processes available
Part	Cable, ribbon cable, 20-pin, '	8	5	g	0.195	0.475	E		No Processes available
Part	Capacitor, electrolyte type, <	36	2	g	0.497	4.67	E		No Processes available
Part	Diode, glass-, through-hole r	12	1	g	0.203	3.75	E		No Processes available
Part	Electronic component, passi	8	2	g	0.149	1.04	E		No Processes available
	Manufacturing total				**21.1**	**305**	**E**		

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Name	Consumables/water/power	Amt	Unit	mPts	CO_2 eq. kg	MS	
Water use				0	0		Add Water Use +
No water use has been added to this SBOM.							
Power use				$3.02x10^{-4}$	0.00540	E	Add Power Use +
Power	Electricity, 240V, Germany	0.0075	kWh	$3.02x10^{-4}$	0.00540	E	
Consumables				0	0		Add Consumables +
No consumables have been added to this SBOM.							
Use total				**$3.02x10^{-4}$**	**0.00540**	**E**	

The Eco-Footprint Assessment of the turntable was conducted using the cloud based 'Life Cycle Assessment' platform, Sustainable Minds. The limitations of this software was apparent in the small range of choices available across all stages of analysis.

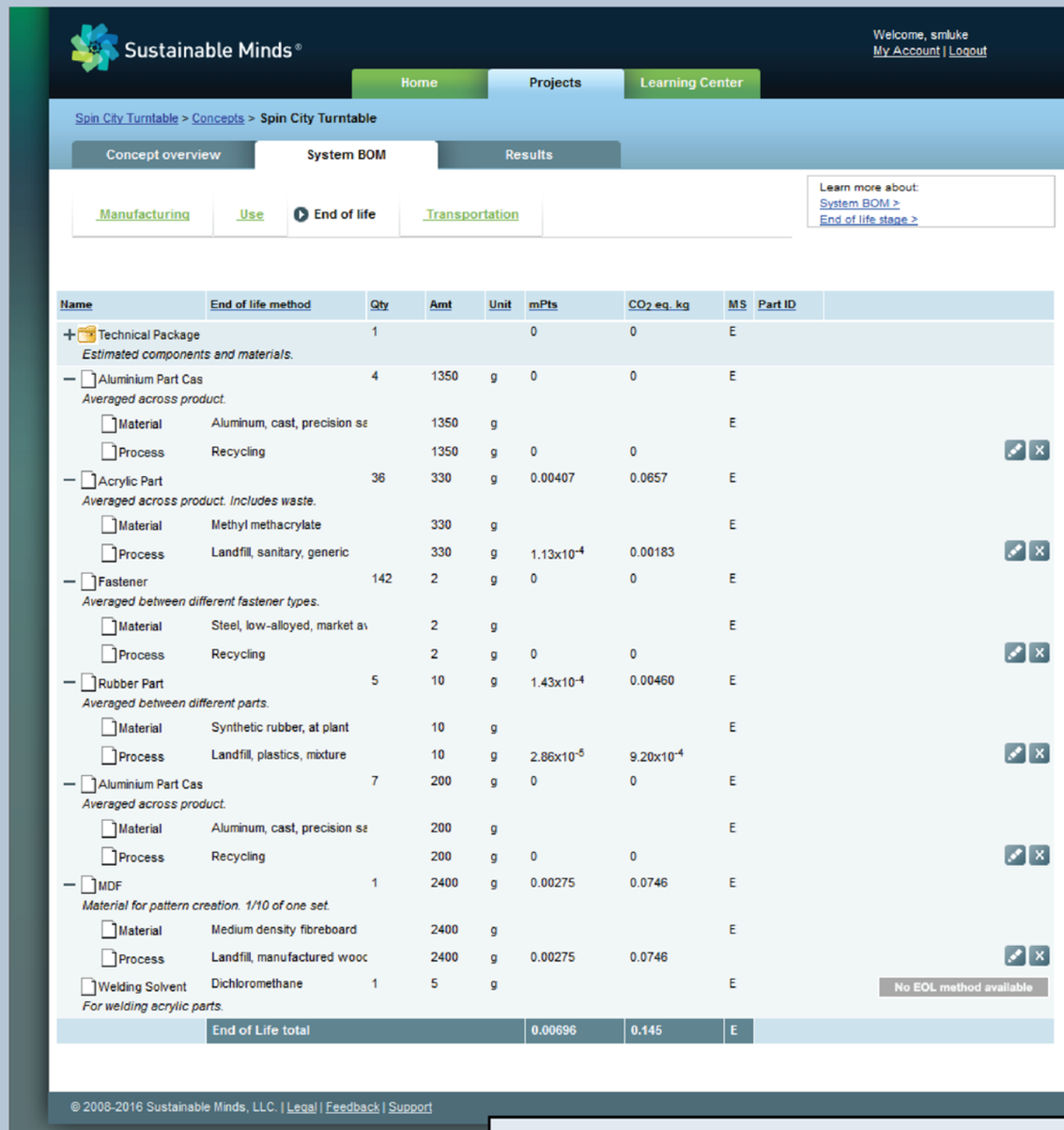
MANUFACTURING

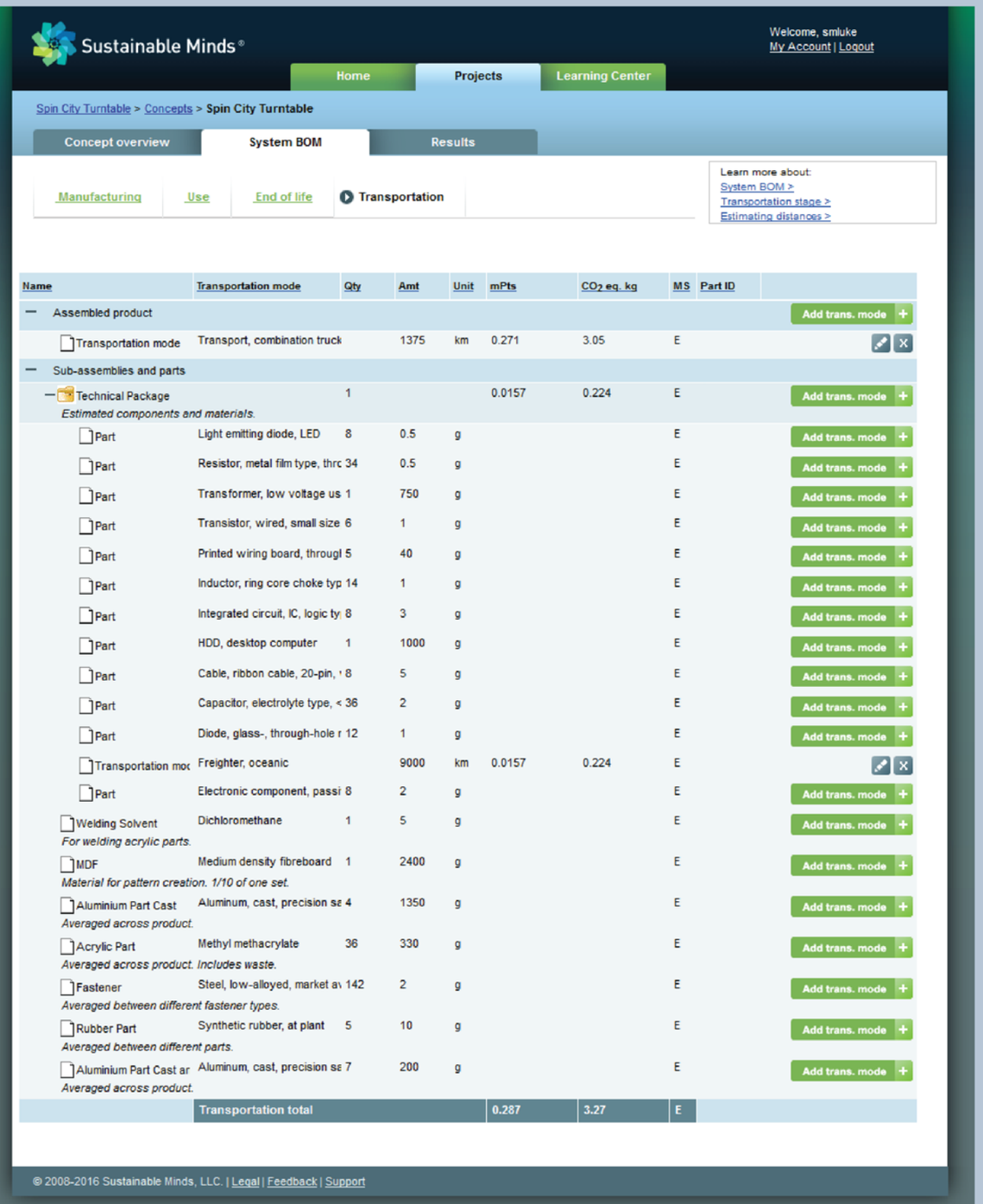
The assessor was particularly interested in comparing the carbon emissions from the materials and manufacture of three categories of parts. As such, the 'manufacturing BOM' covers the aluminium, the acrylic and the technical package, materials and associated processes.

Notes:
- Parts were quantified and assigned an average weight across the entire product.
- Aluminium casting and machining were found in the system, but laser cutting was not.
- The acrylic welding solvent was included. Other chemical adhesives were omitted.
- All small steel parts are included as fasteners. The few rubber parts were added separately.
- The technical package included a computer hard drive to represent both the motor components and tone arm bearings.

USE

Note: The product consumes 7.5W of power.





END OF LIFE

Notes:
- The aluminium and steel parts were deemed easily recyclable.
- It was understood that the technical package would be salvaged.
- All other parts and materials were designated as landfill.

TRANSPORTATION

Notes:
- The technical package is to be freight shipped from China to Sydney.
- The final product is to be trucked from Sydney to Adelaide.

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Spin City Turntable > Concepts > Spin City Turntable

Concept overview | System BOM | Results

Results views

- Scorecard
- Impacts by SBOM inputs
  - Total
  - Carbon footprint
- Impacts by life cycle stage
  - Total
  - Carbon footprint
- Download SBOM

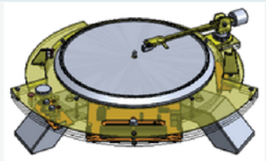
Methodology
SM 2013

Learn more:
Printing & exporting results

Scorecard

Printable view

	Reference
	Spin City Turntable



The first concept created in a project is, by default, the **reference concept**. The reference is the baseline that other concepts in this project will be compared to.

Impacts per functional unit	**51** mPts per 1 year of use
Total amount of service delivered	**0.42 x 1 year of use**
Impacts of total service delivered	21 mPts
Assessment level	Estimate

Greatest impacts

SBOM input	Methyl methacrylate
Impact category	Carcinogenics
Life cycle stage	Manufacturing

Total impacts by impact category

Impact category	%
Ecological damage	
Acidification	3.67
Ecotoxicity	6.85
Eutrophication	2.09
Global warming	20.73
Ozone depletion	0.01
Resource depletion	
Fossil fuel depletion	12.2
Human health damage	
Carcinogenics	39.79
Non carcinogenics	8.82
Respiratory effects	2.78
Smog	3.06

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Impacts by SBOM inputs: Carbon footprint [CO_2 eq. kg/func unit]

Printable view

Display inputs as Materials/Process

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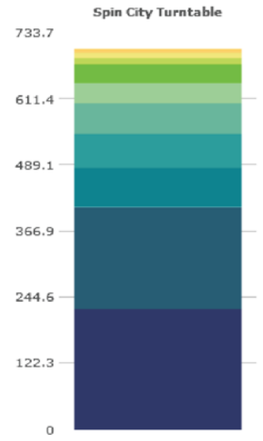

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Total = 730 CO_2 eq. kg/func unit

Input	CO_2 eq. kg/func unit
Material - Aluminum, cast, precision sand casting/kg	223
Material - Methyl methacrylate	188
Material - Integrated circuit, IC, logic type	72.8
Material - HDD, desktop computer	62.5
Material - Aluminum, cast, precision sand casting/kg	57.9
Material - Printed wiring board, through-hole mounted, unspec., Pb containing	37.1
Process - Aluminum, cast, precision sand casting/kg: Turning, aluminum	35.2
Material - Capacitor, electrolyte type, < 2cm height	11.1
Material - Diode, glass-, through-hole mounting	8.93
Material - Transformer, low voltage use	8.03

About this results view

This view shows the carbon footprint of your product system per functional unit. It actually represents the total quantity of global warming gasses created throughout the life cycle of your product concept. The impact units are in kilograms (kgs) of carbon dioxide (CO_2) equivalent because it accounts for all the gasses that contribute to global warming. Many of these have greater global warming capacity per kg than CO_2.

You can identify and compare 'hot spots' (materials, manufacturing processes, power, water and other consumables, end of life methods and transportation activities with high scores) with which you can reduce the global warming impacts of your product concept.

Browse SM2013 Dataset >
Quick Start Guide >
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RESULTS - SCORECARD

- The greatest ecological factor was indicated to be carbon emissions from manufacturing.
- The greatest human health issue was the presence of carcinogenics in the acrylic.

RESULTS - SBOM CARBON FOOTPRINT

- The relative amount of carbon dioxide produced per material type was: Aluminium - 316, Technical Package - 200 and Acrylic - 188

The turntable produces:
730kg of CO_2 Emmissions
in a typical life cycle

Almost all of this is due to using:
Aluminium (45%) Technical Components (28%) and Acrylic (27%)
in its construction

Total Financial Cost Per Unit :	$2921.98
Total Financial Cost Per 100 Units :	$29219.80