The Centre for Sustainable Design®

Business School for the Creative Industries

University for the Creative Arts

UKRI Research England

FARNHAM REPAIR CAFE

REPAIR CAFÉ CARBON CALCULATOR

New online tool to help Repair Cafés quickly estimate CO2 savings

3D PRINTING FOR REPAIR

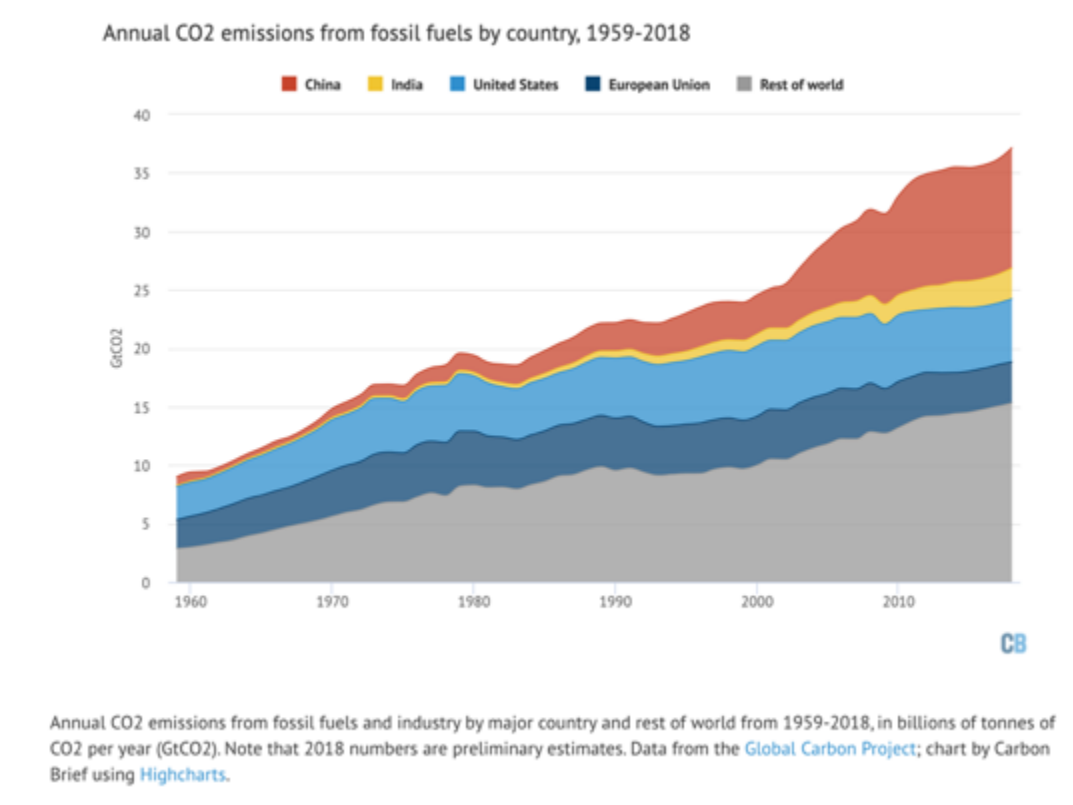
An Introduction based on our experience at FRC

Steve.Privett@googlemail.com Farnham Repair Café trustee

REPAIR CAFÉ CARBON CALCULATOR

- Why? Offers a way to report an environmental benefit that Repair Cafés bring, using a widely recognized driver of the current Climate Emergency – CARBON DIOXIDE (CO_2e)

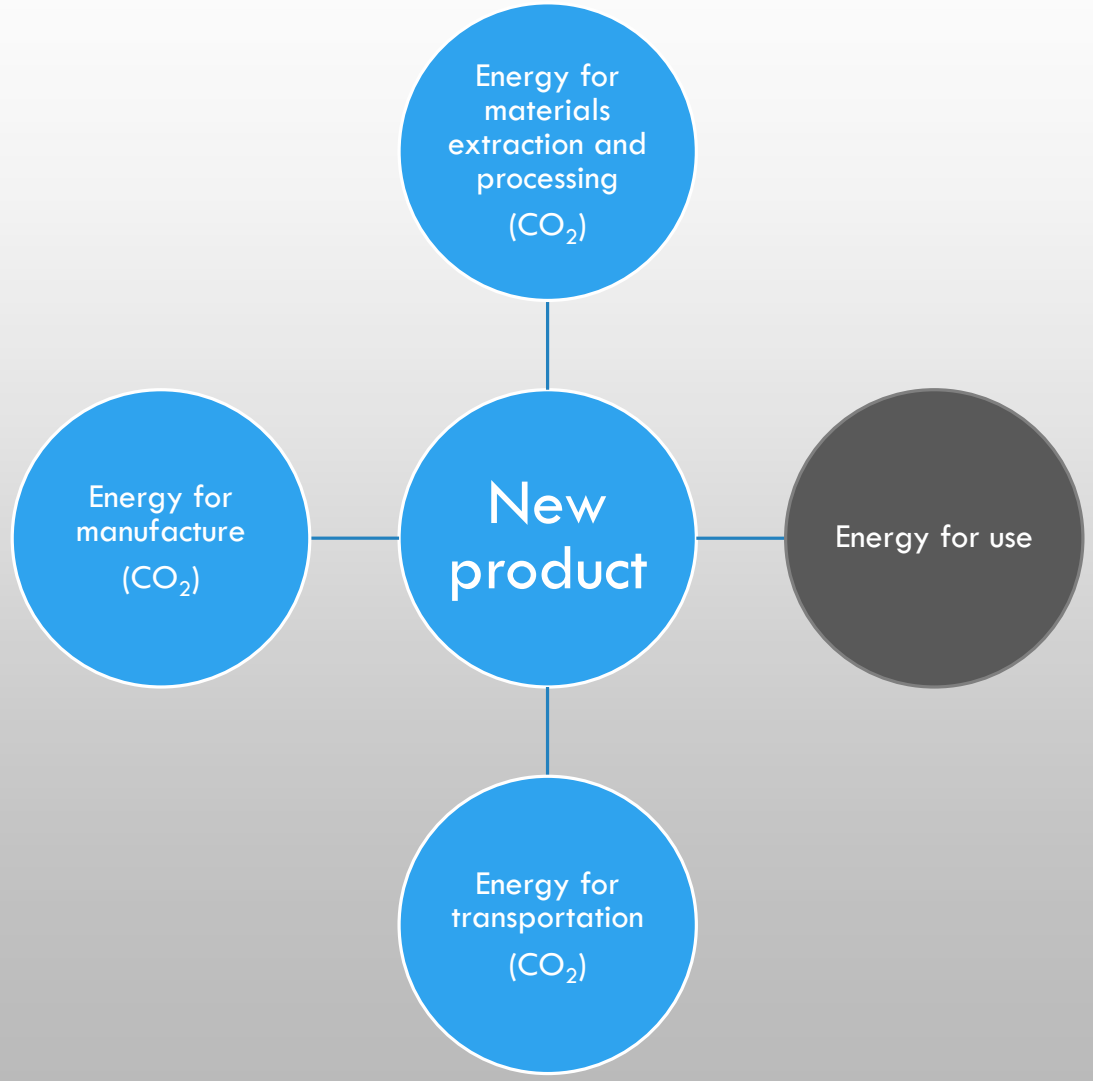
REPAIR CAFÉ CARBON CALCULATOR



Annual CO2 emissions from fossil fuels and industry by major country and rest of world from 1959-2018, in billions of tonnes of CO2 per year (GtCO2). Note that 2018 numbers are preliminary estimates. Data from the Global Carbon Project; chart by Carbon Brief using Highcharts.

- How Repair Cafés help? By reducing the number of newly manufactured products people buy as a result of successful repairs.
- Products are still manufactured and transported using energy predominantly from fossil fuels.

PRODUCTS – EMBODIED CARBON

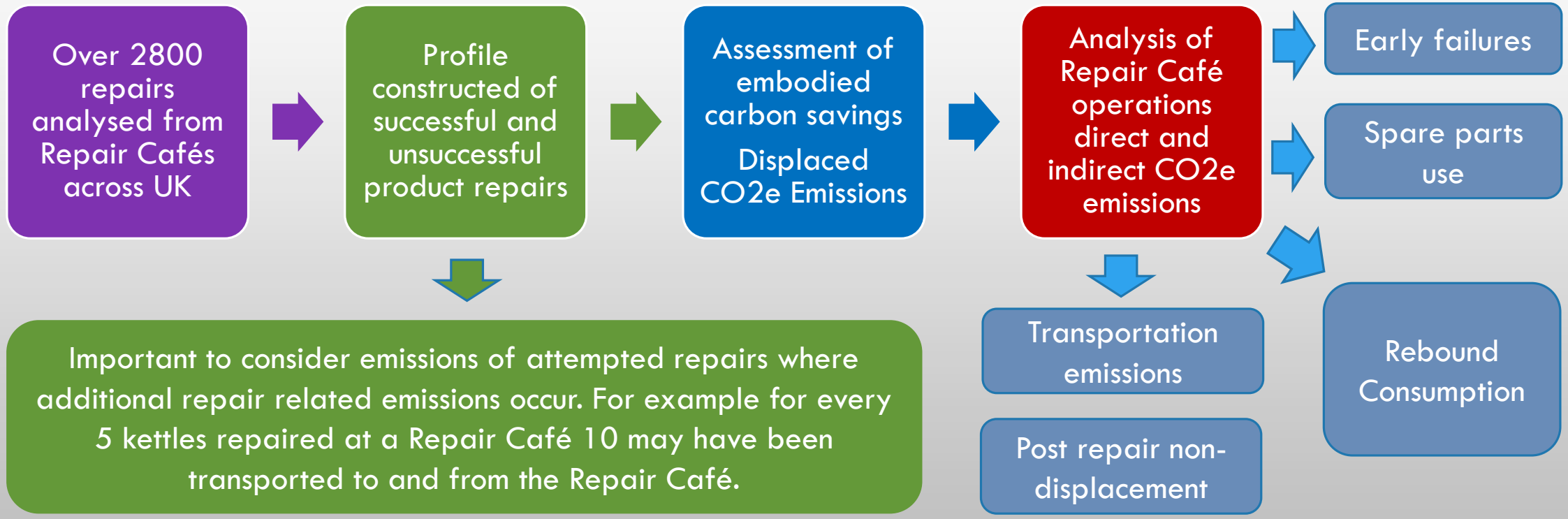


- Embodied Carbon? This is an estimation of all the greenhouse gas emissions that have resulted from the extraction of raw materials, manufacturing processes and transportation to produce a finished saleable product.

- This figure is normally reported as the quantity of greenhouse gases added to the atmosphere as: kg CO2e (CO2 e = equivalent)

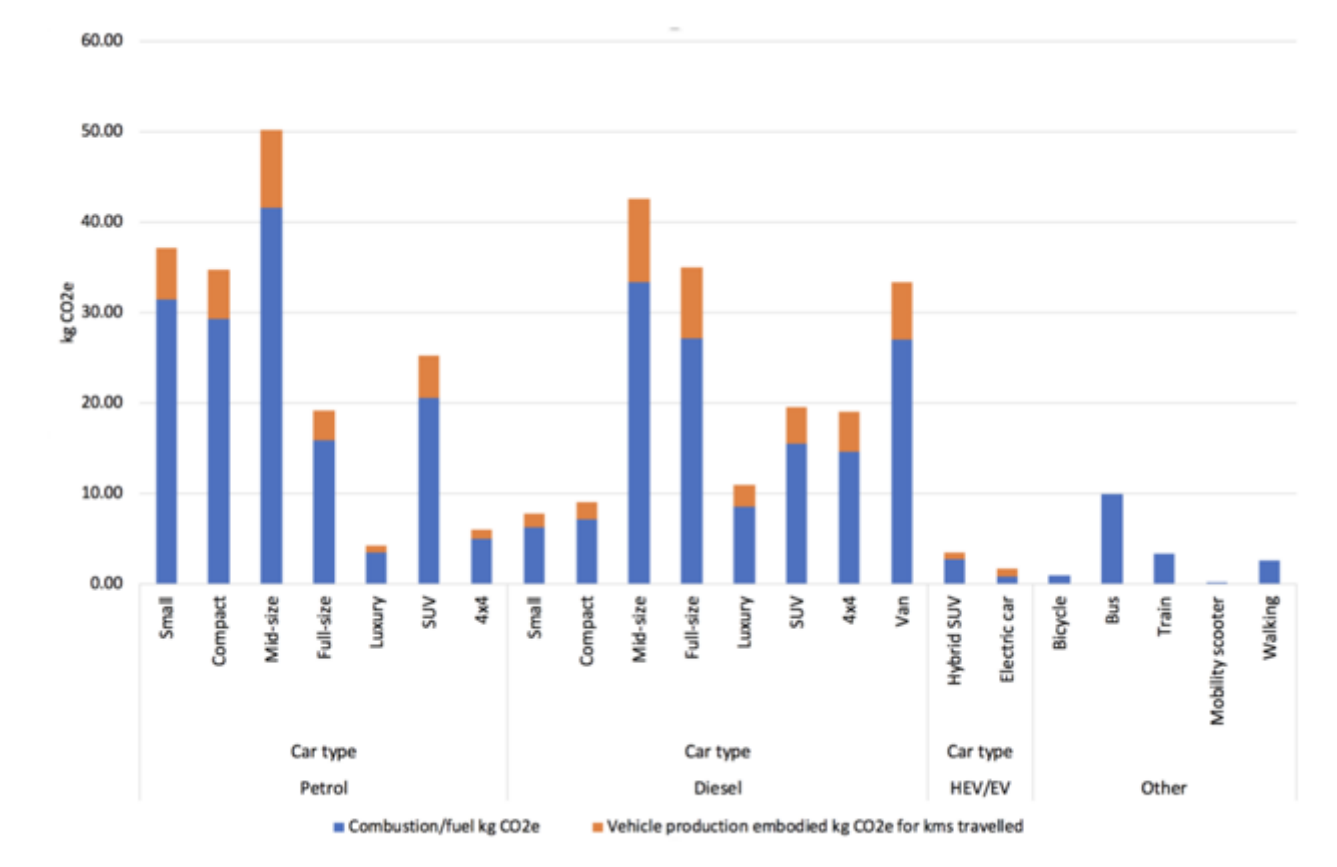
PRODUCT EXAMPLES

REPAIR CAFÉ CARBON CALCULATOR METHODOLOGY*



*Methodology was developed for Masters Degree Dissertation at University of Surrey's Centre for Environment and Sustainability.

REPAIR CAFÉ CARBON CALCULATOR



- Key Point: Calculator is tailored specifically to profile of successfully repaired products seen across UK Repair Cafés, and takes into account direct and indirect greenhouse gas emission as a result of the free/near free repair service.

- For Example included in online calculation is: Typical travel distances, types of transportation used embodied carbon within vehicles.

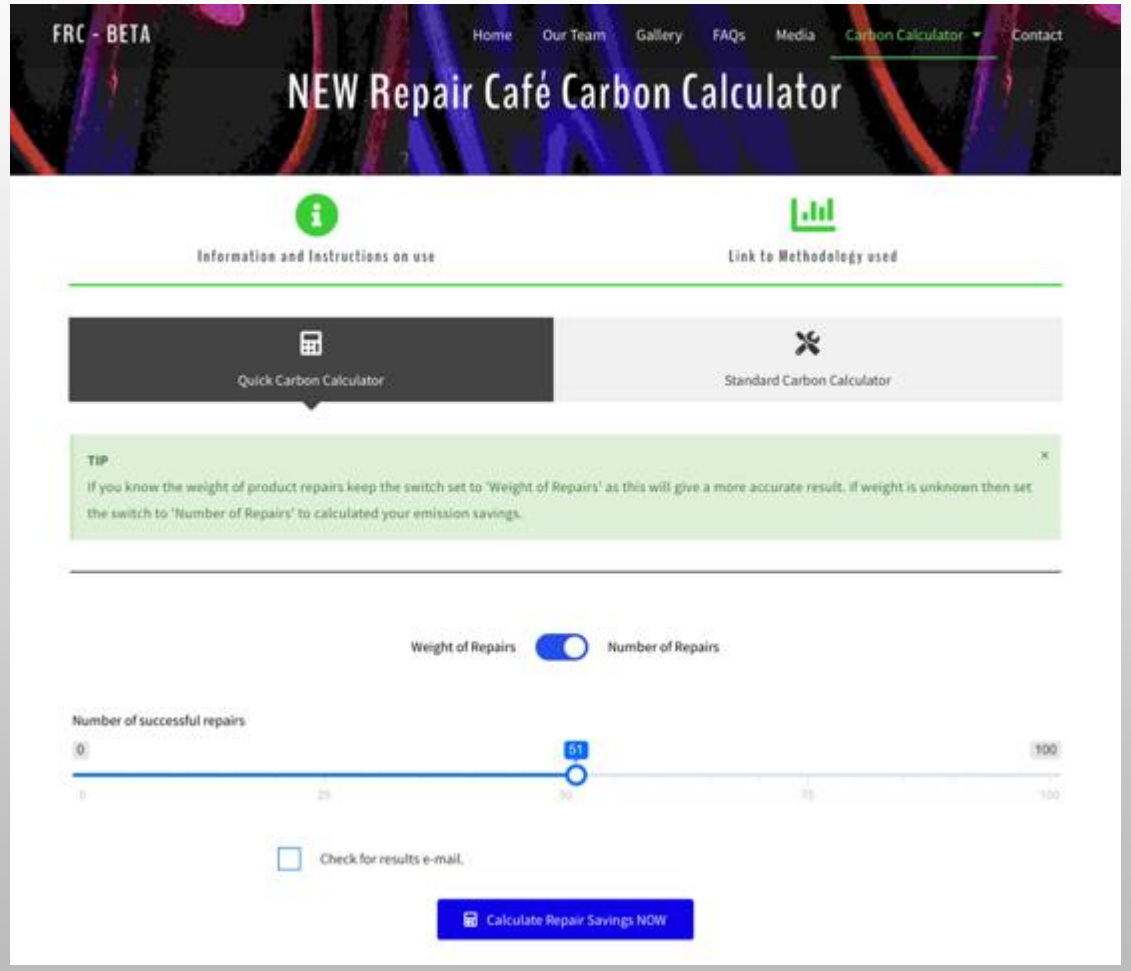
WHO IS THE ONLINE CARBON CALCULATOR FOR?

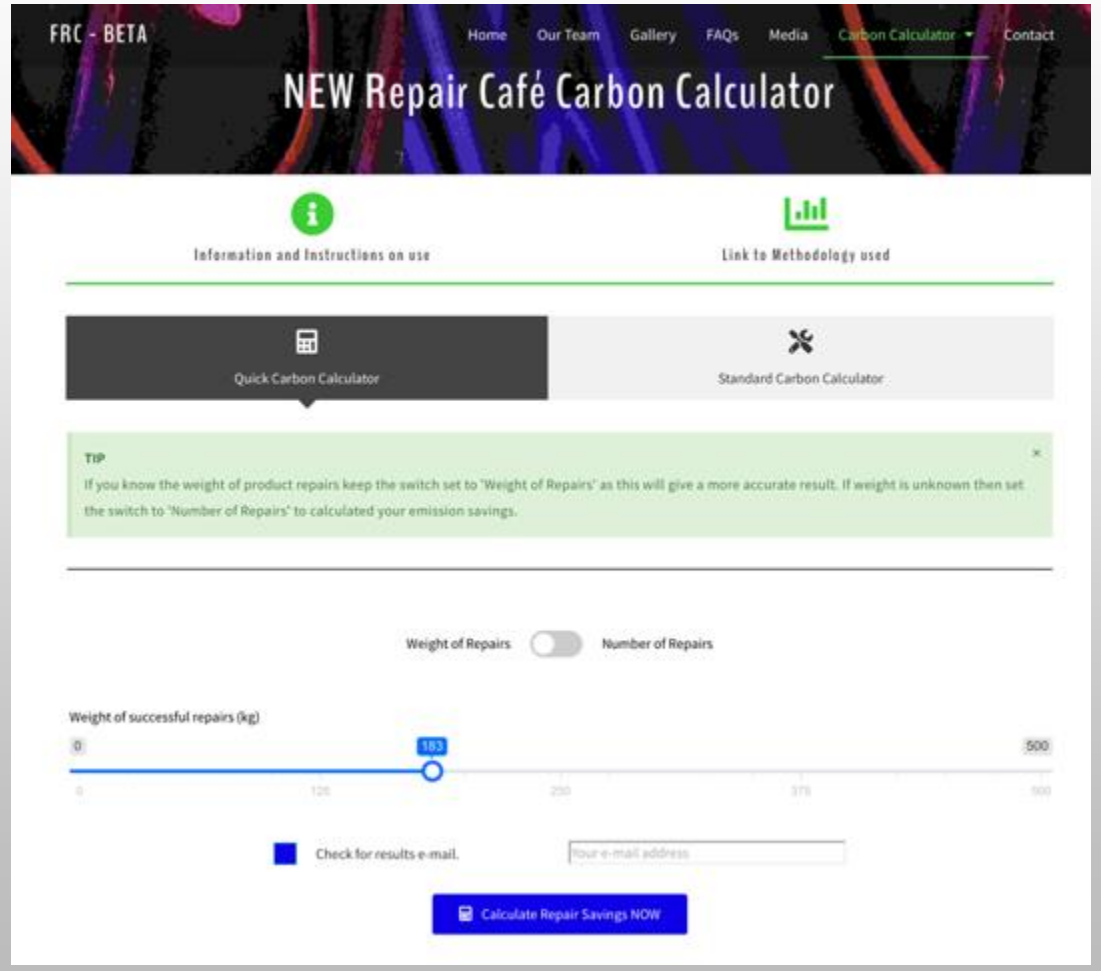
- Any Repair Cafe! Even if you just keep a simple record of how many successful repairs you have each month/session or if you keep a note of product weights you can make a quick estimation of your CO2e and landfill/recyclables savings.

This CO2e estimation is based on average savings per successful product repair from across the UK, taking into account the factors previously discussed.

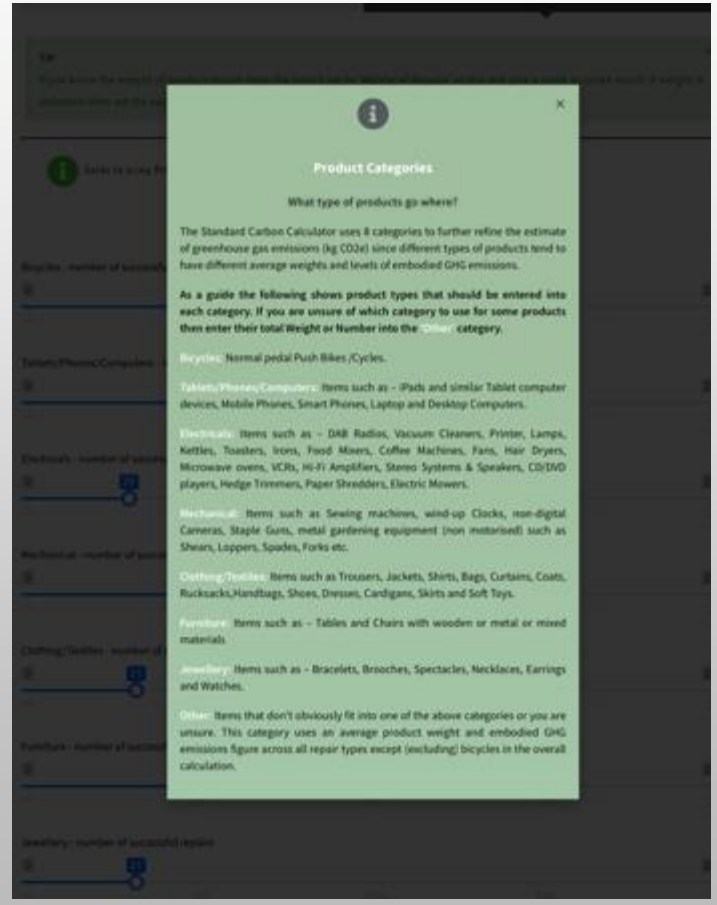
There are presently 2 versions of online Repair Café Carbon Calculator Quick and Standard (a more advanced version may be available in future).

QUICK CALCULATOR

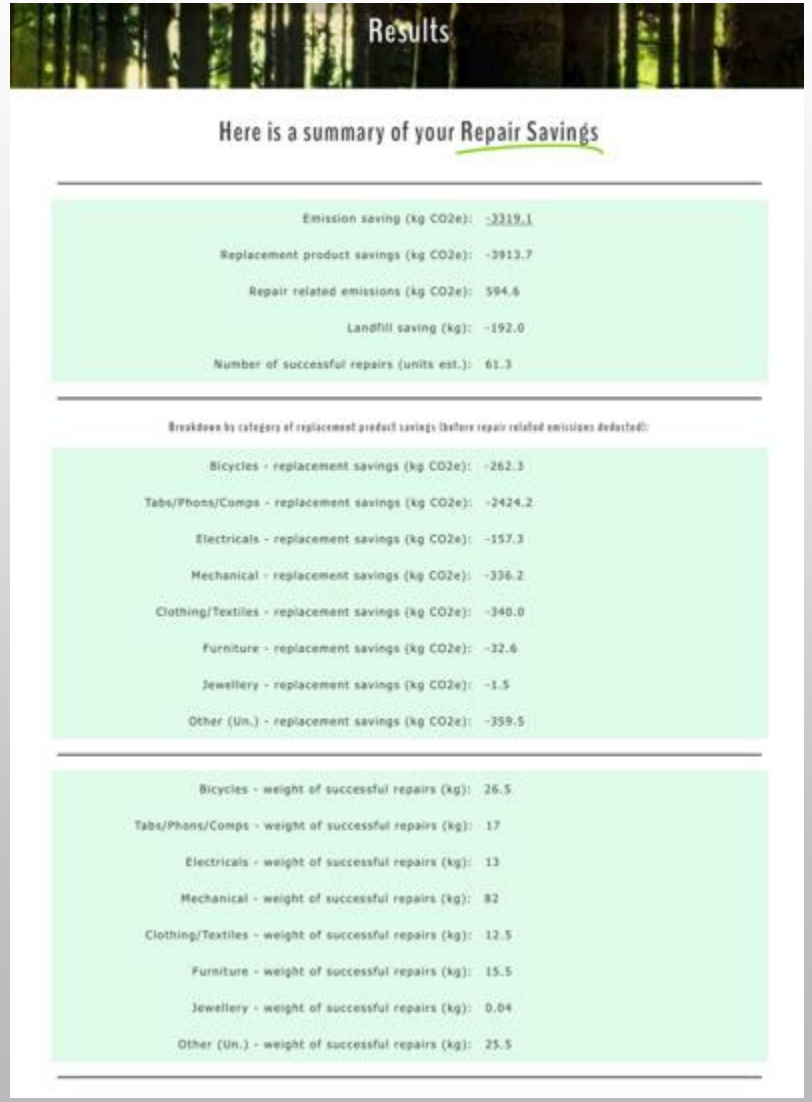




STANDARD CALCULATOR



CARBON SAVINGS RESULT



Results

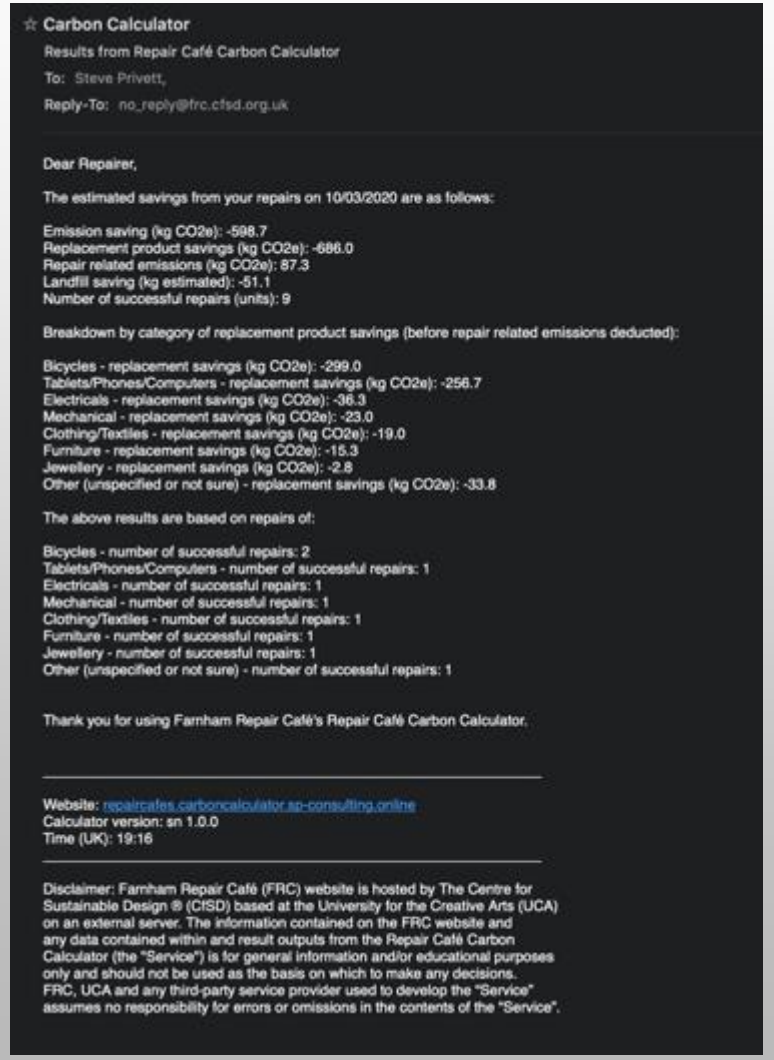
Here is a summary of your Repair Savings

Emission saving (kg CO2e):	-3319.1
Replacement product savings (kg CO2e):	-3913.7
Repair related emissions (kg CO2e):	594.6
Landfill saving (kg):	-192.0
Number of successful repairs (units est.):	61.3

Breakdown by category of replacement product savings (before repair related emissions deducted):

Bicycles - replacement savings (kg CO2e):	-262.3
Tabs/Phons/Comps - replacement savings (kg CO2e):	-2424.2
Electricals - replacement savings (kg CO2e):	-157.3
Mechanical - replacement savings (kg CO2e):	-336.2
Clothing/Textiles - replacement savings (kg CO2e):	-340.0
Furniture - replacement savings (kg CO2e):	-32.6
Jewellery - replacement savings (kg CO2e):	-1.5
Other (Un.) - replacement savings (kg CO2e):	-359.5

Bicycles - weight of successful repairs (kg):	26.5
Tabs/Phons/Comps - weight of successful repairs (kg):	17
Electricals - weight of successful repairs (kg):	13
Mechanical - weight of successful repairs (kg):	82
Clothing/Textiles - weight of successful repairs (kg):	12.5
Furniture - weight of successful repairs (kg):	15.5
Jewellery - weight of successful repairs (kg):	0.04
Other (Un.) - weight of successful repairs (kg):	25.5



☆ Carbon Calculator

Results from Repair Café Carbon Calculator

To: Steve Privett,

Reply-To: no_reply@frc.cfsd.org.uk

Dear Repairer,

The estimated savings from your repairs on 10/03/2020 are as follows:

Emission saving (kg CO2e): -598.7
Replacement product savings (kg CO2e): -686.0
Repair related emissions (kg CO2e): 87.3
Landfill saving (kg estimated): -51.1
Number of successful repairs (units): 9

Breakdown by category of replacement product savings (before repair related emissions deducted):

Bicycles - replacement savings (kg CO2e): -299.0
Tablets/Phones/Computers - replacement savings (kg CO2e): -256.7
Electricals - replacement savings (kg CO2e): -36.3
Mechanical - replacement savings (kg CO2e): -23.0
Clothing/Textiles - replacement savings (kg CO2e): -19.0
Furniture - replacement savings (kg CO2e): -15.3
Jewellery - replacement savings (kg CO2e): -2.8
Other (unspecified or not sure) - replacement savings (kg CO2e): -33.8

The above results are based on repairs of:

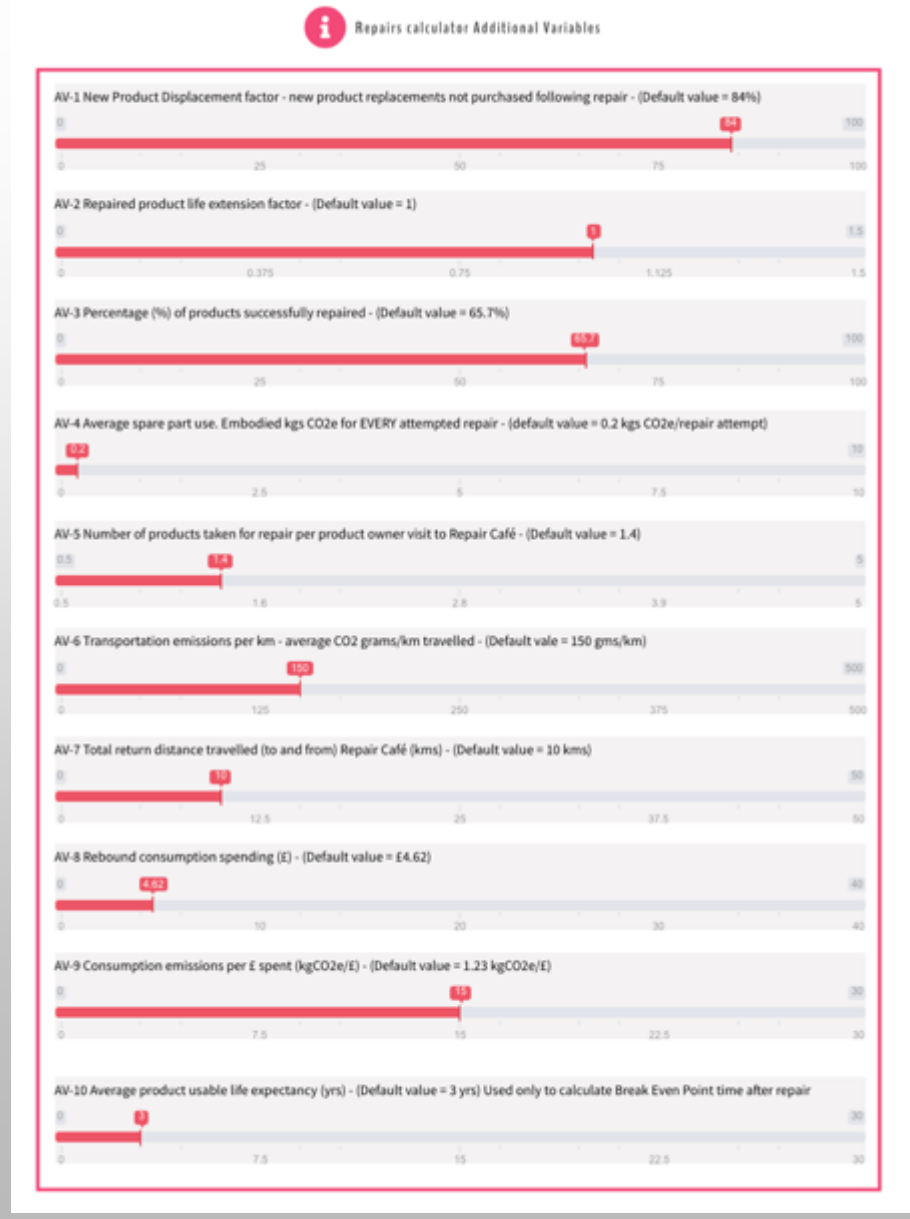
Bicycles - number of successful repairs: 2
Tablets/Phones/Computers - number of successful repairs: 1
Electricals - number of successful repairs: 1
Mechanical - number of successful repairs: 1
Clothing/Textiles - number of successful repairs: 1
Furniture - number of successful repairs: 1
Jewellery - number of successful repairs: 1
Other (unspecified or not sure) - number of successful repairs: 1

Thank you for using Farnham Repair Café's Repair Café Carbon Calculator.

Website: repaircafes.carboncalculator.sp-consulting.online
Calculator version: sn 1.0.0
Time (UK): 19:16

Disclaimer: Farnham Repair Café (FRC) website is hosted by The Centre for Sustainable Design ® (CfSD) based at the University for the Creative Arts (UCA) on an external server. The information contained on the FRC website and any data contained within and result outputs from the Repair Café Carbon Calculator (the "Service") is for general information and/or educational purposes only and should not be used as the basis on which to make any decisions. FRC, UCA and any third-party service provider used to develop the "Service" assumes no responsibility for errors or omissions in the contents of the "Service".

ADVANCED CALCULATOR (MAYBE?)



REASONS TO BE CAUTIOUS 1,2,3

Repair carbon savings are POTENTIAL SAVINGS – they are NOT YET REALISED.

- Carbon savings only start once the repair related emissions are recouped! There is a breakeven point in time after repair. It takes 1 year for the average product to reach the breakeven point after which savings begin to accrue. Keeping a repaired product for as long as possible and not replacing prematurely is VERY important.

- Products with short life expectancies and a high level of embodied carbon offer the greatest scope for savings – Computers, Tablets, Phones etc. Low weight, long life product the least scope for savings – Jewellery for example.

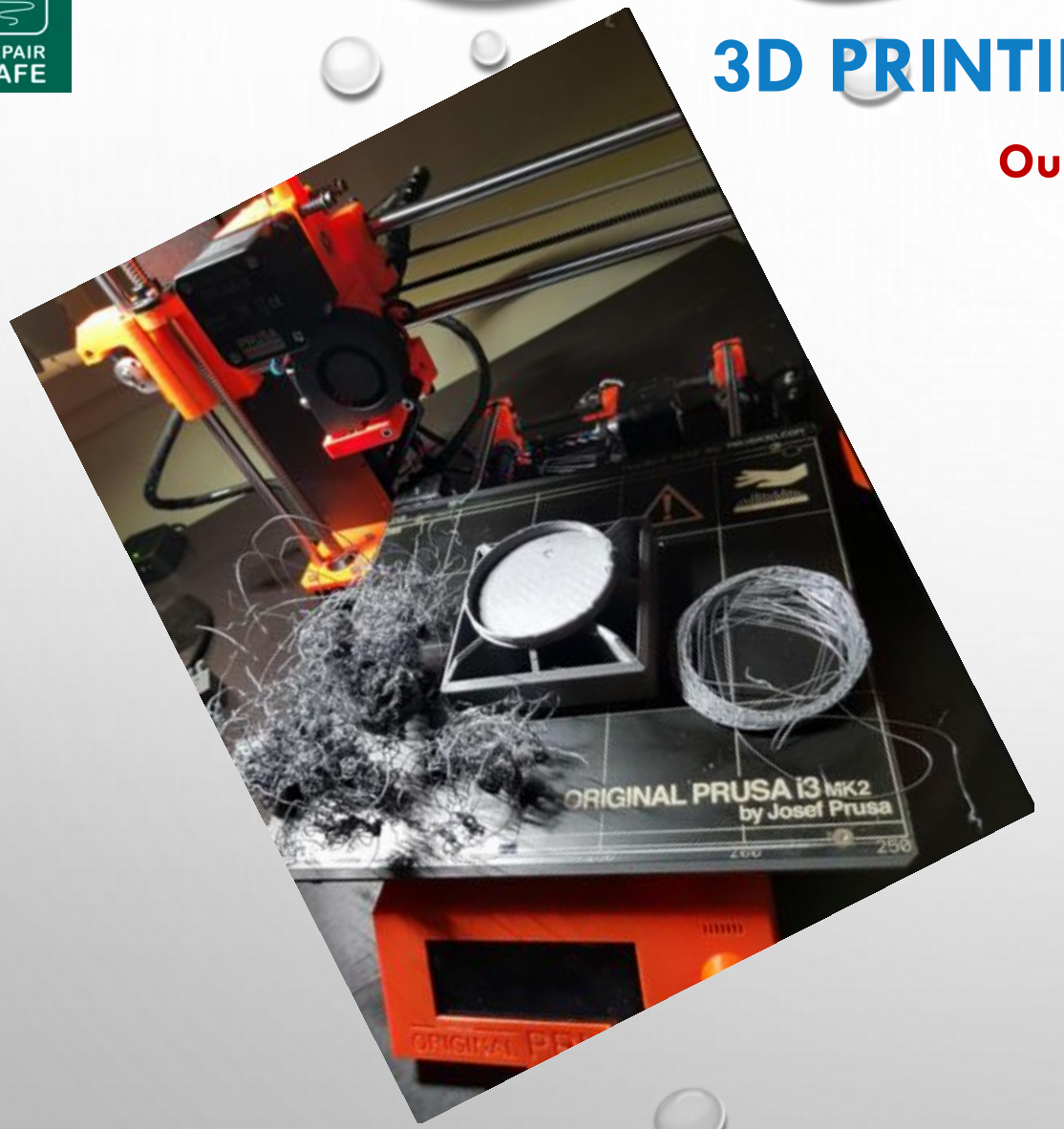
- Repair Café CO2e savings are VERY SENSITIVE to Rebound spending/consumption. People who visit Repair Cafés often (87%) feel they have saved money by visiting a Repair Café even when repairs have not been successful. So - not spending when saving is key - unless it's to plant a tree or buy a renewable energy system!!

REBOUND CONSUMPTION

- For every £1 spent as a result of receiving a free repair 1.23 kg CO2e is created.
- Spending just £10 on additional food and beverages would exceed the emissions created by the manufacture of a NEW toaster!

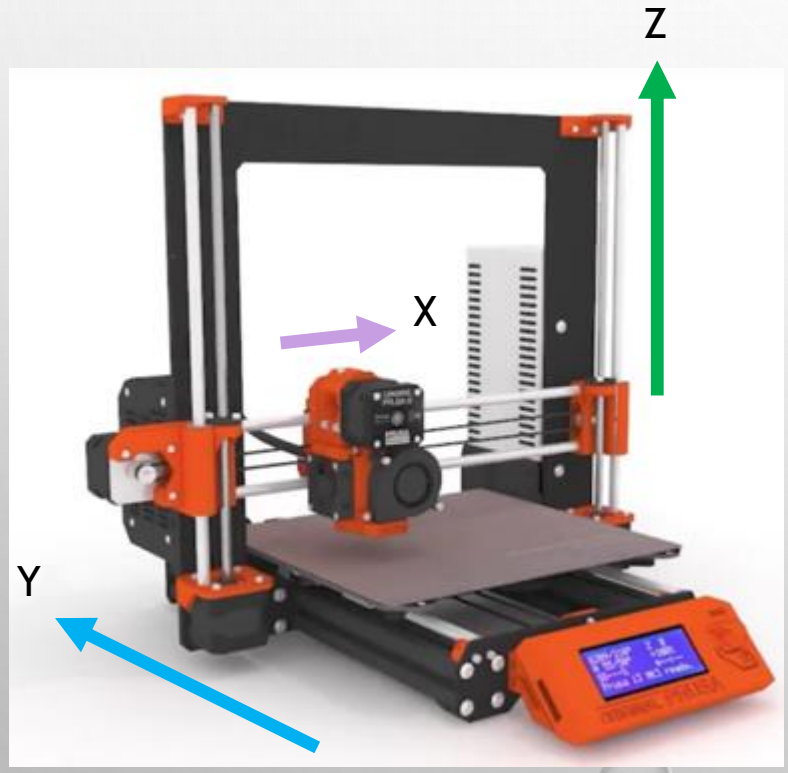
3D PRINTING FOR REPAIR

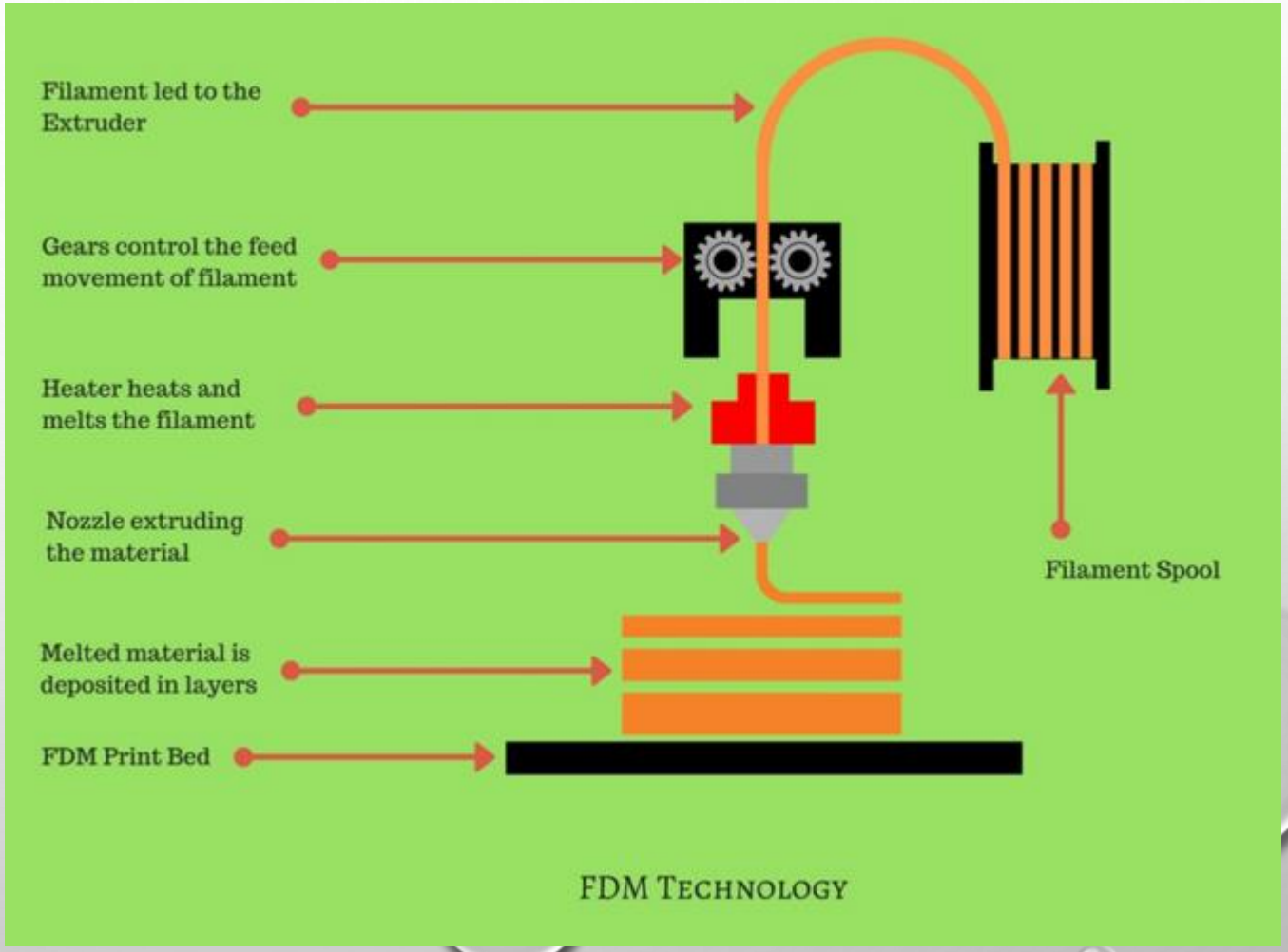
Our experience so far



3D PRINTING PROCESS

FDM = Fused Deposition Modeling





GETTING STARTED

What do you ne

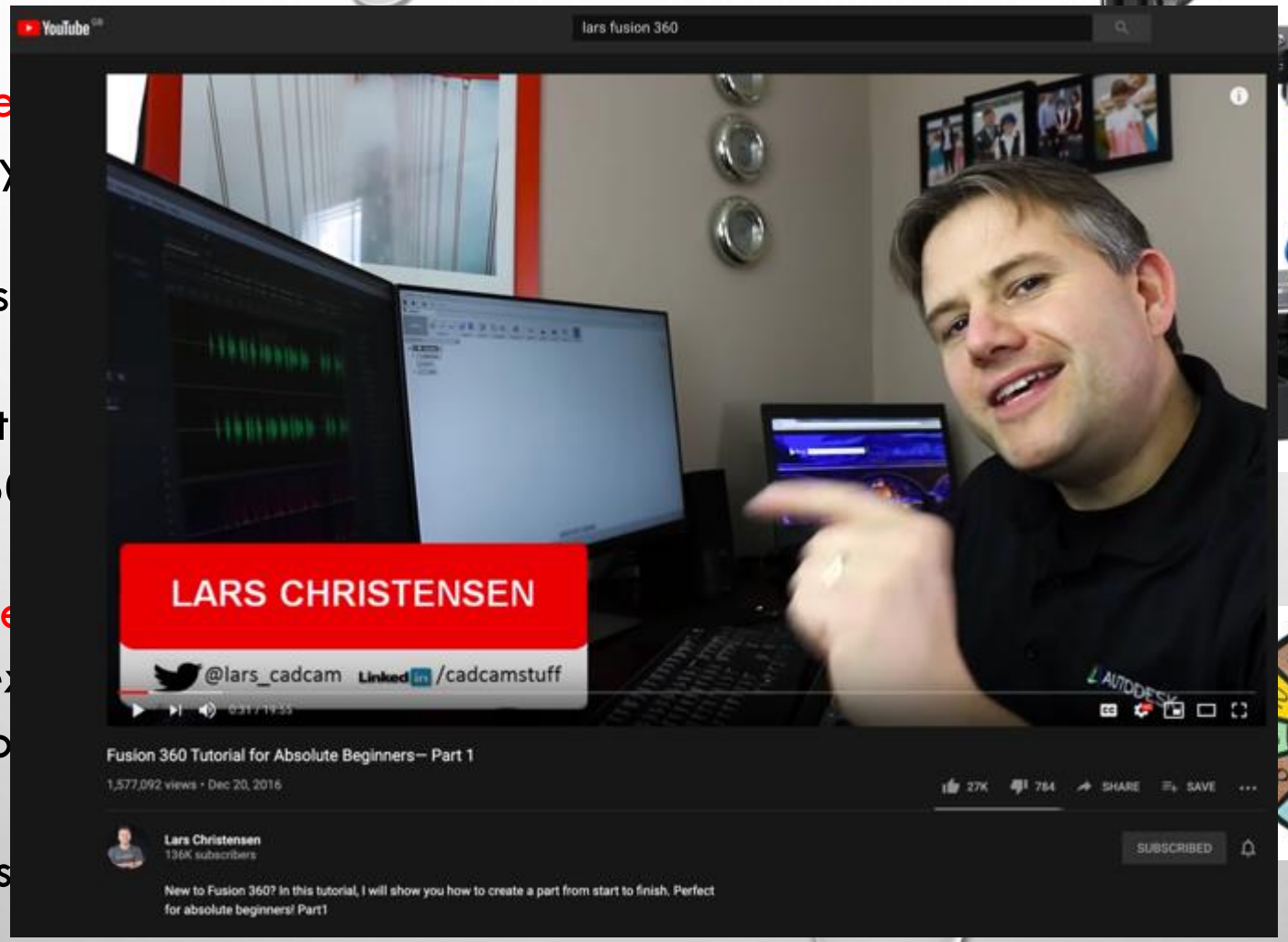
- Reliable easy

- Consumables

- 3D CAD Soft
  Fusion 36

Who do you nee
Someone with ex
or someone who

Free time to des



THINGS TO BE AWARE OF

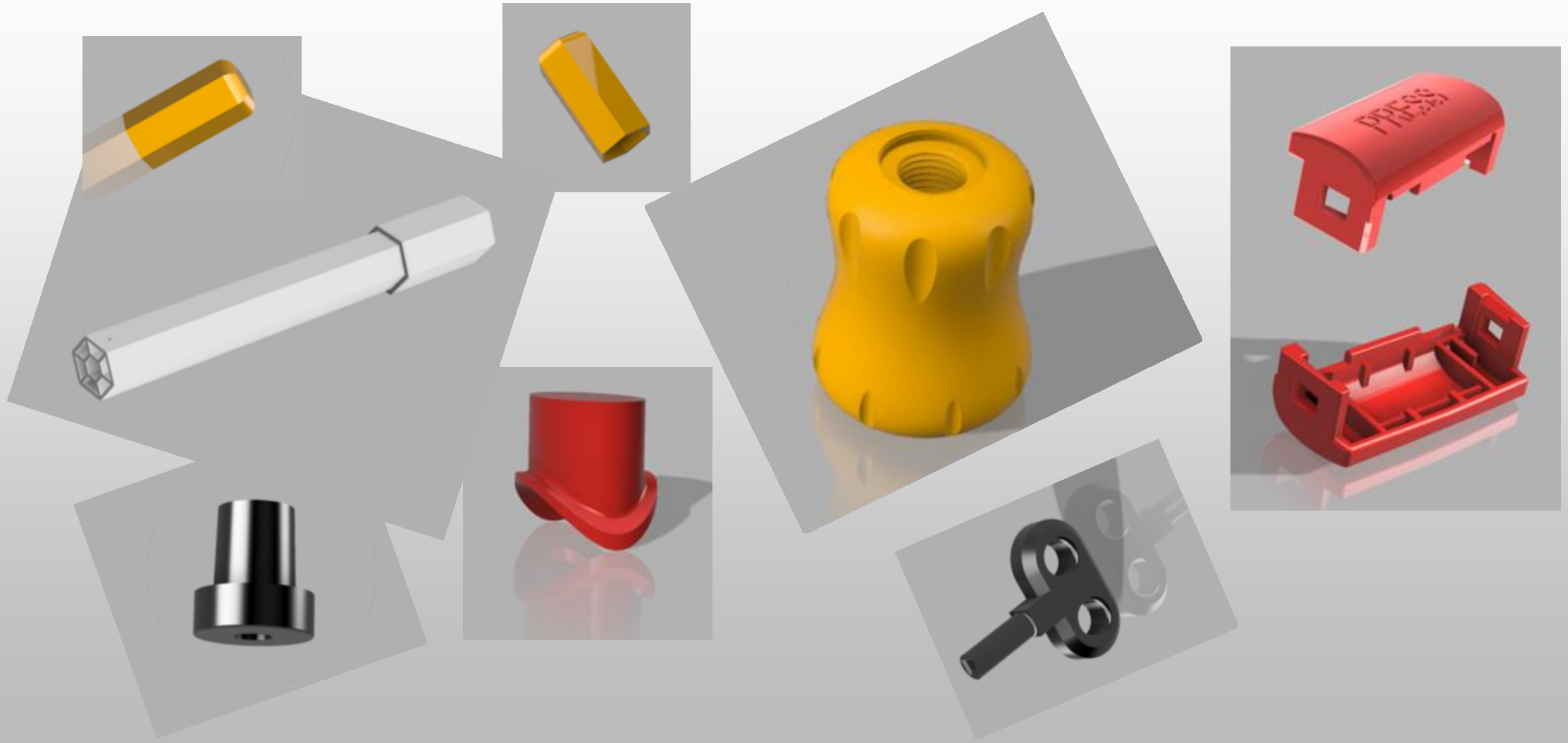
Not suitable for a fast turnaround of repairs
If non 3D printed spare parts are available they should be used!

Large parts can take a very long time to print, handle for umbrella takes nearly 2 hours.

Different filament materials have different mechanical and printing qualities. Some also require a different printing nozzle to be fitted. Some filaments also give off fumes so not suitable for use/demonstration at a Repair Café. PLA is a good filament to start with, it's also the greenest (being plant based) and can be recycled. Oil based filaments are also available such as ABS and PETG.

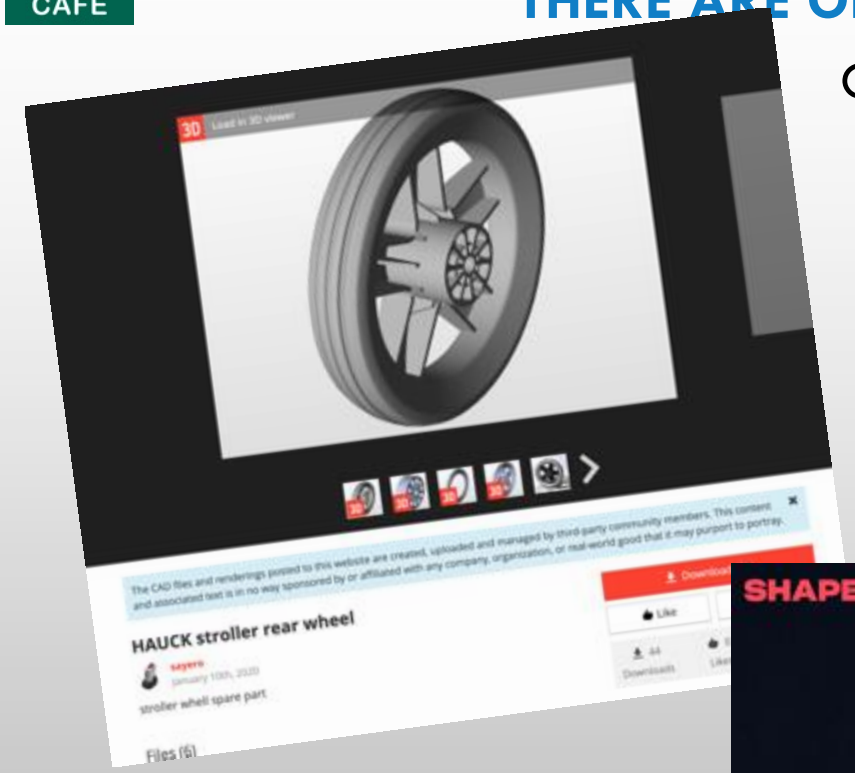
Don't assume that printing very fine layer heights will give the greatest strength or best print quality. Using a 0.1mm – 0.2mm layer printing thickness gives the best results and overall strength with a standard 0.4mm nozzle.

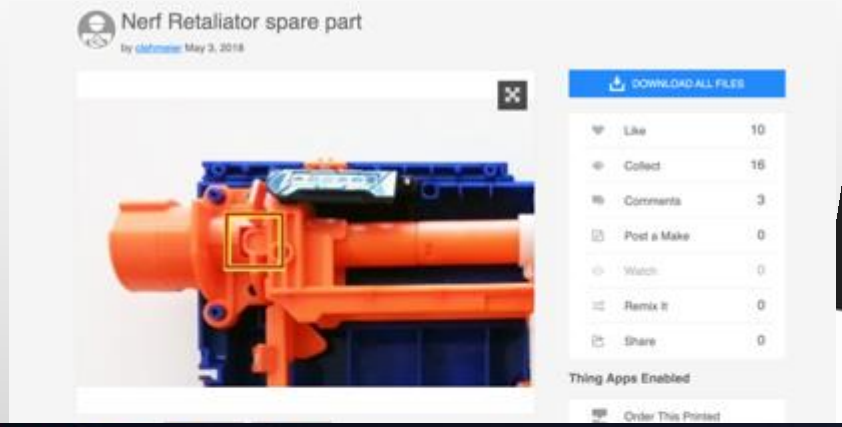
SOME PARTS WE HAVE PRINTED AT FRC

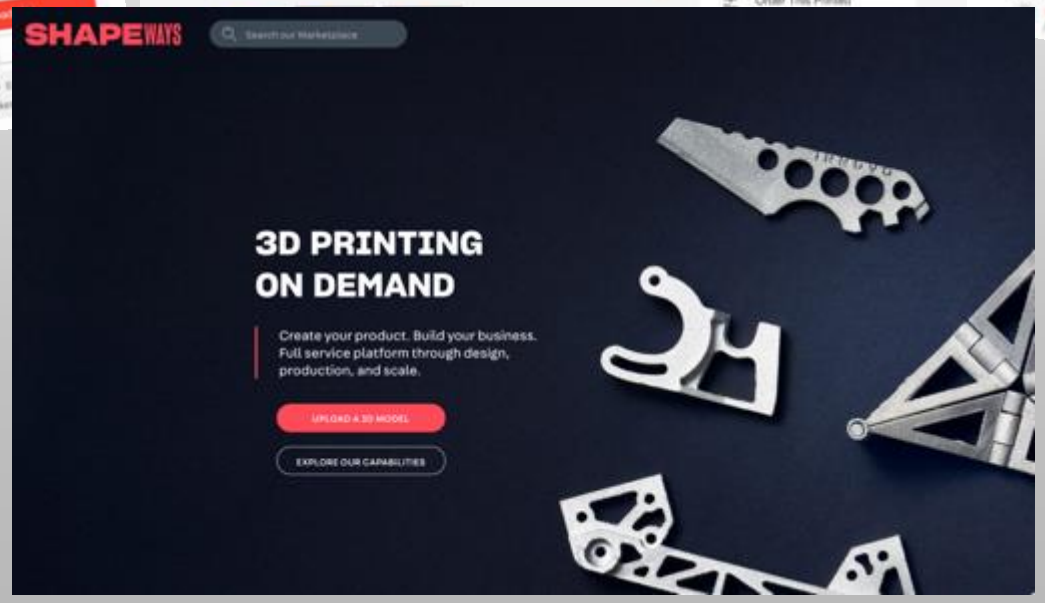


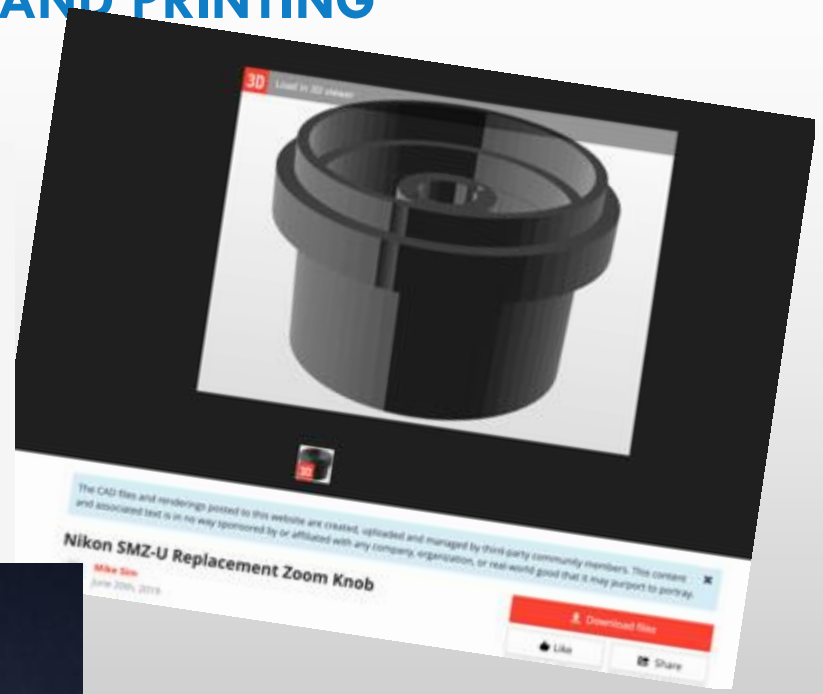
THERE ARE ONLINE RESOURCES FOR 3D FILES AND PRINTING

GrabCAD, Shapeways and Thingiverse









3D Printer use case study

Repair of replica antique lamp

Steve Privett - March 2019

FARNHAM
REPAIR
CAFE

Antique lamp had become unusable due to:

- Cracked and degraded bulb holder.
- Lost shade fixing ring resulting in previous owner gluing the glass shade to the lamp fitting!

Bulb holder

Glass shade

On inspection:

- Bulb holder used was identified as customised Edison ES type that was no longer available.
- The lost shade securing ring was probably a bespoke part as well, and not available!
- In most cases this would probably have resulted in the lamp being thrown away.

Could the use of a 3D printer help save this cherished lamp?

Original custom ES bulb holder with integrated decorative securing cap

Glass shade in need of securing ring

The repair:

- A standard ES threaded bulb holder was purchased together with a new electrical connector.

- The plan was to recreate the decorative securing cap and ring for the shade, but this had to mechanically fit the replacement ES bulb holder. This was different to the unavailable original.

Using a pair of Vernier calipers measurements were taken of the new ES bulb holder and the old decorative shade securing cap

New ES off shelf bulb holder

New electrical bulb connector

Measuring the old part's dimensions

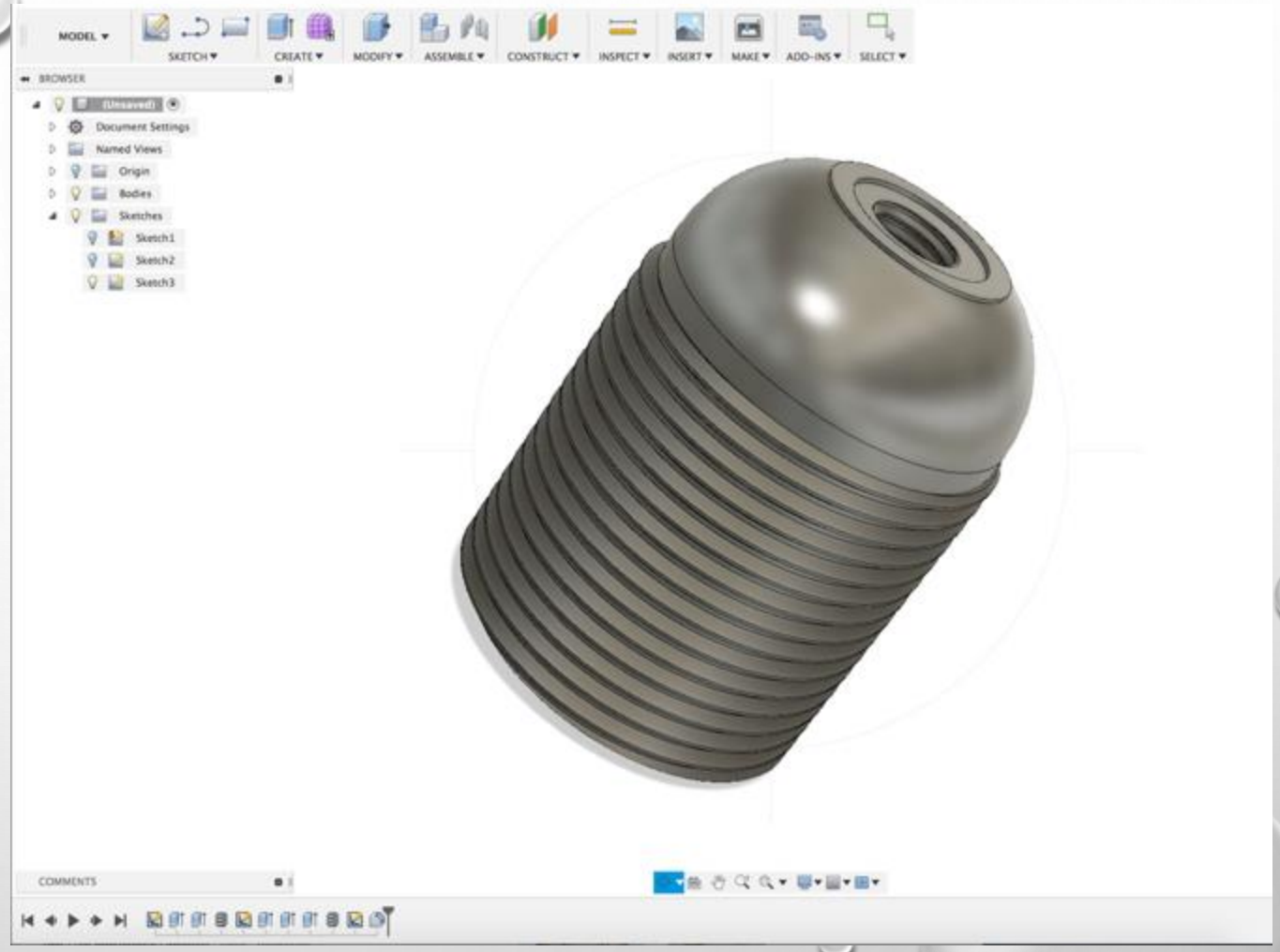
The new parts design process:

- 3D CAD* software was used to create a block model of the new ES bulb holder using the measured dimensions.

- Although this might at first seem unnecessary it did not take much time and reduced the risk of the newly designed 3D parts not fitting!

Once happy that the model was dimensionally correct it was then used to help form the decorative securing cap and ring.

*3 Dimensional Computer Aided Design



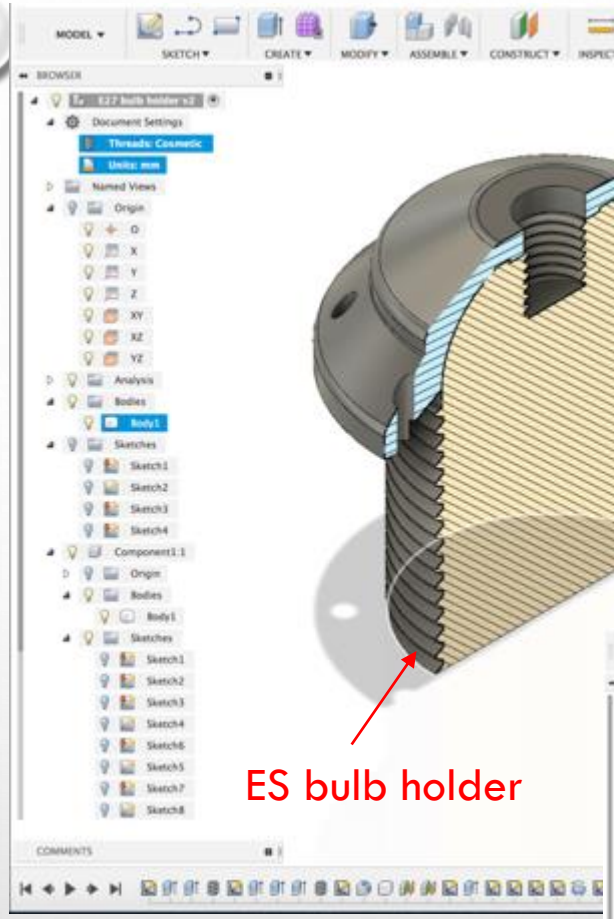
A block 3D model was created of the ES bulb holder in CAD. This would help ensure the new design of decorative securing cap and ring would fit the new bulb holder

The new parts design process:

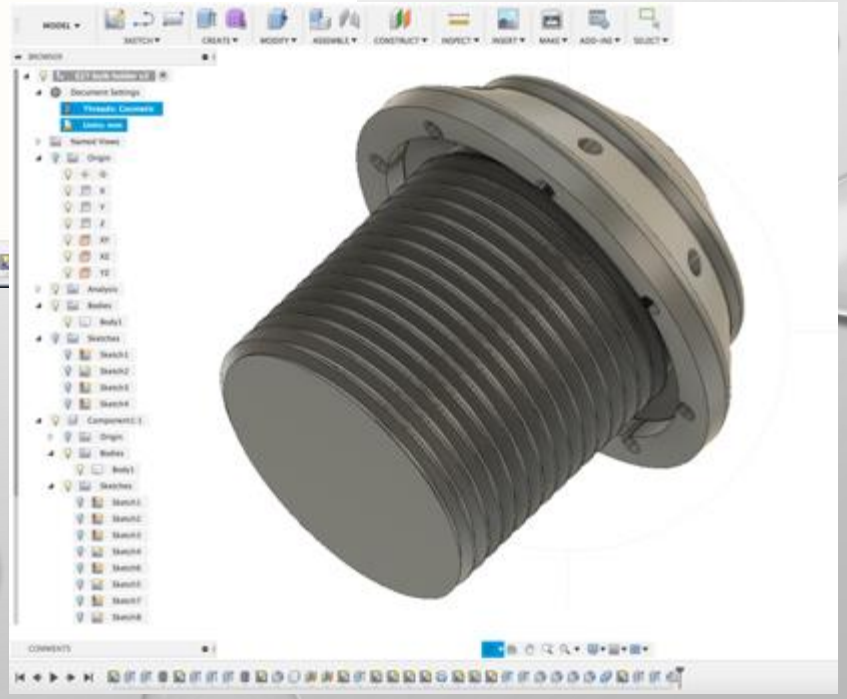
- Using the block model the ES bulb holder the internal profile of the new decorative securing cap was designed so that it mated correctly.

- The top view was used to show a cross section through the two parts so that the fit between them could be checked.

3D CAD also enabled the parts to be viewed from different angles so that the look of the design could be checked before attempting a print.



Recreated decorative securing cap was designed to reflect the design of the original part, but importantly assemble correctly with the new ES bulb holder

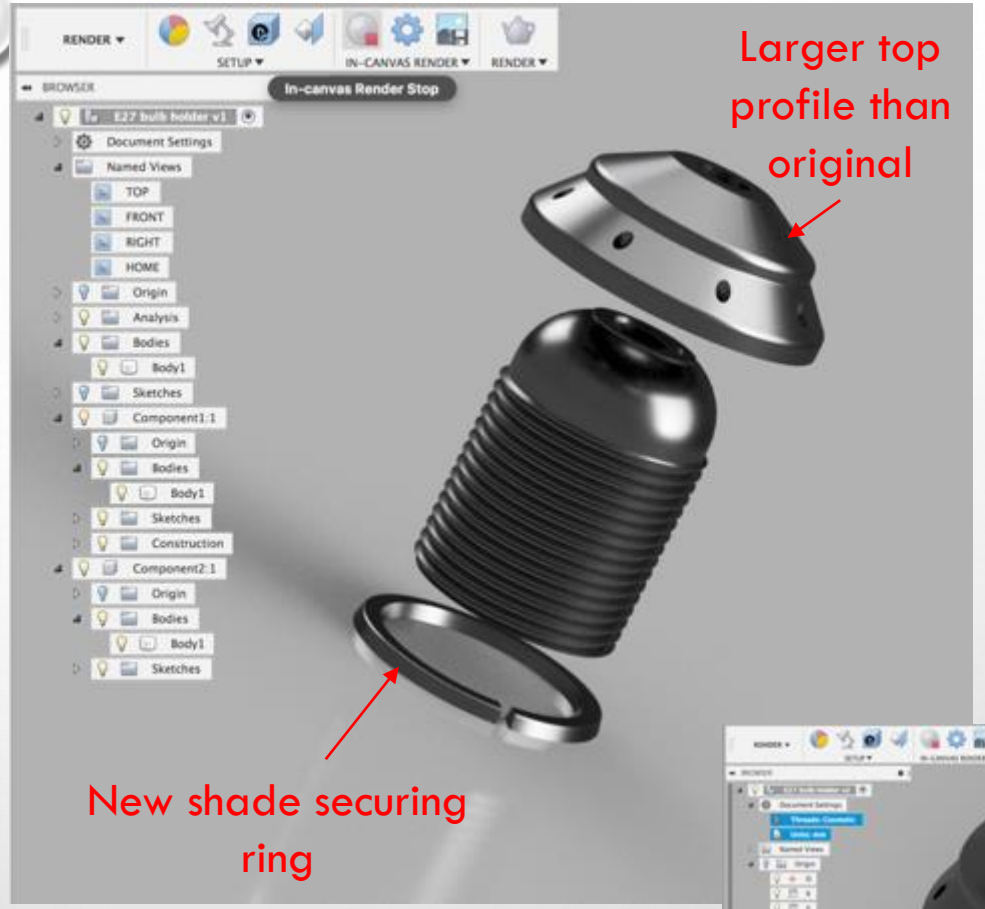


View showing decorative cap assembled with ES bulb holder

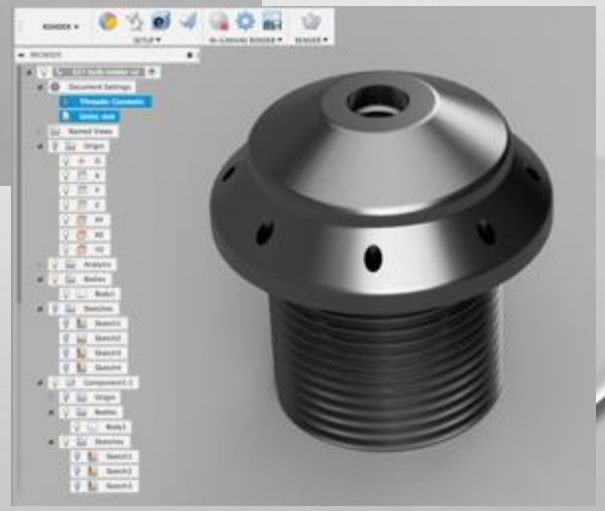
The new parts design process:

- A new shade securing ring was then designed as a new part.
- Once the look and assembly of the components was correct the 2 new parts to be 3D printed were exported from the 3D CAD design software as .stl files.

The type of plastic material used to print the new parts was important, since printed plastics have different physical characteristics such as flexibility, long term durability and print quality.



Rendered view of the parts separated, also showing the design of the new shade securing ring to replace the lost one



Rendered view of assembled new parts

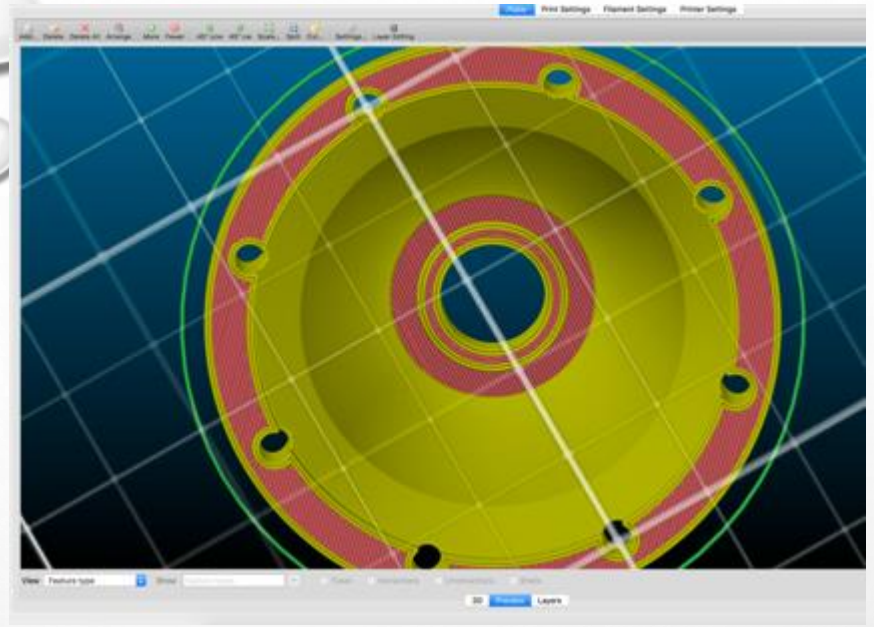
The new parts design process:

- Each new part's .stl* file was imported into a 3D slicer program.

- This program converts the part's design data into a data format that is suitable for the 3D printer.

The 3D slicer program defines how each layer of the new part is printed and the temperature settings needed for the type of plastic filament material used. For these parts PETG filament was used.

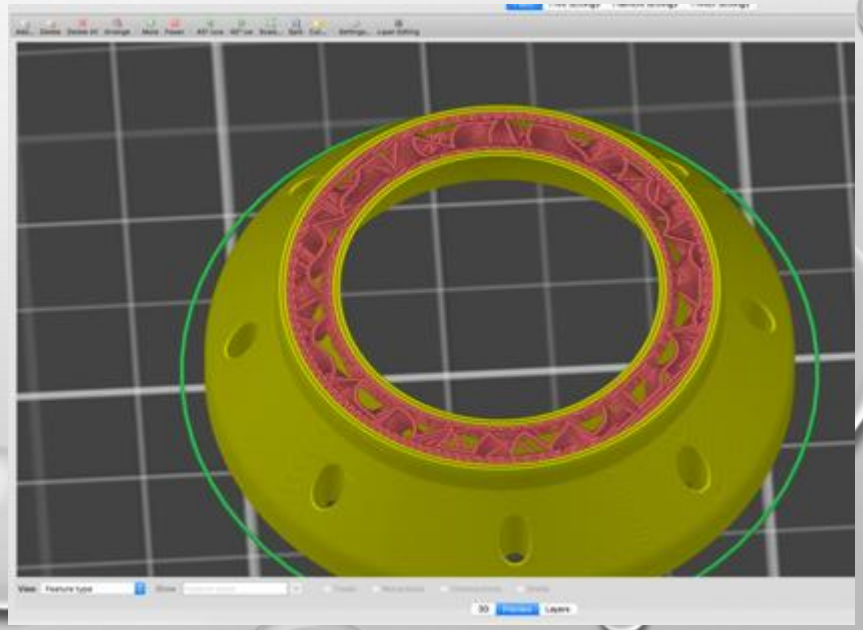
*an abbreviation of 'stereolithography'



The slicer program was used to see how the new part would be printed and define the required 3D printer settings.

This view shows the underside of decorative securing cap.

This view shows a slice through the decorative securing cap. Note that the inner section of the part (red) is not a solid fill – this saves material.

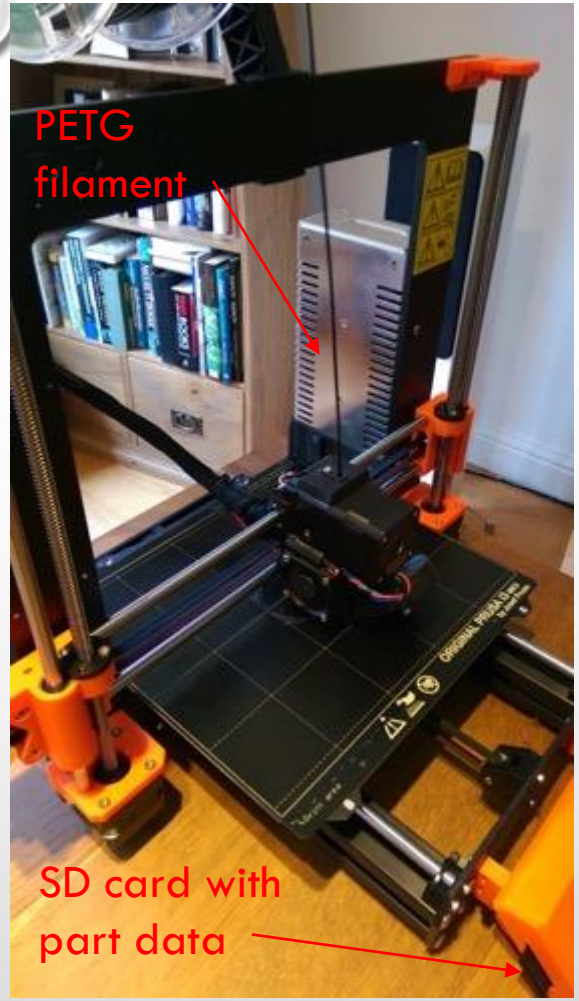


3D printing the new parts:

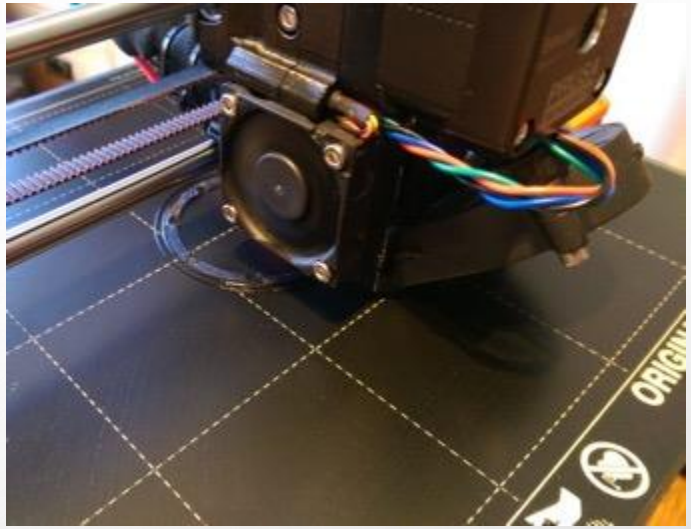
- The 3D sliced decorative cap data was then exported onto an SD memory card for transfer to the 3D printer.

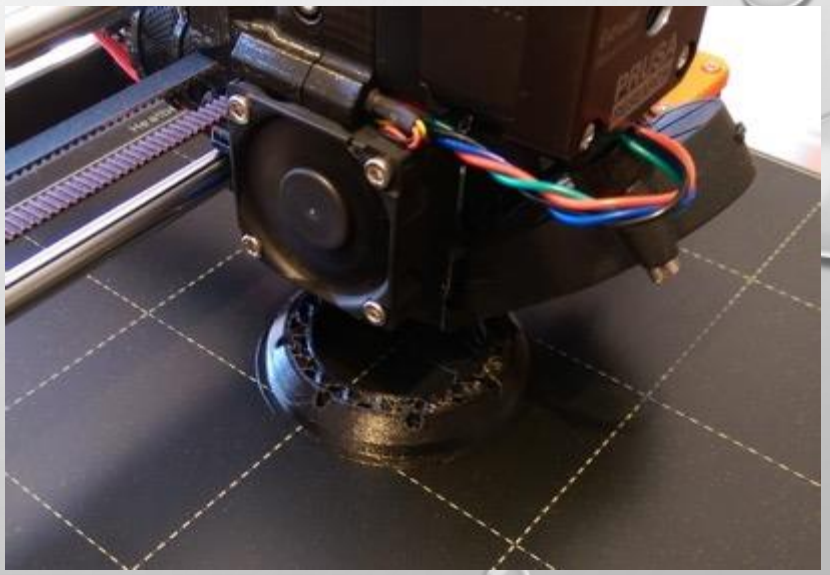
- A reel of PETG filament was loaded onto the printer ready for a test print.

The 3D printer created the new parts by extruding the melted PETG filament at 230 degrees. The parts were built up in fused layers of 0.1 mm height. Total printing time for both parts was 2 hours and 30 minutes.



First layers of decorative cap being printed





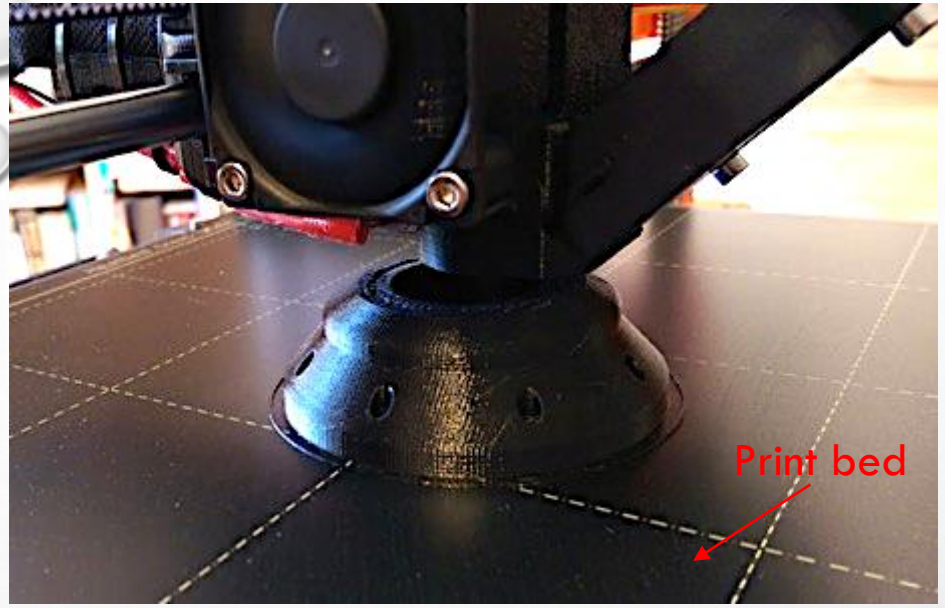
Decorative cap after 30 minutes of printing at 0.1mm layer height

3D printing the new parts:

- Once the printing of the cap had been completed it was allowed to cool before being separated from the print bed.

- Comparing the old and new decorative securing caps highlighted the different profile needed to accommodate the standard replacement ES bulb holder.

Additional finishing of the 3D printed parts was not needed as the owner felt black complimented the lamp.



3D printing of securing cap nearing completion

Glass shade 3D printed securing ring

Old and newly created 3D printed part

Final assembly:

- All the parts were assembled to check fit and finish.

- The original 40W incandescent bulb was replaced with an equivalent 2W LED type. This helped reduce both heat (that might have deformed the newly printed parts) and energy use.

The old wiring and connections were also checked and replaced as necessary together with a final PAT safety check.

Assembled shade with newly created 3D parts

Completed repair of replica antique lamp

3D Printing repair summary

PROS:

- Once the design of the replacement part is completed new parts can be printed quickly and cheaply.
- 3D printed parts can include any necessary design changes to work with other obtainable replacement spare parts needed.
- 3D printed replacement parts can be designed with enhancements to improve durability and future repairability.
- 3D printing offers the possibility of repairing products that would otherwise be thrown away due to non availability of suitable spare parts.
- Low cost 3D printing can now produce parts of an acceptable quality for product repair.

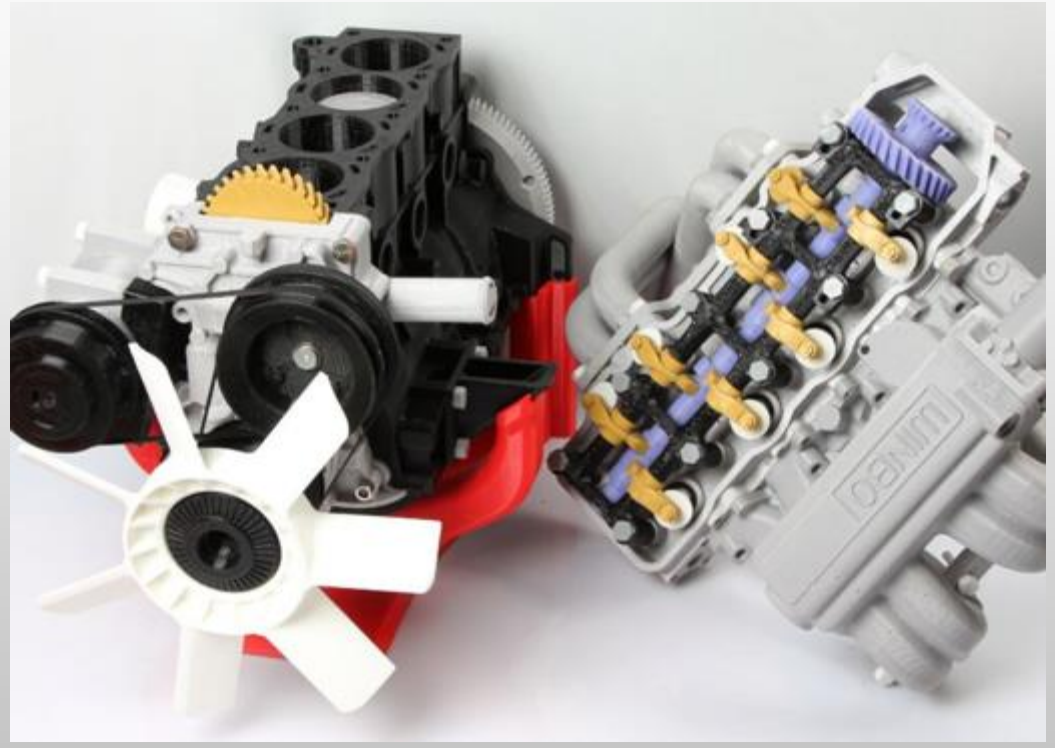
3D Printing repair summary

CONS:

- Some engineering and CAD knowledge is needed to create and design new replacement parts.
- Upfront cost of obtaining a 3D printer.
- Only suitable for non safety critical parts.
- 3D printed parts physical properties might be different to those of the original.
- Some plastic filament materials are not suitable for printing without suitable ventilation.

ANY QUESTIONS?

ALREADY HAVE 3DP EXPERIENCE?



Please share your experience during the discussion session on the 3DP table