AMRC
Design and Prototyping Group

Case study

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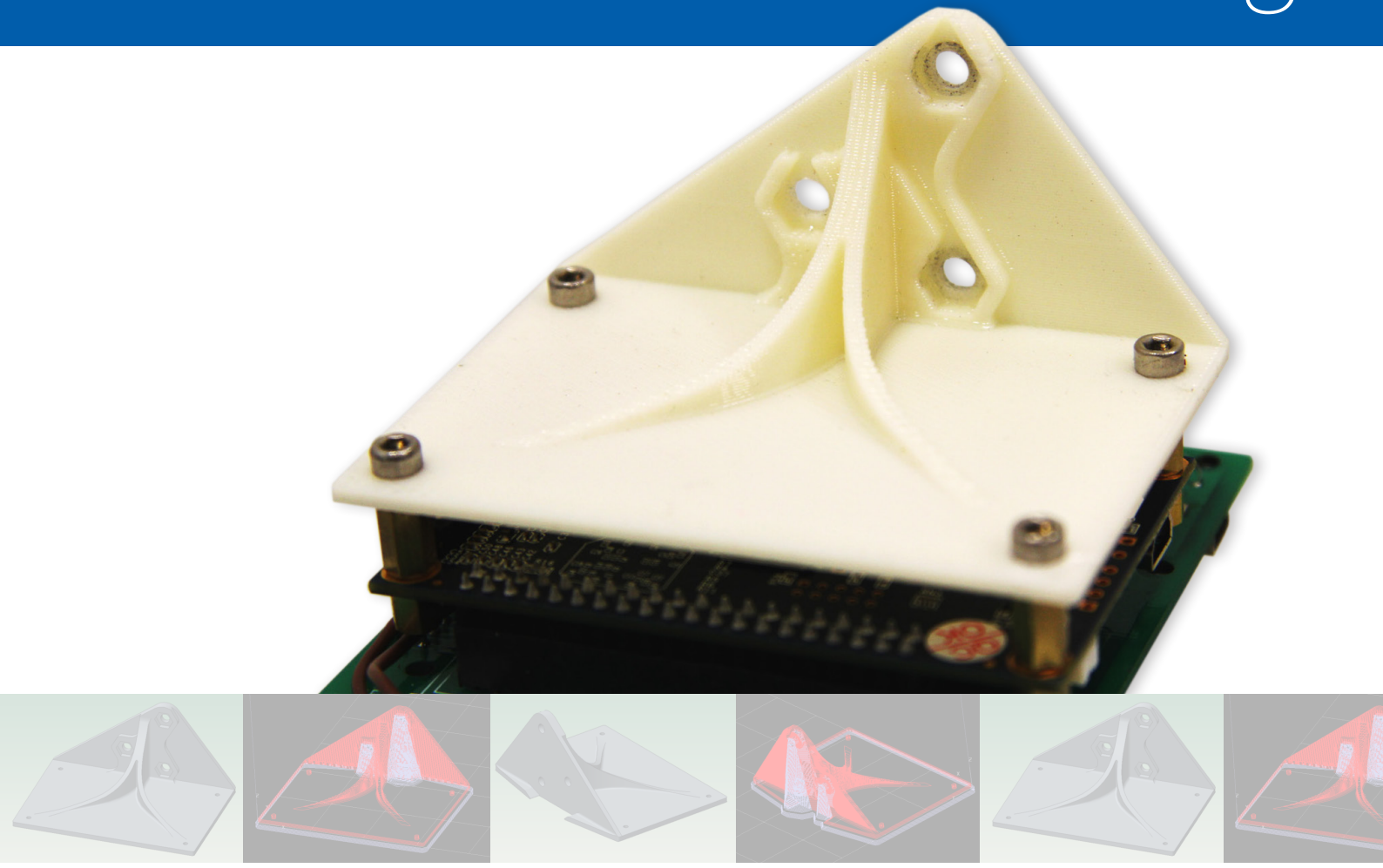
Optimisation of a circuit board bracket for additive manufacturing



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Optimisation of a circuit board bracket for additive manufacture

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Summary

The AMRC Design & Prototyping Group designed and manufactured a circuit board bracket as part of a larger development project. The bracket was designed and manufactured very quickly to mount a new circuit board measuring 56 by 80 mm neatly and securely to the prototype device, using existing mounting points. The bracket was designed and optimised for additive manufacture using fused deposition modelling (FDM) in approximately two hours, and printed on a Stratasys U-Print SE Plus in 46 minutes. Without optimisation, this part would have taken one hour and 44 minutes to print. The optimised design of this bracket significantly reduced print time by removing the requirement for support material in the main build.

Initial bracket design (non-optimised)

- **Print time:** 1 hour 44 minutes
- **Model material:** 15.36 cm^3
- **Support material :** 5.94 cm^3

The initial design featured curved reinforcing ribs and through-holes on both flat faces to fix the circuit board to the bracket (the four smaller holes) and the bracket to the prototype (the three larger holes). The mounting holes for bolting to the prototype have hexagonal recesses for nuts to allow for easier assembly with fewer tools. The model is shown in Figures 1 & 2.

This model was processed using CatalystEX software. This generated toolpaths for support material to support the horizontal holes and the upper parts of the nut recesses, as shown in Figures 3 & 4.

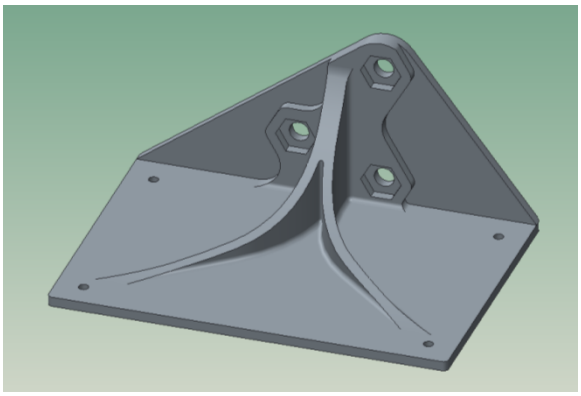

Figure 2

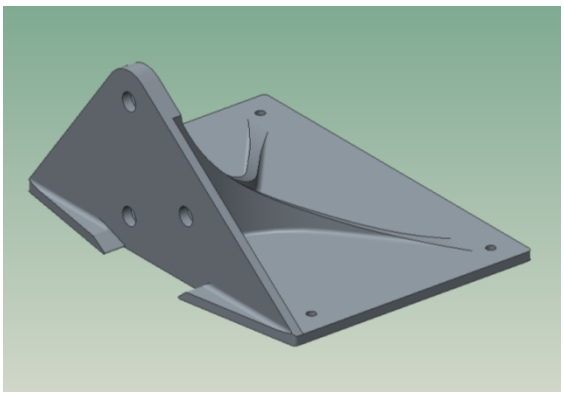

Figure 1

Screenshots from design software showing 3D representation of the initial circuit bracket design.

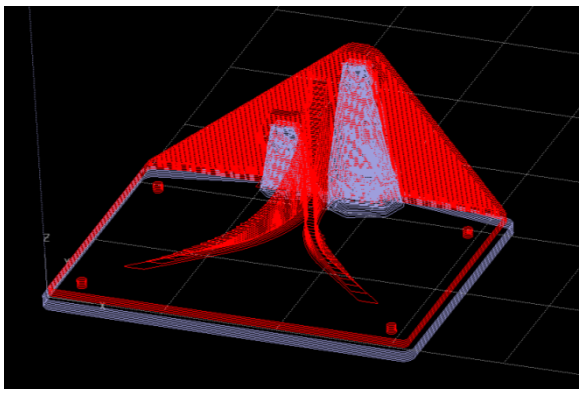

Figure 3

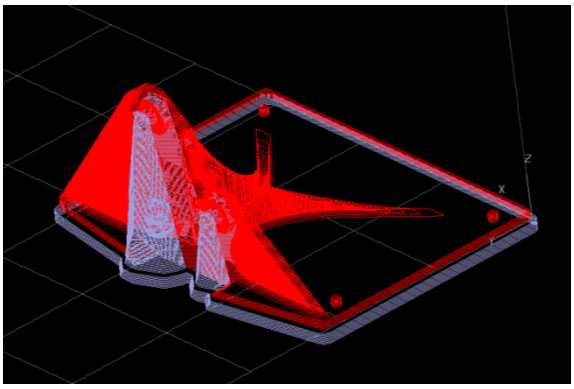

Figure 4

Screenshots from CatalystEX showing model material outline (red) and support material outline (white).

Optimised bracket

- **Print time:** 46 minutes (reduction of 58 minutes, 56%)
- **Model material:** 15.28 cm^3 (reduction of 0.08 cm^3, 0.005%)
- **Support material:** 4.61 cm^3 (reduction of 1.33 cm^3, 22.4%)
- **Total cost reduction:** 40%

The optimised bracket shares the same external dimensions as the original bracket and has the same reinforcing ribs – however, the build time was considerably reduced by identifying which features of the model required additional support material, then modifying these features to remove that requirement. The bracket had two types of feature that required support material:

- The top horizontal face of each nut-retaining recess.
- The three horizontal holes for the bolts to pass through.

When these had been identified, different methods were used to remove their dependence on support material for build. These methods were based on the knowledge that overhanging features can be produced on the U-Print SE Plus at an angle of up to 30 degrees from vertical.

The nut recesses were redesigned with five sides which retain the nut. The top face, which required support, was removed completely. Each nut recess finishes with a small opening at the top edge of the part, so no support material is needed to produce the top face of the recess, as shown in Figure 5.

The horizontal holes were removed and replaced with centre marks, and the holes drilled manually after printing. The centre marks were chamfered at a 30 degree angle to the vertical face, so that they wouldn't cause support material toolpaths to be generated. Figure 6 shows that the back of the upright wall of the bracket is flat with no features or detail. The centre marks for the holes which were drilled after printing are shown in Figure 5.

Figures 7 & 8 show how these changes affect the toolpath generation for build and support material. Compared with the initial design shown in Figures 3 & 4, there is now no need for support material to produce the features on the upright wall.

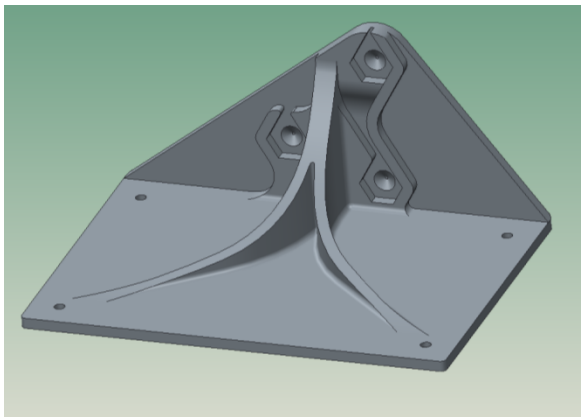

Figure 5

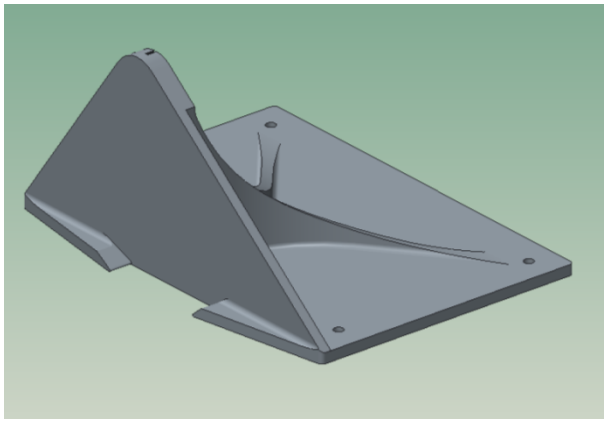

Figure 6

Screenshots from design software showing 3D representation of the optimised circuit bracket design.

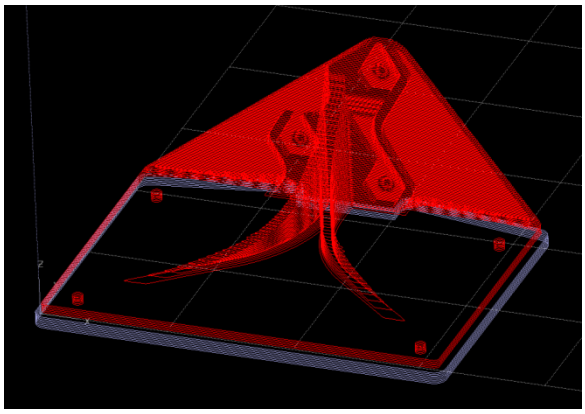

Figure 7

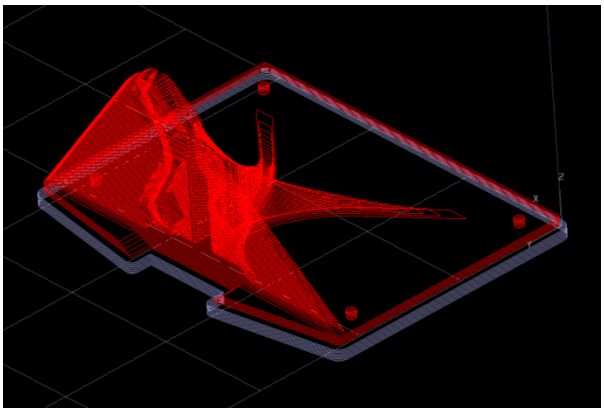

Figure 8

Screenshots from CatalystEX showing model material outline (red) and support material outline (white).

Conclusion

This study demonstrates how build times for producing parts by FDM can be significantly affected by small changes to the design, and that build times can be significantly reduced by removing features that require support material.

Redesigning this bracket reduced build time by 56 per cent. The project also shows that the reduction in build time isn't proportional to the amount of support material saved – just 22 per cent less support material was used, as support material must always be printed between the print bed and the part to allow the component to be removed after printing. Printing support material does increase build time, but most of the additional time comes from the need to change heads between build material and support material for each layer.

This study also shows that, although FDM allows finished parts to be produced straight from the printer, build time can be reduced with minor post-processing operations. If the horizontal holes in this part were produced during printing, they would require support material and build time would still be around one hour and 40 minutes. The post-processing – drilling three holes at 4mm diameter – took less than five minutes, so the total production time is much less than if the holes were included in the print geometry.