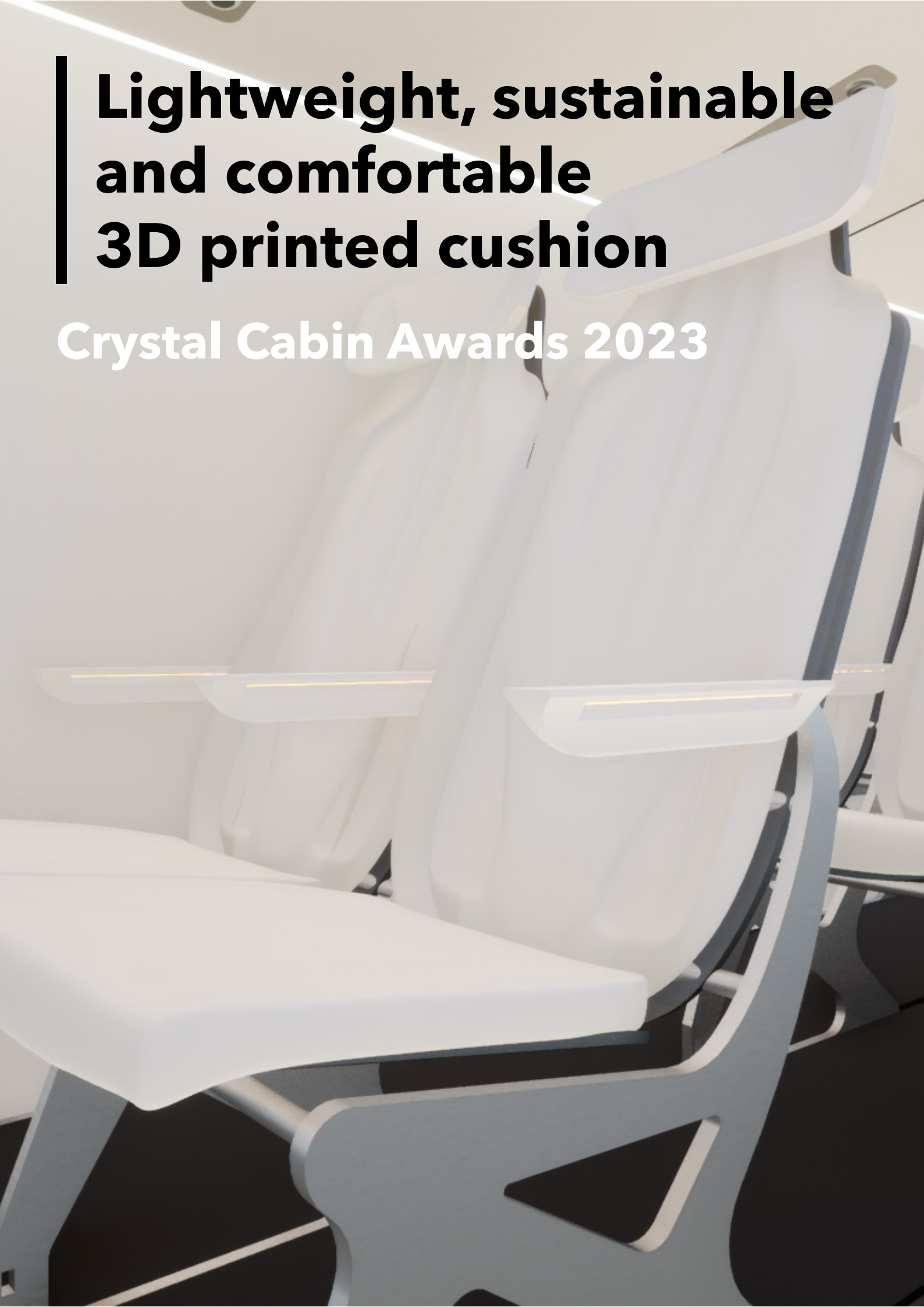
Lightweight, sustainable and comfortable 3D printed cushion

Crystal Cabin Awards 2023



This seat is developed for the Embraer electric aircraft with hydrogen tanks, a fuel cell and propellers. The current Embraer e195e2 fuselage will be used in this airplane. It will be a short to medium distance airplane. (Embraer, 2022). To enlarge the range of this short/medium distance airplane, the current interior of the aircraft should be more lightweight.

The designed seat is lightweight, comfortable and sustainable.
Lightweight because, the cushions of the seat are made of flexible thermoplastic elastomer TPU-98A via Fused Deposition Modelling (FDM); a specific 3D printing technique. Via this technique 'shape memory' can be implemented, the shape returns to its original form after deflection. By using different infill percentages of a gyroid structure (figure 1) in the seating, different parts of the body can be supported. And these different infill percentages mean that there is an overall weight reduction of the cushions. With 15% the body parts that need more support are supported; this means that just 15% of the material has to be used in this area. The same goes for 10% and 5%. The 3D printed cushion is lighter compared to a conventional cushion of a KLM city hopper recaro SL3170. The weight of this cushion with connections is 1.7 kg. The weight of our cushion is 115 grams.

Figure 1: Seat pan with different infill percentages to support different parts of the body; this method can also be used for the backrest.

These cushions also contribute to the ergonomic comfort of the passenger. By applying higher and lower infill percentages, based on pressure maps and ideal seat shapes (Zenk et al., 2012) (Fiorillo et al., 2021), the pressure distribution is focused at more comfort for each passenger (figure 2).

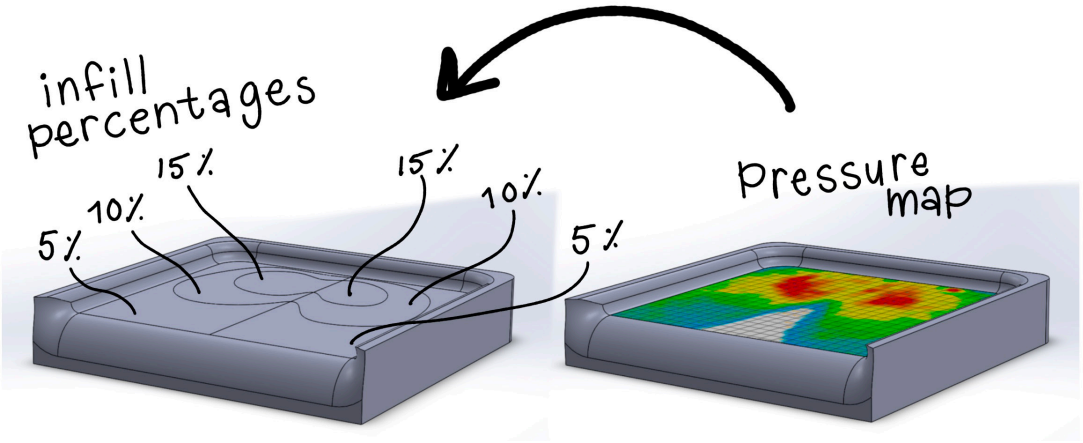


Figure 2: Combined pressure map and seat shape.

For the curve in the backrest, sizes are used based on research from Carcone & Keir (2007) and Korte (2013). The angle in which a person sits, is based on research from Goossens (1996). Sizes such as width and height are based on our own research. This is also why there are some cut outs in the lower and higher part of the backrest (figure 3). We found that this material does not have a concrete function, but it was easier to produce. With FDM this does not have to be taken into account, so the seat can have curves and cut outs.

Figure 3: Highlighted cut outs in the seat.

The top layer of the chair is made of cactus leather, this is leather made of cacti and can be harvested without killing them and in half a year a new skin is produced (figure 4). It is highly durable and gives users an expensive feel. Next to this, it also grows in Brazil, close to the Embraer plant. The only thing that should be done to make it applicable in aircrafts is a coating for flammability. This brings us to sustainability, because the 3D printed cushions do not need coating to make them flame retardant, they are self-extinguishing. They can also be reused for 3D printing at the end of their life.

Figure 4: The top layer is made from cactus leather, grown locally in Brazil (close to the Embraer plant).

The seat (cushions and top layer) can already be used on a conventional frame, a frame that is currently used in the short/medium distance airplanes. This way the new cushions can be implemented after certification, in planes that are already in use.

Not only passengers benefit but there are economic benefits as well. The market on which our innovation focusses is short/medium distance flights. The TPU printed cushioning lasts longer than the current foam, so replacement does not need to happen that often. Next to that, they not only last longer but the quality will also remain high for a long period of time. The seats can be implemented on the frames that are currently being used in these airplanes. So, our innovation is easy to adapt and implement in planes that are currently flying.

The current development status of this innovation is TRL level 3-4, the complete seat and corresponding aircraft interior, with the right sizes are made in CAD (figure 5). Next to this, there is a 3D printed model of the TPU FDM printed part of the seat pan, which is shown in figure 6. The seat pan proves that this FDM 3D print technique can be used for printing replacements for cushioning. There are no patent and certification requests pending.

Figure 5: A render of the VR inside the CAD model of the interior.

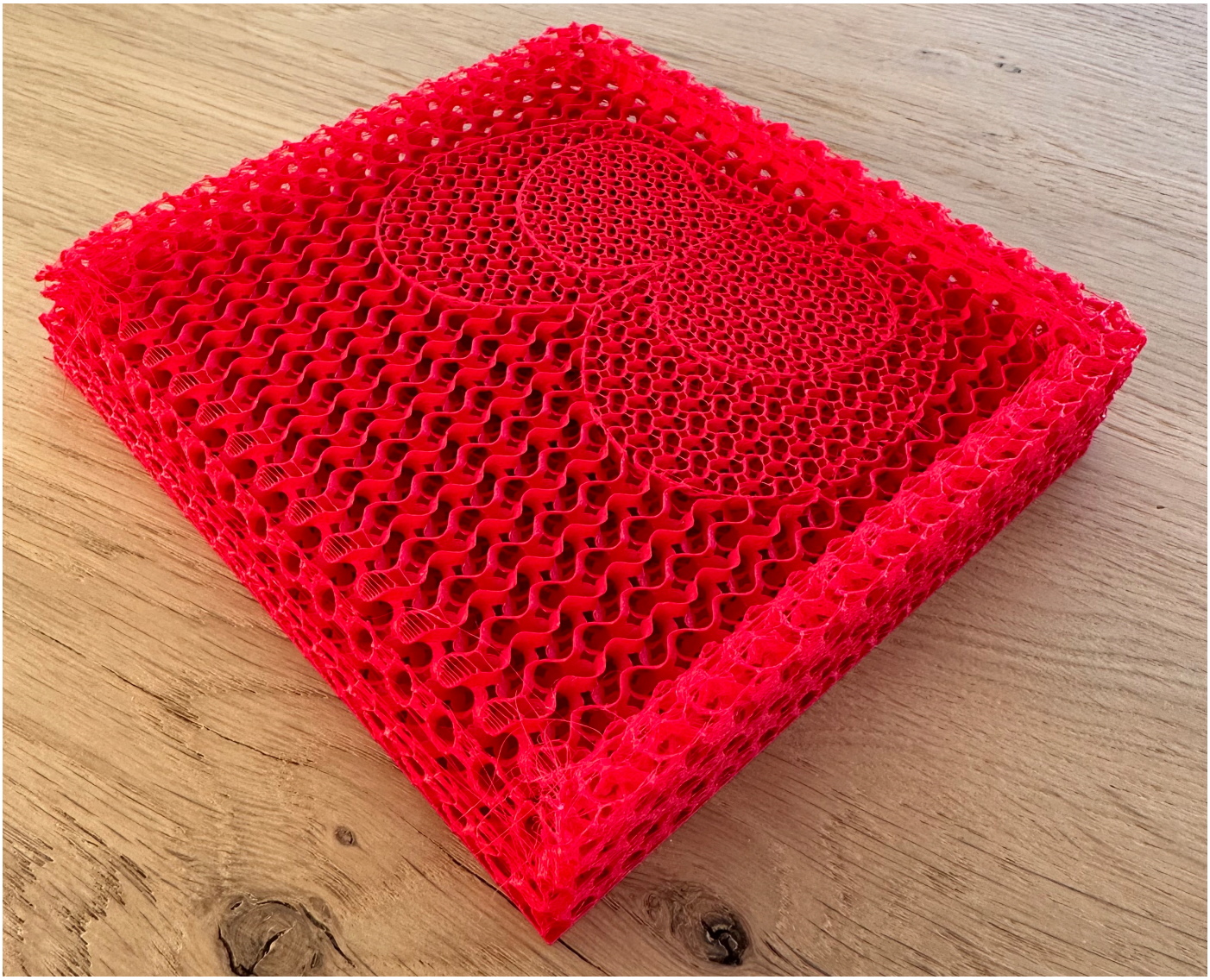


Figure 6: TPU FDM printed scale model 1:3 of the seat pan.