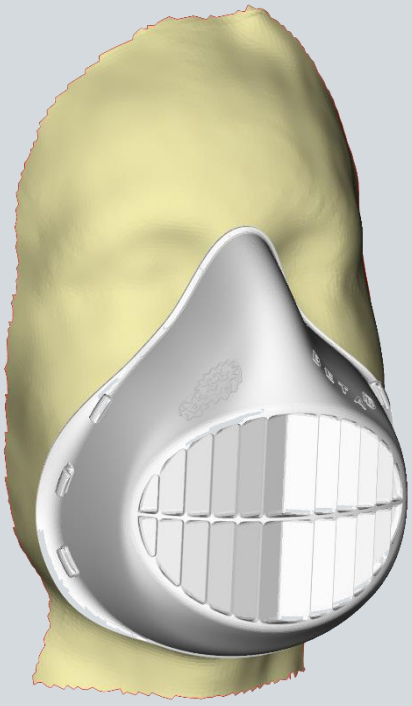
Laboratory of Machine Elements and Machine Design
of Aristotle University of Thessaloniki

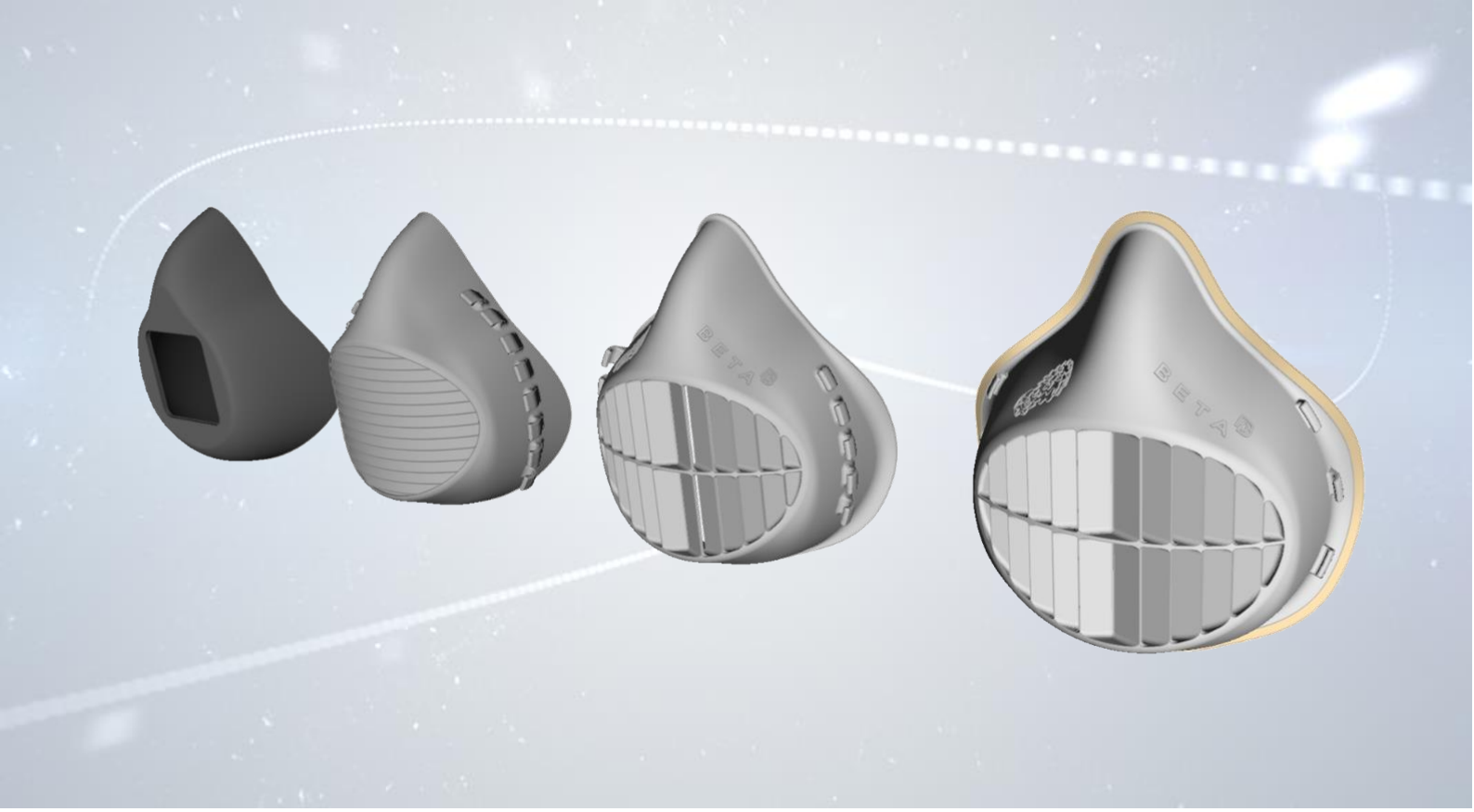
User-specific reusable high protection mask

From helping to address the medical equipment shortages during the COVID -19 pandemic, to the creation of a future oriented, personalized, and reusable high protection, 3D-printed mask.

With the COVID – 19 pandemic soaring, medical personnel were exposed to high risk due to shortages in protective gear. Offering them support, several organizations and individuals, exploited their expertise to design, build, and offer the urgently needed medical equipment. The development of a high protection mask is such an initiative between the **Laboratory of Machine Elements and Machine Design, of the School of Mechanical Engineering** of the Aristotle University of Thessaloniki and BETA CAE Systems.
The aim was to develop a very high protection mask, which would initially be provided to the AHEPA hospital of Thessaloniki, a designated coronavirus reference hospital.

We all have seen the pictures of hardworking hospital personnel with the sores and marks on their faces. They were caused by the high pressure applied from the mask, which was necessary to provide for effective sealing. Aiming at reducing this drawback, the design team decided to extend the filter up to the mask frame border. In this way, no pressure on the sensitive face skin is required.





In fact, the mask stays in place by simple, adjustable Velcro straps; elastic bands around the ears are not needed any more. Moreover, the filter material is far more skin-friendly than plastic.
Starting from a Template Face Model the first prototype was created using an EOS SLS 3D printer. Although a successful endeavor, improvements at the mask's body could be made to achieve better fit comfort and implement design changes at the blinds, as proposed by the medical team of the AHEPA hospital.

Eventually as each mask body would be 3D, printed it was possible to create a personalized reusable mask, tailor made for each doctor or nurse, having to only change the filter, which is easy and cost effective at the same time.

Ultimately this mask will also find post COVID – 19 use, as protective masks are needed when working in harsh environments.

This joint effort was made possible by the software tools of BETA CAE Systems and the expertise of the engineering team of both the Laboratory of Machine Elements and Machine Design and BETA.

Challenge

The fast design of a protective face mask with the ability to adapt to a human face, intended to be specifically used by medical personnel treating COVID-19 patients in intensive care units.

The design adaptation and production process must be applicable for small groups of 10-50 persons and should be completed within a short time margin.

The design adaptation process must be streamlined, with minimal user input.

This joint effort was made possible with the software tools of BETA CAE Systems and the expertise of the engineering team of both the Laboratory of Machine Elements and Machine Design and BETA.

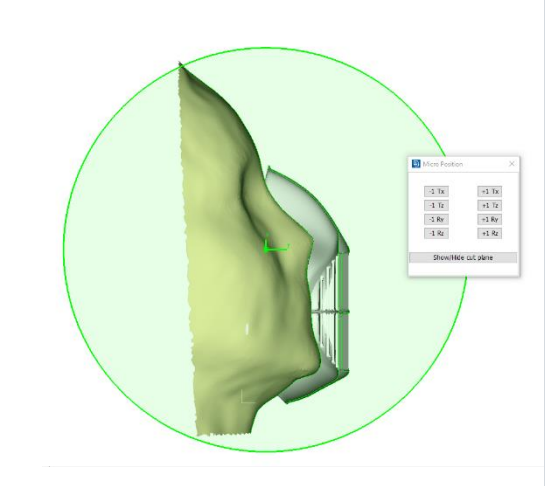
Approach

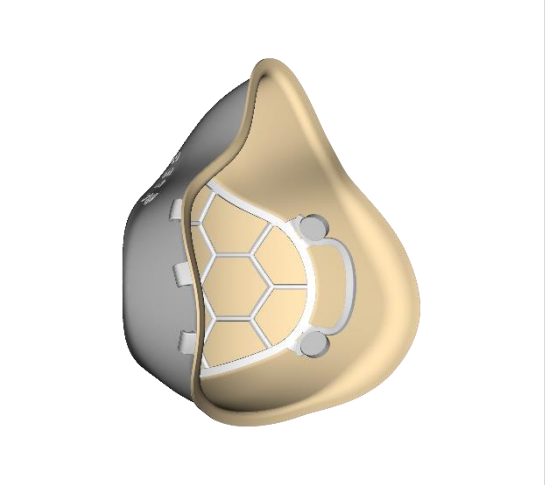
A template mask shape was designed in a CAD system with two discreet zones, a non-deformable fixed zone at the front, and a morphing zone at the rear and around the circumference in touch with the face.

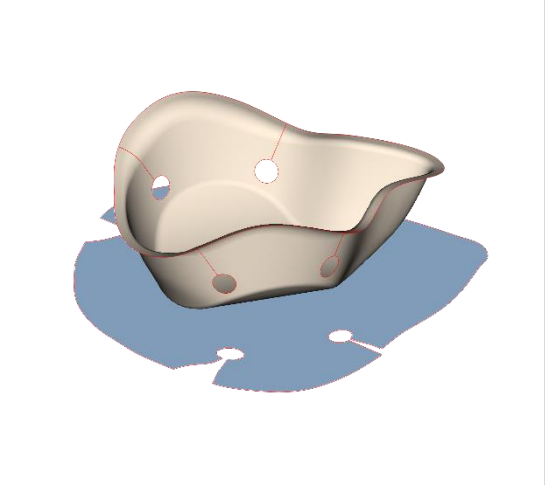
The face of the user is 3D scanned using a handheld device and the generated STL files were imported in ANSA. And the design was completed in the following three steps:

1. Geometry treatment
The geometry is checked, and any imperfections are treated through automatic fixing algorithms. In case of surface noise, the mesh is improved via dedicated algorithms.
2. Positioning
Each face shape is positioned to fit in the initial mask shape at its design position by a custom developed script.
3 Morphing
The mask was designed considering the final step would be morphing. A characteristic feature line is imprinted. This line is used by the morphing algorithm and is fitted on the geometry of the scanned face. Then pre-defined morphing is executed, and the mask shape is adapted to the face. The entire morphing process is automated through script with minimum user interaction and is fully customizable.

The updated designs are then exported to a 3D print compatible file format and the production can start.







Results

The procedure followed, resulted not only in a successful design of a face protection mask, but also demonstrates the huge potential of the highly intelligent software tools and the modern 3D printing processes on the product development may have

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