

# Washington State University Vancouver

## Hybrid Face Mask / Face Shield Design

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### ***Project Statement***

In the year 2020, the world was faced with the global Coronavirus/COVID-19 pandemic which brought a variety of healthcare and economic challenges the world has never experienced in the last decade. Because of this global dilemma, this year's SME Digital Manufacturing Challenge focuses on implementing 3D printing and additive manufacturing technology to relieve the world's need for rapid medical response.

According to the World Health Organization [1], a face mask is the simplest personal protective equipment that limits the transmission of SARS-CoV-2, the virus that causes COVID-19. For this project, a 3D-printable hybrid design that combines a face mask and a face shield was developed as an inexpensive and readily scalable solution to face shield needs during a pandemic or medical crisis.

### ***Functionality and Durability***

The hybrid face mask/face shield design combines the filtration of a facemask and protection against aerosol projectiles through the face shield. This design features only two main components: the face shield, and the headband. The headband also includes the ability to adjust the fit to the user. The first component is the face shield, it is designed to have a slot that could be used with the mounting points to mount onto the connecting point of the headband. It is made out of thin sheet plastic which is easy to cut and can be cut at a manufacturing scale using die cutting techniques or more simply, by an at-home user using a blade or scissors. The next component is the headband. The headband is the frame of the whole product since all the components of the design are mounted to it. It features a band that wraps around the wearer's head to prevent the headband from sliding forward due to the tension of the facemask. The headband should be thin enough that it can be printed in just under two hours. Since one of the goals of the new design is to improve comfort, so the shape of the mask is conducive to wearing a mask in conjunction with a mask. The loops of a mask can be fitted around the headband and it prevents back-of-ear chafing. The whole assembly is also so light that it also doesn't wear on the user. It is also made of polymers so that it can be sanitized with soap and water.

### ***Cost-benefit/Value analysis***

Today, hospital personnel use face shields everyday, using anywhere from 1-3 face shields a shift. Assuming the average personnel size for a hospital of 982 workers, approximately 982 to 2946 units are used per day [2]. Current face shields used in hospitals cost approximately \$0.65 per unit when bought in bulk [3]. The face shield designed by Washington State University Vancouver students uses 11 grams of plastic, bringing the cost of the frame to \$0.20 per unit assuming a cost of \$18/kg of commercial commercial-grade PLA. This means 90 units can be printed from 1kg of commercial grade PLA. The face shield can be bought in bulk by buying plastic rolls and cutting the plastic face shield into the desired shape. The plastic can be bought in bulk, bringing the cost of the plastic face shield to \$0.22 a unit [4]. The cost of the plastic face shield and 3-D printed frame brings the total cost to \$0.42 / unit. The major advantage of this design is its quick print time of approximately 1 hour 45 minutes per unit. This quick print time is due to the whole face shield being designed to print in multiple parts flat and then utilizing the flexible features of thin PLA to shape into the frame of the face shield. Minimizing the amount

of time needed to print out the frame by minimizing the number of layers that need to be printed. The footprint of the print itself is approximately 6x6 inches allowing this print to be printed on most amature sized printers.

### **Material Selection**

In the prototyping stage of the design, TPU and PLA were the two filaments that were considered to be used for printing the headband. PLA is readily available and in thinly printed sections is flexible enough for flat prints to behave in a curved manner. TPU is a flexible material that should provide additional comfort and flexibility. During prototyping, face shields printed using TPU had trouble mating together, due to the ductility of the TPU. For the sake of the current design, PLA will be used as the primary type of plastic. When using PLA, the multi-piece headband can be printed in 1 hour and 45 minutes while using 8.89 cm<sup>3</sup> of PLA which translates to 11 g.

### **Utilization/Justification of DDM Processes**

The DDM process used for the design is fused filament fabrication (FFF), which is a form of 3D printing. FFF can be used to rapidly manufacture the headband for hybrid face mask/face shield design due to its minimal thickness, which is why it is suitable for direct digital manufacturing. The frame of the face shield is able to be printed in 1 hour and 45 minutes which is due to the whole frame being printed flat on the bed, minimizing the number of layers printed. With this short print time, one could print multiple copies of the headband which can be used as a mounting point for a face shield and a face mask. Figure 1(a) shows the flat printed parts of the multi-piece headband design. The use of a direct digital manufacturing process such as FFF for the design allows for scalability which can range from personal, local to large scale. On the personal scale, consumer-grade 3D printers can be used to print the headband and scissors can be used to cut the face shield from a single sheet of plastic. On the local scale, the design of the headband can be sent to 3D printing farms to be printed and the face shield can be die-cut [5]. Finally, the large scale manufacturing involves making a mold for the headband which can be used to easily cast the headband. For this year's SME Digital Manufacturing Challenge, rapid response to medical situations is the main focus. With the ability to print the multi-piece headband in a short period of time, a direct digital manufacturing process such as FFF is very much suitable for this design.

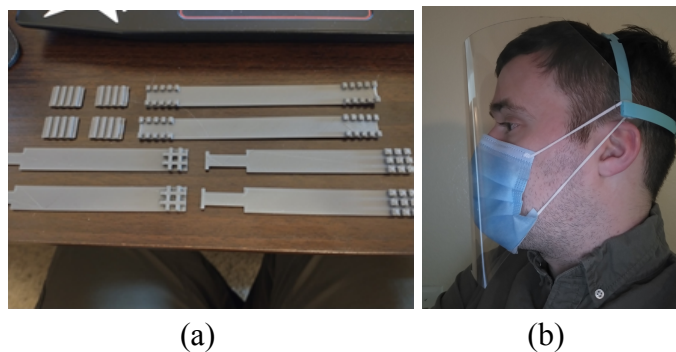


Figure 1. (a) Printed multi-piece headband. (b) Hybrid face mask/face shield design.

### ***Design Integration and Innovation***

To disseminate the design on the personal scale, the design will be made available through open-source CAD websites such as Thingiverse or GrabCAD. This allows for continuous improvements since consumers can take the files from the open-source CAD websites and make improvements as they see fit. On the local scale, the design will be sent to Slant 3D, the largest 3D printing farm in the U.S., with more than 800 fully automated 3D printers operating 24/7 [6].

### ***Marketing and Logistics/distribution***

For the scalability portion of this project, there was a consideration for ease of manufacture. The more complicated a component becomes, the harder the headband is to be injection molded. Designing for a 3D printed part is different from a part that is made out of a mold. So although this can be 3D printed, it is also designed flat so that if it is scaled up to mass production. This means that it can be sourced locally in smaller batches and as demand moves up the initial demand can partially met using 3D printing and then mold making can be spooled up in response to demand. Another form of marketing for the headband is placing free STL files on Thingiverse, GrabCAD, and Cults3D that way people with 3D printers have access to print the headband.

### ***Social and Environmental Impact***

This mask is a low-impact item, it is meant to be reusable and cleanable. If there is any component breakage, individual parts can be reprinted in order to replace them. The material, PLA, is also a thermoplastic, so it has the potential to be recycled. The most environmentally harmful component is the face shield. The face shield polymer is potentially replaceable but depending on the type used it may be something that ends up in landfills over time.

The expected social impact is akin to the original “ear saver”. The design is simple and something that anybody can use. It’s meant to make things more comfortable and keep costs down. It should be met with a generally positive attitude due to the overall helpful nature and consideration for the end-user. Releasing the 3D model will also allow savvy users to adjust the design to meet their personal needs. Another social impact for the face shield/ face mask headband is this allows for safer gatherings of people while allowing people to have personal protection equipment for today's global pandemic and also makes people feel comfortable and safer to be in public places.

## References

- [1] COVID-19: Considerations for Wearing Masks. (n.d.). Retrieved from <https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/cloth-face-cover-guidance.html#:~:text=Masks are a simple barrier,you do not feel sick.>
- [2] “Industry Market Research, Reports, and Statistics.” *IBISWorld*, [www.ibisworld.com/industry-statistics/employment/hospitals-united-states/#:~:text=How%20many%20people%20does%20the,the%20US%20has%20982.0%20employees.](http://www.ibisworld.com/industry-statistics/employment/hospitals-united-states/#:~:text=How%20many%20people%20does%20the,the%20US%20has%20982.0%20employees.)
- [3] “Face Mask Shield Buy: Face Mask Shield Protector - Customlanyard.Net.” *CustomLanyard.net*, [www.customlanyard.net/face-shield-5603-nproducts?sale=1&tpage=PPESALE&gclid=CjwKCAjwvMqDBhB8EiwA2iSmPGb\\_pul-jZ9eNmPOrnrm8FdUjFiOjdv7eWwdXNsW0pquNjtc6yKofxoCQCQQA\\_vD\\_BwE.](http://www.customlanyard.net/face-shield-5603-nproducts?sale=1&tpage=PPESALE&gclid=CjwKCAjwvMqDBhB8EiwA2iSmPGb_pul-jZ9eNmPOrnrm8FdUjFiOjdv7eWwdXNsW0pquNjtc6yKofxoCQCQQA_vD_BwE.)
- [4] “72’ 6 Gauge Clear Vinyl - 15 Yards.” *OnlineFabricStore*, [www.onlinefabricstore.com/72-inch-6-gauge-clear-vinyl-15-yards-.htm?gclid=CjwKCAjwvMqDBhB8EiwA2iSmPMrZSHtKf9UBXdHkuhiGoTAFUkjITMIWWYmyTHFLff2gMEN\\_Xy\\_QbBoC7kQQA\\_vD\\_BwE.](http://www.onlinefabricstore.com/72-inch-6-gauge-clear-vinyl-15-yards-.htm?gclid=CjwKCAjwvMqDBhB8EiwA2iSmPMrZSHtKf9UBXdHkuhiGoTAFUkjITMIWWYmyTHFLff2gMEN_Xy_QbBoC7kQQA_vD_BwE.)
- [5] “High Volume 3D Printing Service.” *Slant 3D Production 3D Printing Service*, [www.slant3d.com/](http://www.slant3d.com/).
- [6] Bentz, Gabe. “Slant3D.” <https://www.slant3d.com/about.html>

Appendix

Bill of Materials for Multi-Piece Headband

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Top band		2
2	Side band		2
3	Back Bands		2
4	Cap		4

		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES		DRAWN	JC 4/20/21
		TOLERANCES:		CHECKED	
		FRACTIONAL ±		ENG APPR.	
		ANGULAR: MACH ± BEND ±		MFG APPR.	
		TWO PLACE DECIMAL ±		Q.A.	
		THREE PLACE DECIMAL ±		COMMENTS:	
		INTERPRET GEOMETRIC TOLERANCING PER:		TITLE: <b>HEADBAND EXPLODED VIEW</b>	
		MATERIAL PLA		SIZE	DWG. NO. <b>A 042021A</b>
		FINISH		REV	
NEXT ASSY	USED ON	APPLICATION		SCALE: 1:4 WEIGHT: SHEET 1 OF 1	
		DO NOT SCALE DRAWING			

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