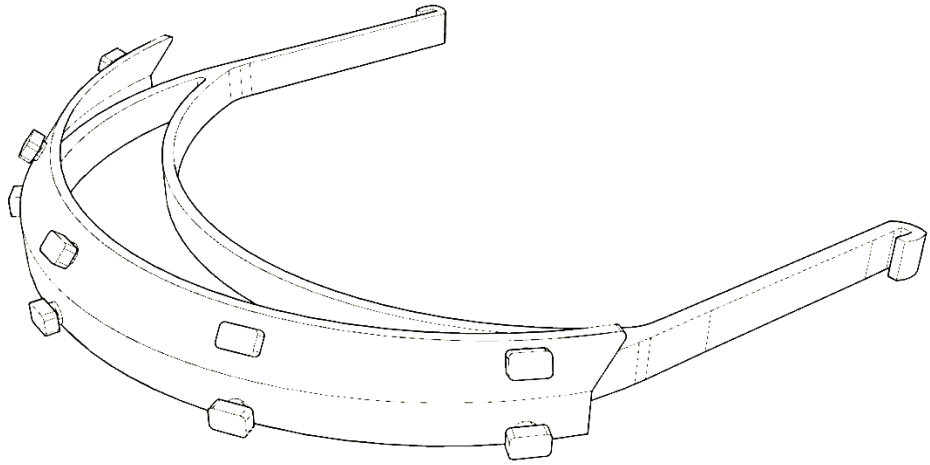

Title/name: ASU v4.1 / 3D Printed Protective Face Shield Headband
Model ID: NIH # TBD

3D-printed headband for protective Face Shield

This latest iteration of the ASU 3D printed headband (v4.1), has been designed as a support for a flexible face shield "lens" and a flexible "cowl" to protect front-line health workers from toxic aerosols and splatter.

ASU v4.0. (update: v4.1 features improved retainer "tang" design).

Other designers (e.g., NIH ID 3DPX-013359) have incorporated a "cowl" or shield to cover hole in top of mask assembly as part of the head band design, but this has added significantly to the "build-times" using standard home 3D printers.

In any case, many designs currently circulating on the Internet leave gaps at the top of the mask, exposing workers to aerosols and splatter. Our recommendation is to utilize either the currently available design (3DPX-013359) on the NIH 3D Print Exchange or utilize this design which can be printed in less than half the time (less than 3 hours). This design incorporates features from the Prusa RC3 (3DPX – 013409), a French design called "Noisettetbou" (originally found on the Prusa website, but no longer available), the design by TPrestero on the NIH site (3DPX-013359), and a number of our own improvements including the following: reducing vertical dimension to improve print time, incorporating angled support ring to hold both a face shield or (optional) protective cowling, improved temple hooks, improved retainer/tang design and number to better secure thicker lens materials, and a simplified side profile (no slots or additional printing).

Recommended material is PLA (Poly Lactic Acid) due to low cost, material availability, bio-compatibility, and ease of 3D printing on low end home printers. PLA has become a popular material due to it being economically produced from renewable resources. This bioplastic is a polyester made from fermented plant starch typically derived from corn, cassava, sugarcane, or sugar beet pulp.

Each unit (the head band alone), if made in low cost PLA (~$20 a KG reel with approx. 46.5 cubic inches of material), would be less than $1.00 (US) produce. One 1 KG reel should yield 23 – 25 headbands. With lens, strap, and cowling, the whole assembly can be made for around $3.00 each. This will not hold up to sterilization by autoclave so must be cleaned by alternate approved methods.

Higher end (non-degradable) plastic (e.g., ABS, Nylon 12, or Polycarbonate) is desirable for long term use; however, the price for head band alone will be around three times as much or about $3.00 (US). ($3.00 + strap/lens/cowling = $5.00) and requires access to higher end 3D printers that can handle higher heat requirements and finicky "professional" filaments (which are inclined to warpage and high shrink rates).

For purposes of communication, planning, and budgeting, a unit price of $5.00 (materials cost only… this does not include equipment, personnel, space, utilities or other costs) is a reasonable estimate at current materials prices as of the date of this upload — irrespective of 3D printer used.

Dimensions of outer envelope of 3d-printed headband is as follows:

- Width: 189.92 mm (~7.5 inches)
- Length: 173.19 mm (~6.8 inches)

- Height: 20.56 mm (~.8 inches)

Weight of headband (3D printed part): less than 1.5 oz.

FUTURE CONSIDERATIONS

Create separate .stl files that carry labeling specifying what material the head band is made from and dimensional info about cowling and face shield lens. Alternatively, a website with this info could be printed directly into the head band.

IMPORTANT:

- Print in a clean environment free of dirt, hair, food/drink, and other possible contaminants
- Wear gloves and a face shield whenever handling printed parts
- When part is complete, store in a closed box or bag

NIH Category: Labware & Devices

PRODUCT POINT-OF-VIEW

Healthcare workers responding to COVID-19 who face PPE supply gaps while waiting for domestic face shield production to catch up with demand NEED a transparent face shield that limits aerosol and splatter exposure from in front and above, while providing top ventilation. Other designers (e.g., 3DPX-013238) have incorporated a "cowl" or shield to cover hold in top of mask, but many designs leave gaps at top of the mask, exposing workers to aerosols and splatter. Both front and top shielding is necessary to reduce aerosol and splatter exposure on N95 and other face masks. This design is re-usable for a single user (can survive multiple daily washes; transparent visor can be replaced from readily sourced materials when worn out), is easy to fabricate within a few days of design approval (i.e. no complex supply chains or production bottlenecks), is comfortable to wear, extremely light weight (full assembly is under 4 oz) and easy to don and doff (as it will be taken on and off dozens of times in a twelve-hour shift), and provides protection to broader area of face compared to standard safety goggles or glasses.

BILL OF MATERIALS

3d-printed headband in PLA, roughly 50g/1.75oz per part.

Dimensions of fully assembled face shield with cowling and front lens is 255 mm high, 230mm wide, and 170 mm deep.

Print time is less than 3 hours per part on an inexpensive home 3D printer (e.g., Ender 3) using following settings: 3 walls, no infill, manually set low resolution (e.g., .30 resolution) and limited supports (for pins on front of headband only), and a print speed of 55 mm/sec. Standard nozzle with .4 mm orifice where the plastic filament diameter is 1.75 mm.

Acceptable alternate 3d printing materials include PETG, ABS, ASA, Nylon, Polycarbonate(PC).

Elastic for the headband: Currently using “Knit Non-Roll Elastic” manufactured by Dritz in 1” width. Could be 7” x 1/8” rubber bands, 13” strip of 3/4" wide buttonhole elastic, coflex/coban tape, or similar.

A standard US letter-sized transparency or report-cover is used for the shield’s front lens, 2-10mil (0.002-0.01”, 0.05-0.25mm) thickness is minimal lens thickness. Acceptable alternative materials include clear PETG, PMMA or mylar in the same thicknesses cut to ~8.5” x ~9.75” (216 mm x 246 mm).

Holes can be made using US-style single-hole hand-held punch: five 6 x 8 mm “elongated” holes (produced by “double punching” 2 overlapping holes) with the mid-point of each elongated hole spaced 55 mm apart.

See below for specific transparency recommendations.
Options:

Clinicians and caregivers who have worn the device on service recommend the following additions to the headband to improve comfort: add a wrap of foam tape or "chest tube foam tape", tape layers of gauze or a folded paper towel on the headband; dispose as necessary. If using thinner materials for lens such as 2-10mil (0.002-0.01”, 0.05-0.25mm)add tape (duct tape, medical cloth tape, etc) to reinforce the holes at top of the transparency sheet during repeat use and washings. Remove and replace tape between patients as necessary. It is recommended that thicker clear lens material in the .3 - .5 mm range would be a better choice and not require addition of reinforcing tape.

INSTRUCTIONS FOR USE & ASSEMBLY
Punch holes in standard US letter-sized transparency (~8.5x 9.75 in) with a standard US hand held hole punch.
Attach transparency to headband on the five mounting “tangs” starting with middle tang and working out to the edges.
Attach elastic to headband with hooks near temples, adjust to fit. Some users may find 7” rubber band too tight, consider chaining elastic bands as necessary.

To clean, follow CDC recommendations in Strategies for Optimizing the Supply of Eye Protection - Selected Options for Reprocessing Eye Protection. DO NOT submerge or soak 3D-printed headband in cleaning solution as the headband may absorb the solution and leak it out onto the wearer’s forehead over time. Do NOT insert in autoclave or other high-temperature device as PLA will distort (ABS, Nylon 12, and PC can tolerate higher sanitation procedures). Alcohol (Isopropyl 91) can be safely used to disinfect PLA surfaces.

Discard and replace the transparent visor as appropriate, after excessive wear or fogging.

FDA REFERENCES
FDA 2017 - Technical Considerations for Additive Manufactured Medical Devices
FDA 2020 - Personal Protective Equipment for Infection Control

FDA 2020 - Face Mask For General Public/Healthcare Personnel Per Iie Guidance (product classification)
FDA 2020 - Coronavirus (COVID-19) Update: Daily Roundup March 26, 2020
FDA 2020 - FAQs on 3D Printing of Medical Devices, Accessories, Components, and Parts During the COVID-19 Pandemic
CDC GUIDELINES
CDC Eye Infection Control Recommendations
CDC - Interim Infection Prevention and Control Recommendations for Patients with Suspected or Confirmed Coronavirus Disease 2019 (COVID-19) in Healthcare Settings
CDC - Guidelines for Disinfection and Sterilization in Healthcare Facilities
CDC - PPE Donning and Doffing Sequence
CDC 2020 - Strategies for Optimizing the Supply of Eye Protection
CDC 2020 - Strategies for Optimizing the Supply of Face Masks
CDC 2020 - Strategies for Optimizing the Supply of N95 Respirators
CDC 2020 - Interim U.S. Guidance for Risk Assessment and Public Health Management of Healthcare Personnel with Potential Exposure in a Healthcare Setting to Patients with Coronavirus Disease (COVID-19)
CDC NIOSH 2009 - Latex Allergies
This design is a remix of the Prusa Printers RC2 face shield.

UPDATE ON TRANSPARENT LENS MATERIAL 3/29/2020:
#1 BEST: Water clear PETG or similar in thickness ranging from .3 - .5 mm.

#2 GOOD:
Avery Clear Easy View Durable Plastic Dividers Item 16741
https://www.amazon.com/Avery-Durable-Plastic-Dividers-16741/dp/B017ETNUTC

#3 ALSO GOOD
Office Depot "clear gloss poly binding cover" Item 459-207
https://www.officedepot.com/a/products/459207/Office-Depot-Brand-Binding...
Fellowes 52311 Crystals Presentation Covers with Round Corners, 8mil 11 1/4 x 8 3/4, Clear (Pack of 100)
https://www.amazon.com/Fellowes-52311-Crystals-Presentation-Corners/dp/B...

WORST: any kind of thin overhead transparency. Many have subtle textures that spoil visibility. They also tend to be so thin that they flutter.

Keyword(s)
PPE face shield COVID-19 face shield
3D Modeling/CAD Software
Fusion 360

CONTACTS:

Dan Collins, Professor
Arizona State University
Dan.collins@asu.ed

Mick Dalrymple, Director, University Sustainability Practices
Arizona State University
mick.dalryumple@asu.edu

Tyler Smith, Associate Director, Luminosity Lab
Arizona State University
tyler.smith@asu.edu

Joseph Miceli, Project Mgr Research
Biodesign Center for Personalized Diagnostics
jfmiceli@asu.edu

Lenny Bucholz, SEMTE Student Machine Shop Manager
Ira A.Fulton Schools of Engineering
Arizona State University
lenny.bucholz@asu.edu