

3D Printing PPE: A Three-Minute Face Shield Solution

Elizabeth Bishop

Postgraduate Researcher, University of Warwick, UK



About me

Elizabeth Bishop

- 2012 – 2017 MEng Mechanical Engineering
- 2016 – 2017 UAV Group Project
- 2017 – 2021 PhD in Large-Scale Additive Manufacturing (3D Printing)
- Maker in Residence at Warwick Engineering Build Space

 @LizBish94

 @WEDesignMake

 Elizabeth Bishop

You may remember us from...



Learning Objectives

OBJECTIVE 1

Learn about the global maker's response to the COVID-19 crisis

OBJECTIVE 2

Learn how Warwick University responded and helped using 3D printing

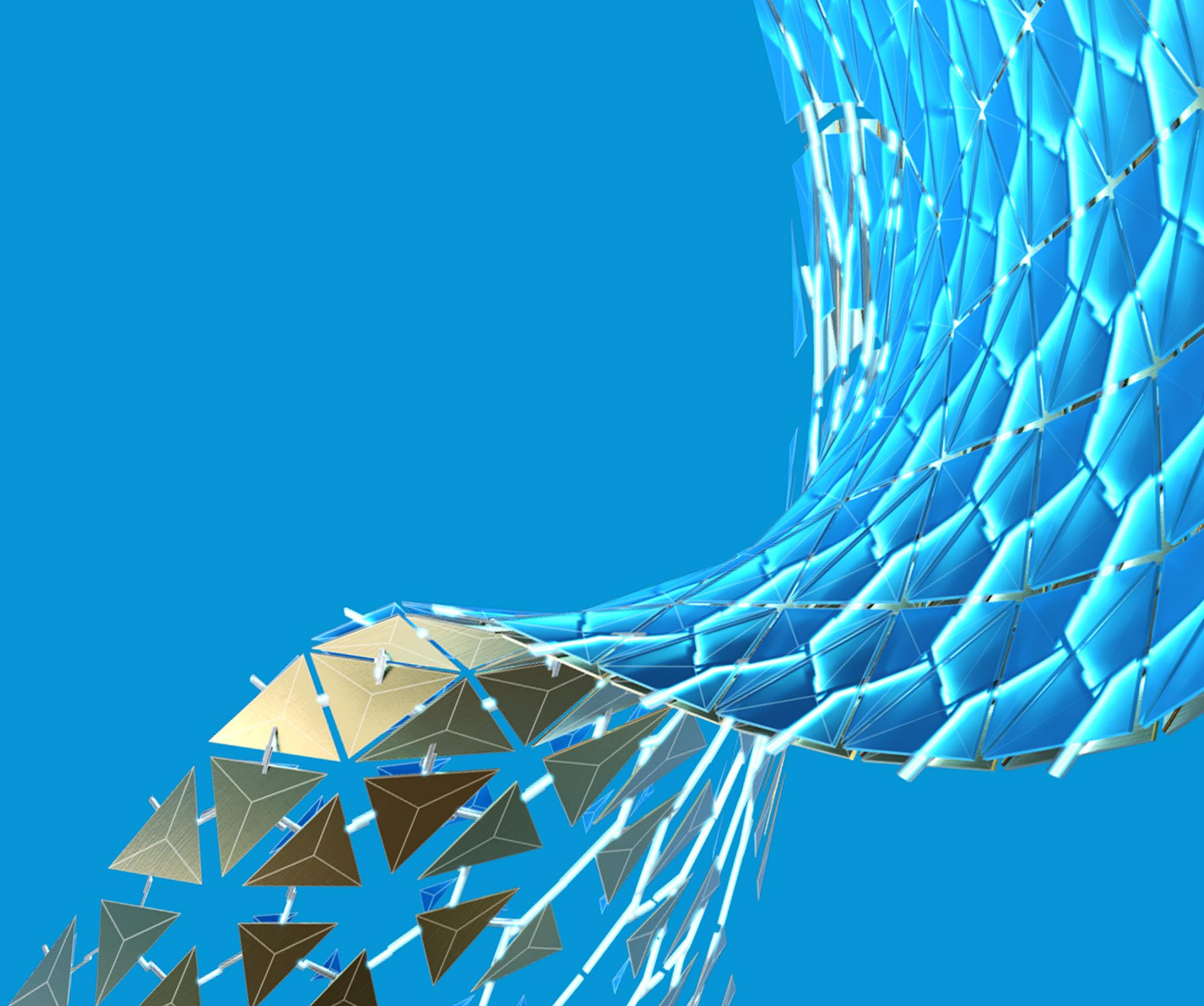
OBJECTIVE 3

Learn how to print a PPE face shield in under three minutes

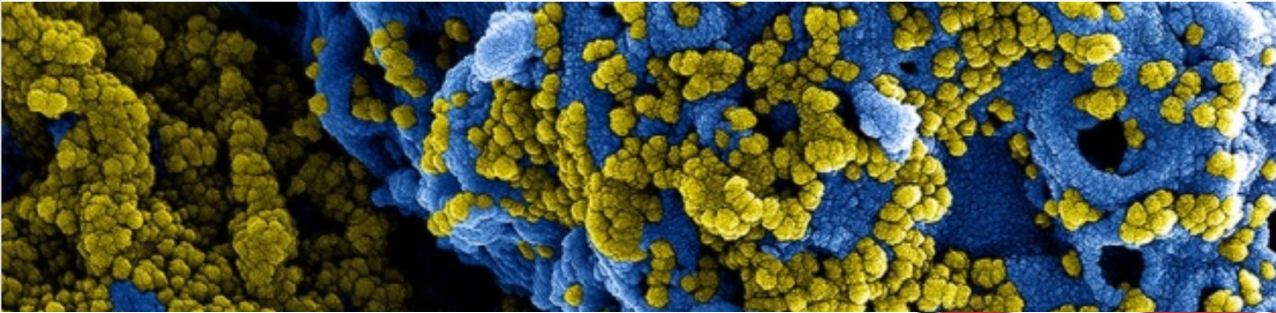
OBJECTIVE 4

Learn about large-scale additive manufacturing

Introduction



WHO Declares Coronavirus a Public Health Emergency, Highlights Need to Support Countries 'Weaker Health Systems'



GOOD HEALTH
10-PAGE SPECIAL
STARTS PAGES 35-45

Daily Mail
TUESDAY, MARCH 24, 2020
www.dailymail.co.uk

70p

The good news? Newsagents to stay open – and CAN deliver the Mail to your door...

FREE DELIVERY FOR 6 WEEKS
DETAILS: PAGES 20-21

PM's historic stay-at-home plea to beat virus

LOCKDOWN BRITAIN

Astonishing restrictions on daily life ++ NO travel unless essential ++ Don't see friends or family ++ Only one exercise outing a day ++ Fines if you don't obey ++ Mass closures of shops ++ All for at least 3 weeks

Friday 24 March 2020

Puzzles Plus
Brilliant new puzzles section with four extra pages of teasers to keep your mind active
Page 10

The Daily Telegraph
FRIDAY, MARCH 24, 2020

End of freedom

Public gatherings of more than two to be outlawed with threat of fines
All non-essential shops to be closed as restrictions imposed for three-week period
Scientists told Prime Minister the NHS faced collapse without lockdown

HOME DELIVERY
Sign up for our Tim In The Mail newsletter
Average 100 per month

FREE DELIVERY FOR 12 WEEKS

Sun
Sunday, March 24, 2020
THE PEOPLE'S PAPER
55p
www.sun.co.uk

FREE HOME DELIVERY FOR 12 WEEKS

HOUSE ARREST

PM: Brits must stay home

Police fines up to £1,000

Gatherings over 2 banned

Only shop for basics

CORONAVIRUS CRISIS

BRITAIN ON LOCKDOWN

CRAMMED SCENES ON THE TUBE THAT PROVED MEASURES WEREN'T ENOUGH
Page 1

PM SAYS STAY AT
ALL GATHERING
ONLY ONE FORM



for six weeks
Get the Guardian sent to your home, with no delivery charge

The Guardian

PM: 'Stay at home, this is a national emergency'

- Johnson drastically restricts movement to combat coronavirus
- Gatherings of more than two people in public to be prohibited
- Police given powers to disperse groups and enforce lockdown

Inside
The Downing Street...
The Downing Street...
The Downing Street...

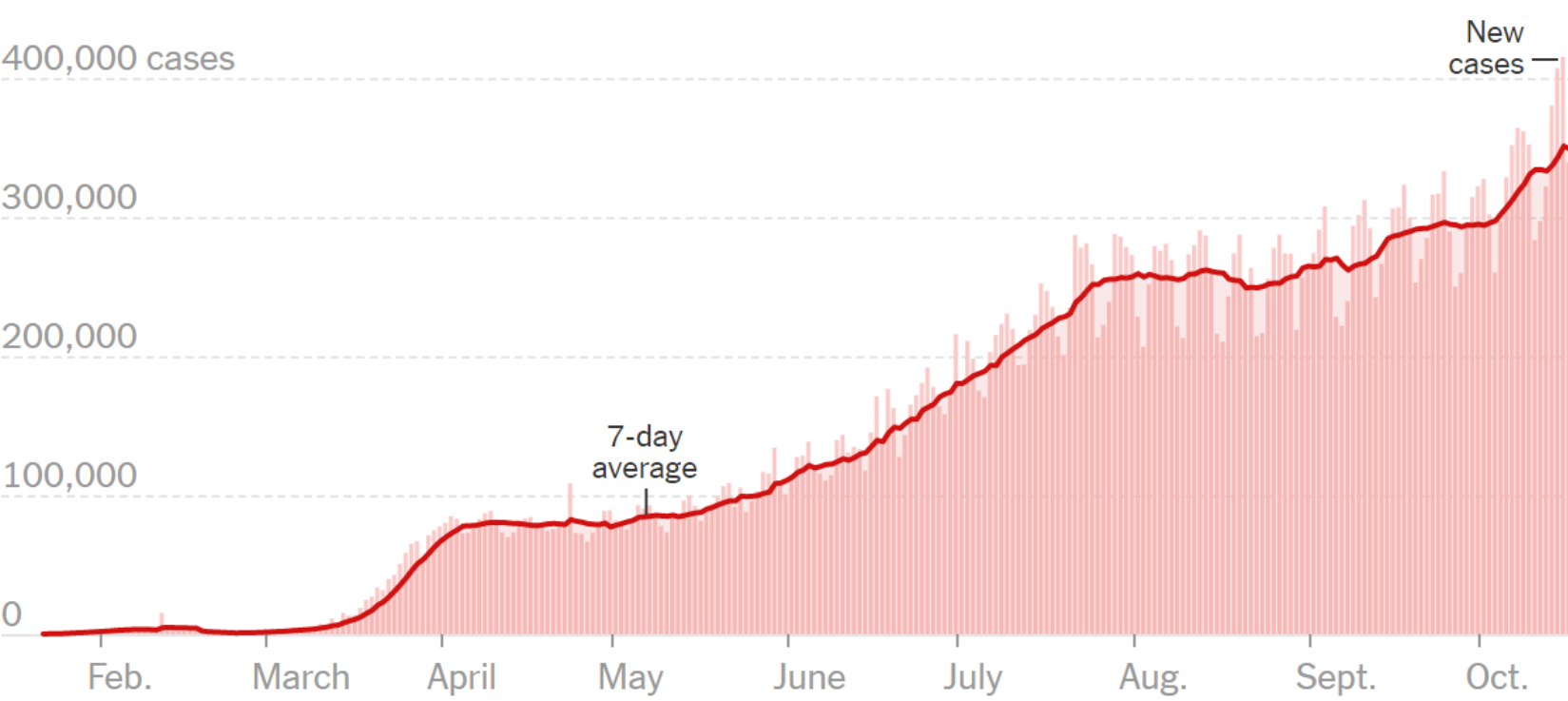
THE TIMES
Tuesday March 24 2020 | 60p | www.thetimes.co.uk

Alex Salmond: not Scotland's former leader cleared of sex

'You must stay at'

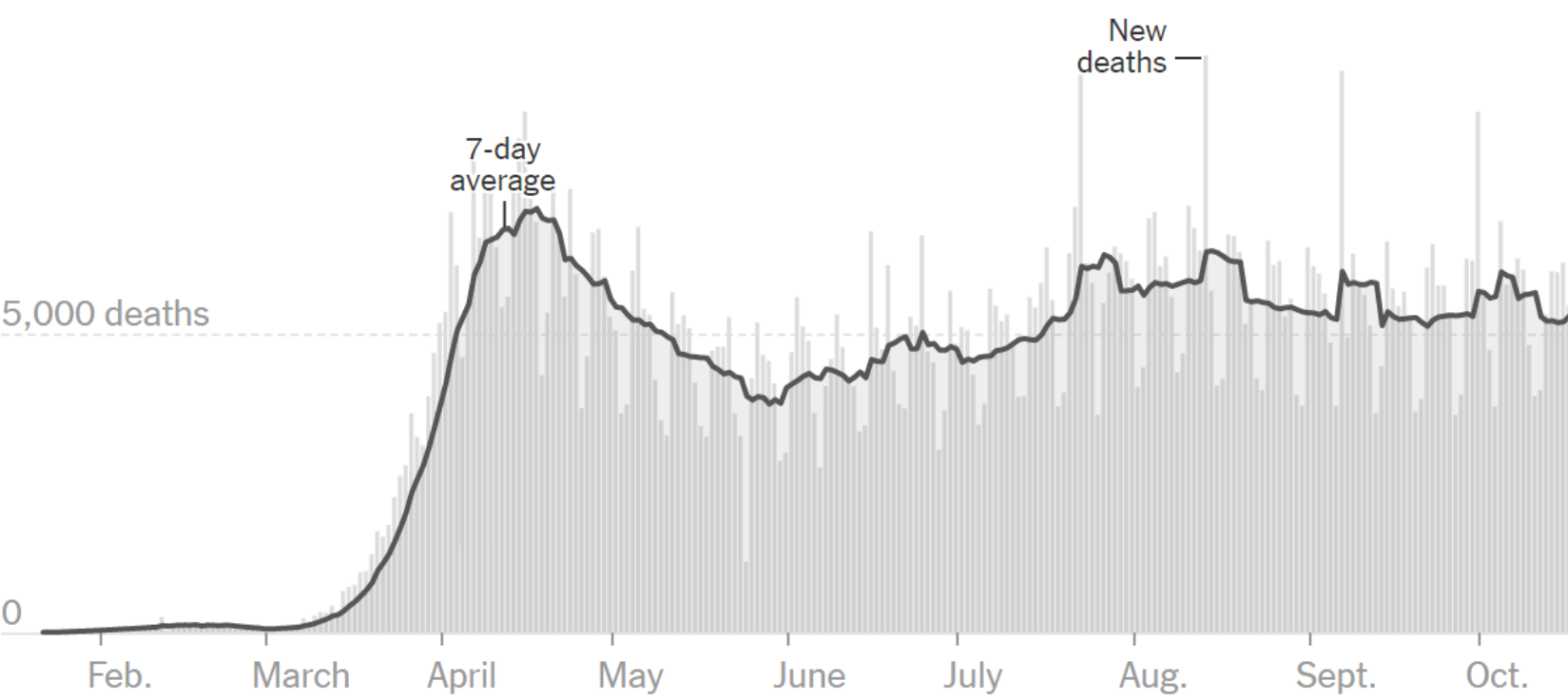
PM declares national emergency • Meetings of more than two banned • F

New reported cases by day across the world



Note: The seven-day average is the average of a day and the previous six days of data.

New reported deaths by day across the world



Note: Scale for deaths chart is adjusted from cases chart to display trend.

Coronavirus: UK failed to stockpile crucial PPE

28 April

Coronavirus pandemic



Contribute → Subscribe →

NewsOpinionSportCultureLifestyleMore ▾

UK World Business Coronavirus Football Environment UK politics Education Society Science Tech Global development

NHS

What is the situation with personal protective equipment in the UK?

PPE - or the lack of it - has been one of the key issues making headlines since coronavirus reached the UK

- Coronavirus - latest updates
- See all our coronavirus coverage

Haroon Siddique

Tue 14 Apr 2020 15:17 BST

f

t

e

84



▲ Student Ailsa Fleming checks a face shield at Edinburgh Shield Force, a pop-up factory manufacturing face shields for medics and nurses. Photograph: Murdo MacLeod/The Guardian

Since the coronavirus outbreak in the UK was first identified, the issue of

Is there a PPE shortage, and how can NHS workers use it safely?

Personal Protective Equipment (PPE) is essential for frontline workers, but why is there a shortage in the UK?

By Laura Donnelly, HEALTH EDITOR
10 May 2020 • 12:35pm



Related Topics

Coronavirus Q&A, Coronavirus, PPE, NHS, Face masks

t

f

o

e

NEWS

HomeCoronavirusUS ElectionUKWorldBusinessPoliticsTechScienceHealthFamily & Education

Health

Coronavirus: Has the NHS got enough PPE?

By Michelle Roberts
Health editor, BBC News online

28 September

Coronavirus pandemic



Daily Mail

Monday APRIL 20, 2020

MURDERS MOST FOUL

Gripping true crime four-page special PAGES 50-53

FREE £5 to spend at Sainsbury's, Argos or eBay

When you sign up for the Mail+ digital edition

Just £1 for 30 days

BETRAYAL OF OUR BRAVEST

Hospitals set to run out of protective gowns TODAY as airlift of 400,000 replacements grounded ++ Nov doctors face stark choice: Save patients or themselves

COMMENT

DOCTORS have warned they could stop treating coronavirus patients to protect their own lives as equipment shortages become critical.

Elton rocks the world... from his garden

DAILY MIRROR

THE HEART OF BRITAIN

Monday April 20, 2020

A TASTE OF ITALY

THE BEST OF PRIMATES

Easy-to-make recipes with Gregg and Anna Wallace

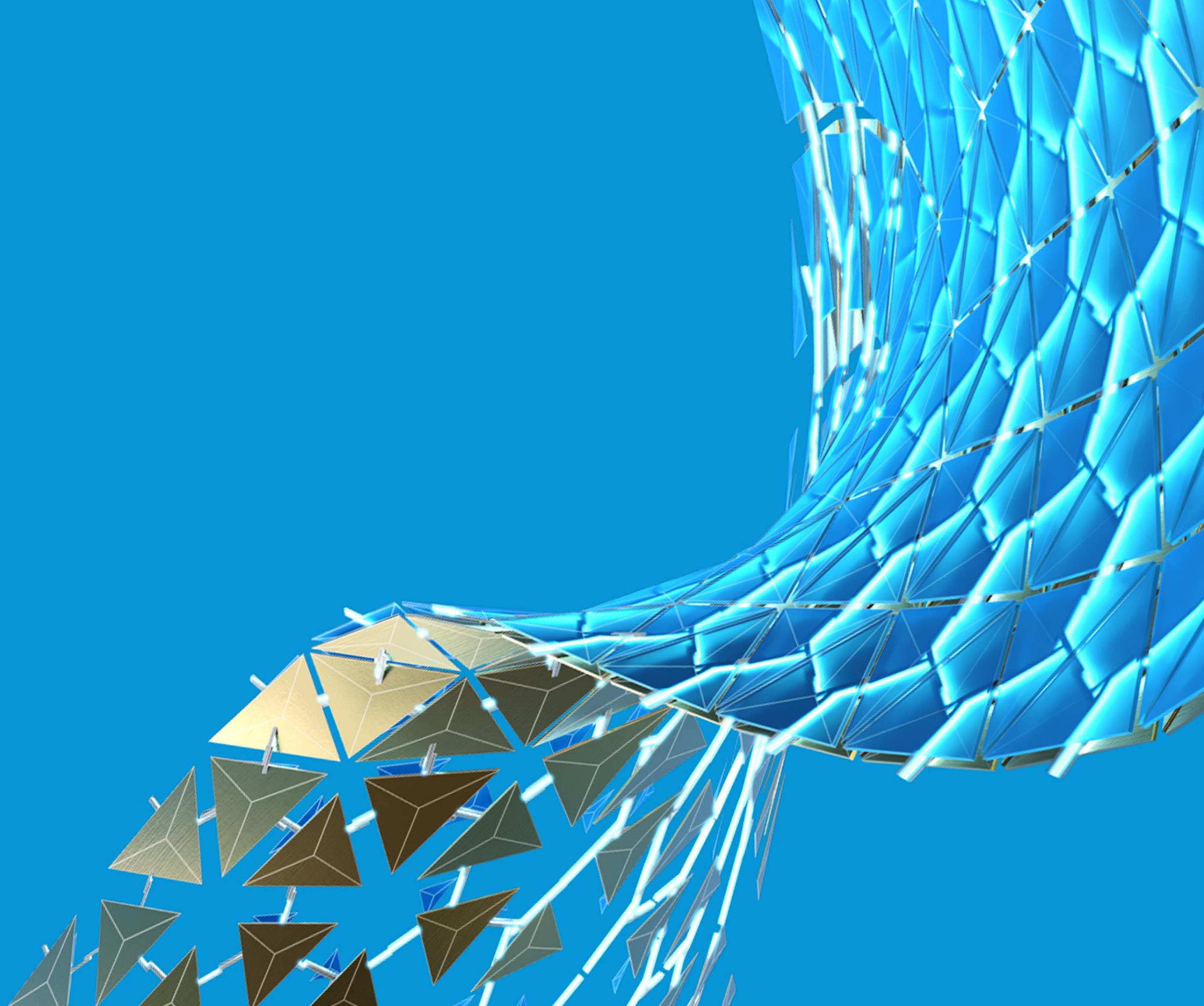
CORONAVIRUS SHAMBLES

Now lifesaving kit for NHS heroes doesn't turn up

Crucial shipment delayed... doctors demand answers over PPE shortages

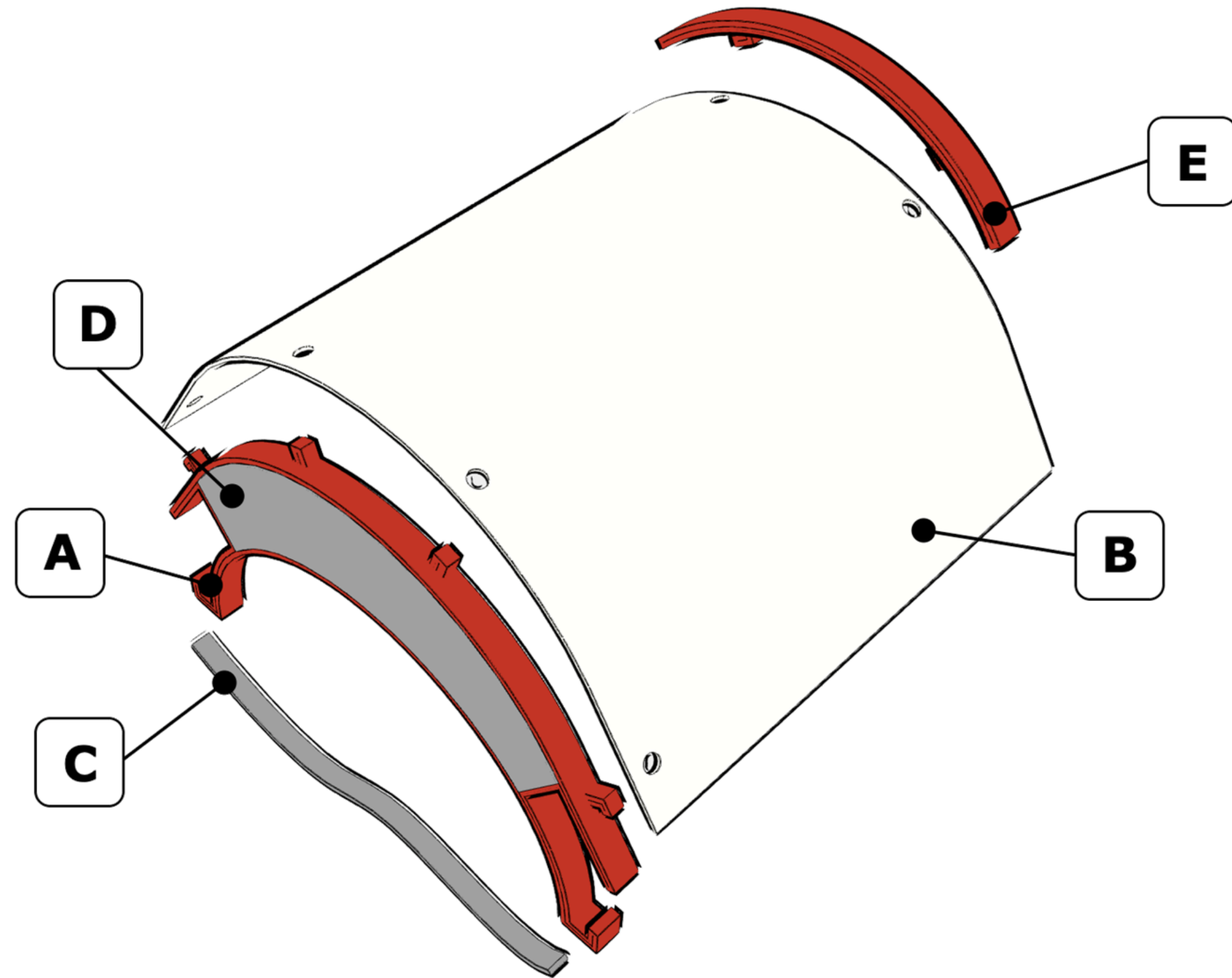
PM missed FIVE vital meetings as Govt failed to prepare for crisis

What is PPE?



PPE protects the user against health or safety risks at work. It can include items such as safety helmets, gloves, eye protection, high-visibility clothing, safety footwear and safety harnesses. It also includes respiratory protective equipment, such as face masks.

Face Shields



A – Headband

B – Visor/Lens

C – Strap

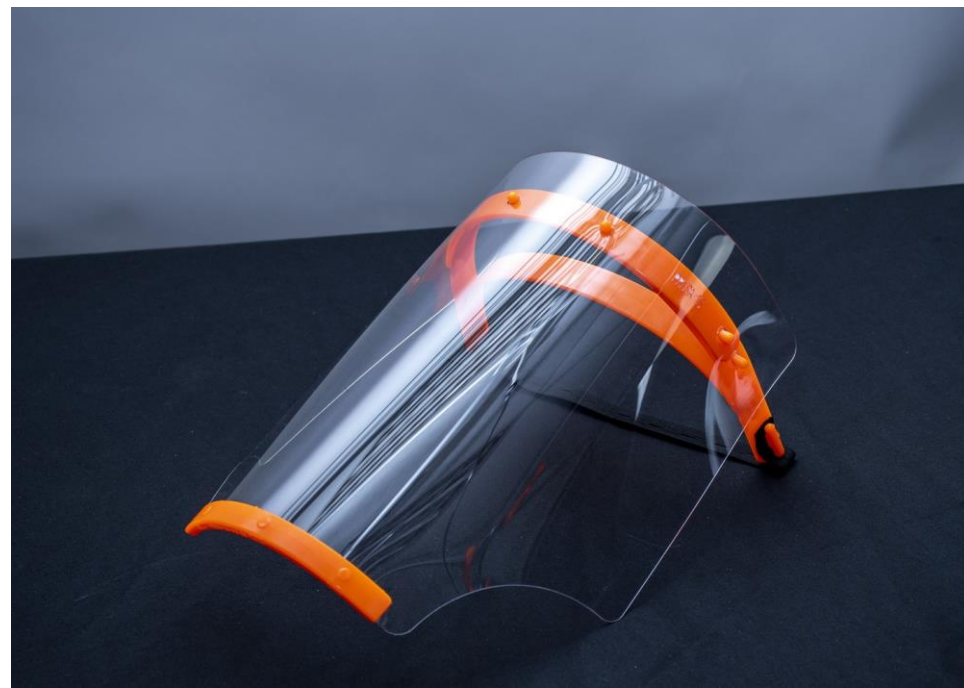
D – Optional foam insert

E – Optional bottom reinforcement piece

3D Printing Community Response



Biggest Responders



Prusa Research

Printed and donated almost 200,000 shields



N3DPS

National 3D Printing Society, UK
Established UK distribution network
for individual's 3D printing PPE



3DVERKSTAN

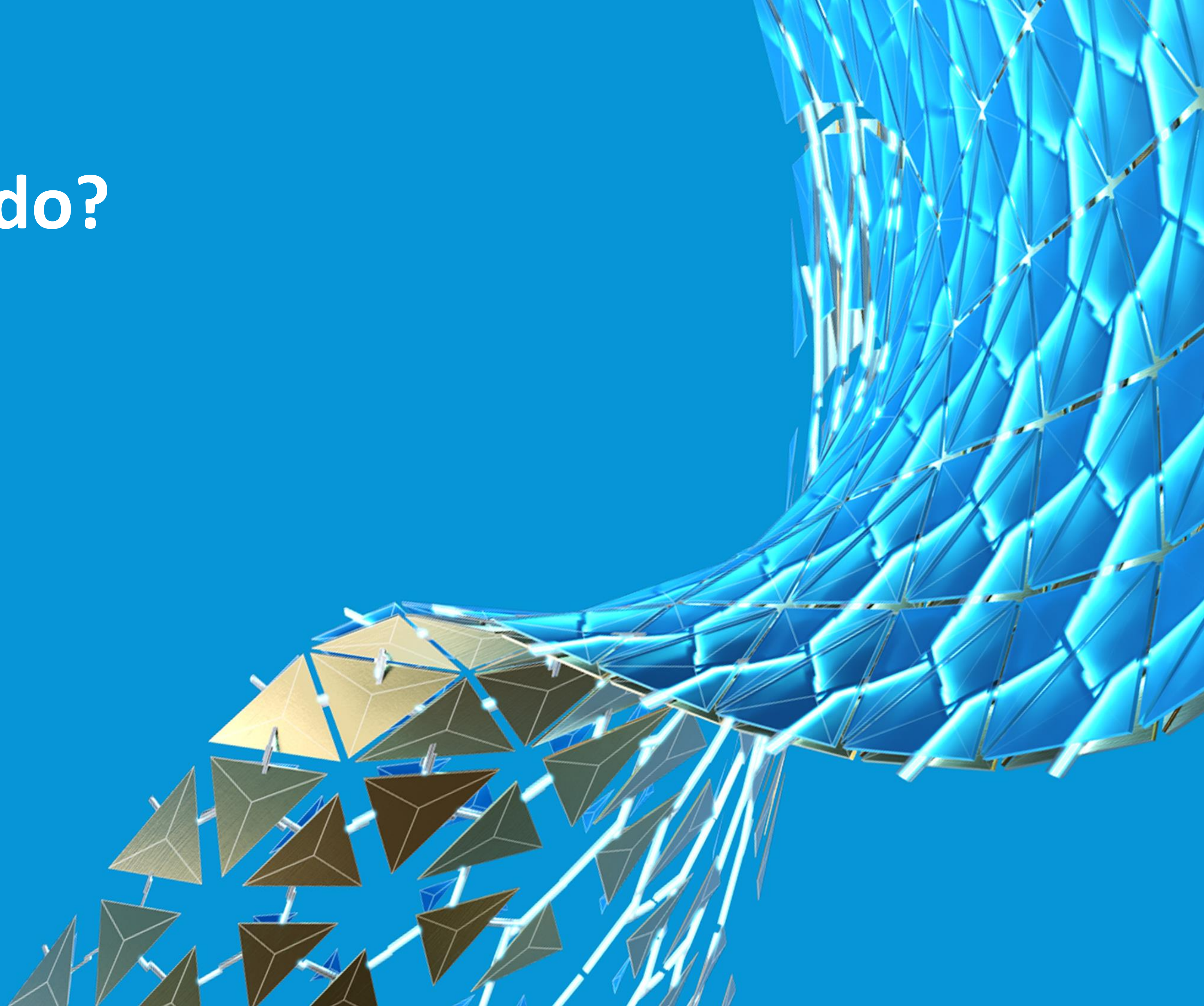
Swedish distribution network for
individual's 3D printing PPE



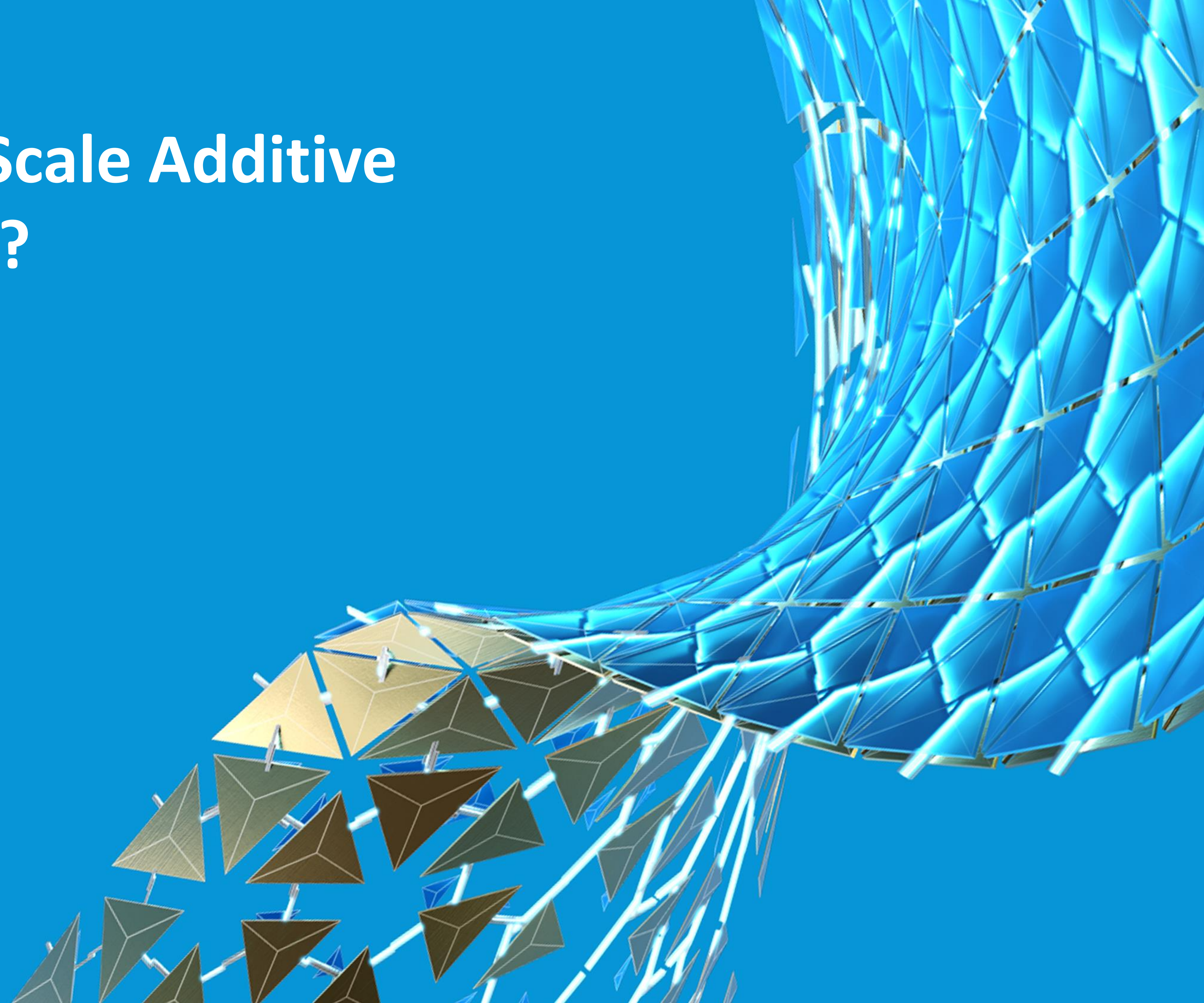
Photocentric

Supplying NHS with 7.6 million face
shields

What did we do?



What is Large-Scale Additive Manufacturing?



The process of joining materials to make parts from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing and formative manufacturing methodologies

ASTM 52900



Large-Scale Additive Manufacturing



DESKTOP SCALE

Ultimaker 3 Extended



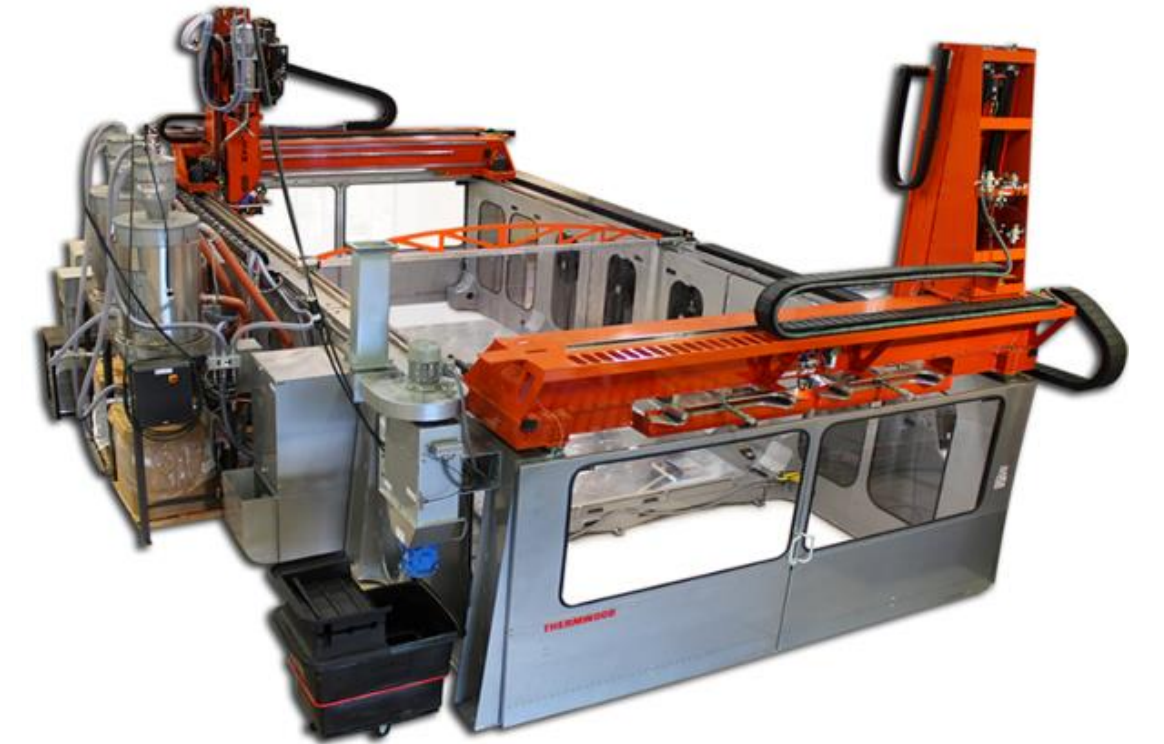
LARGE-FORMAT

*3DP WorkBench + E3D
Extruder*



LARGE-SCALE

*3DP WorkBench + HFE (High
Flow Extruder) 300*



VERY LARGE-SCALE

Thermwood LSAM 1020

Advantages and Disadvantages

Advantages

High flow rate

Faster printing

Large-build volumes

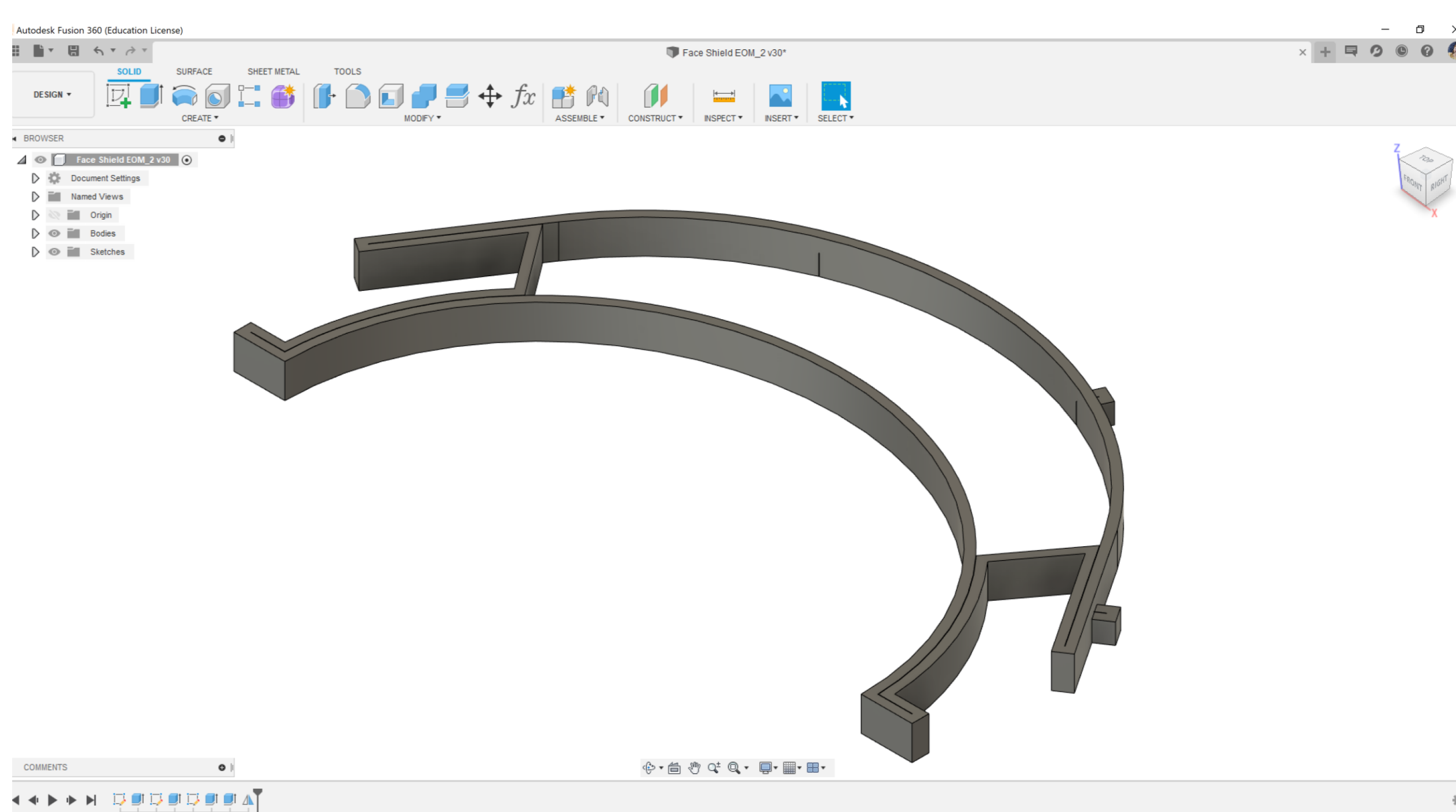
Stronger parts

Disadvantages

Extrusion control more difficult

- More stringing
- Artefacts in part

Faster printing means more waste if it goes wrong



Designing in Fusion 360

Parameter Driven

2.5 mm nozzle



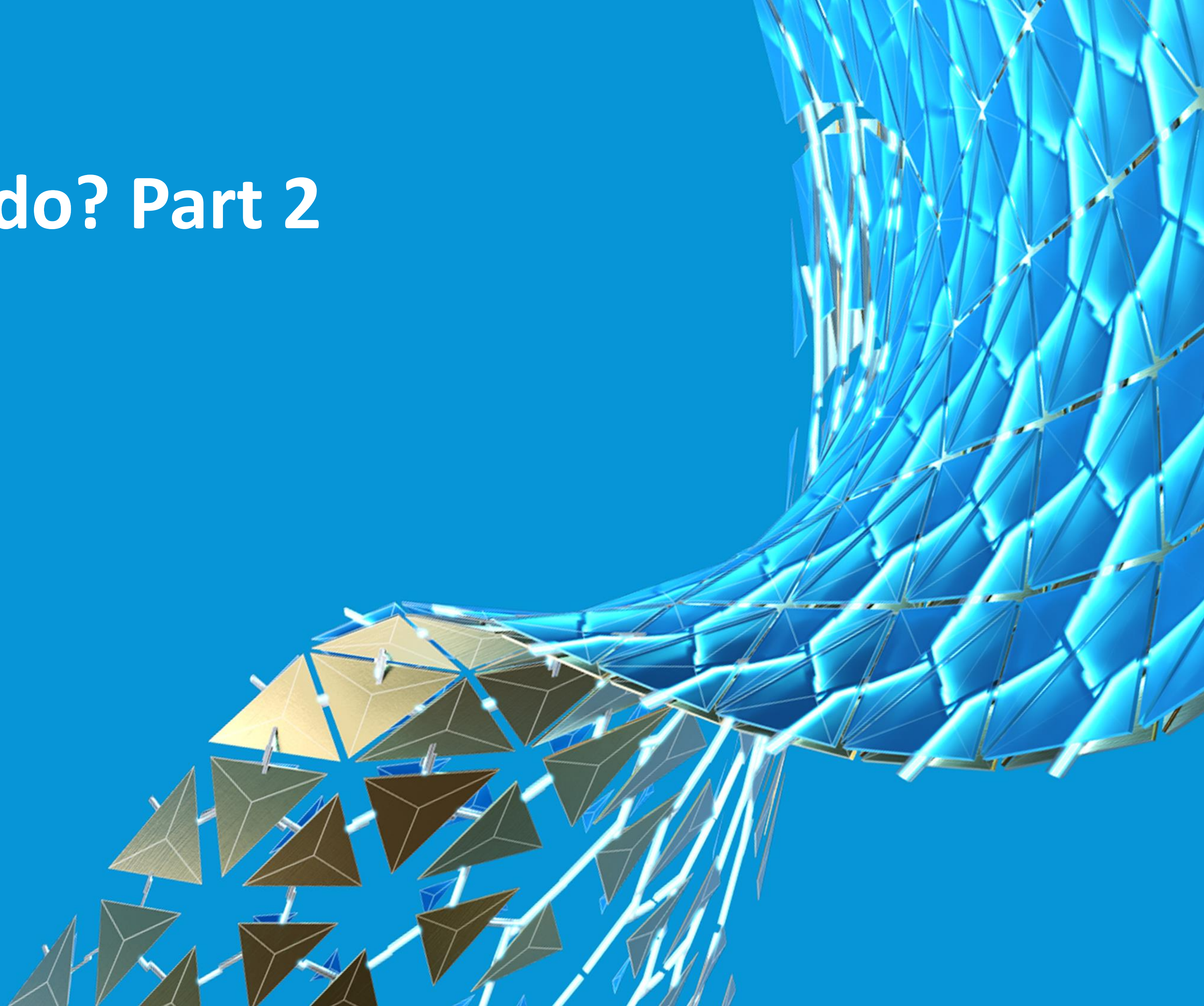
First Test Print

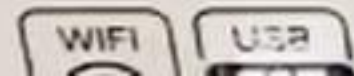
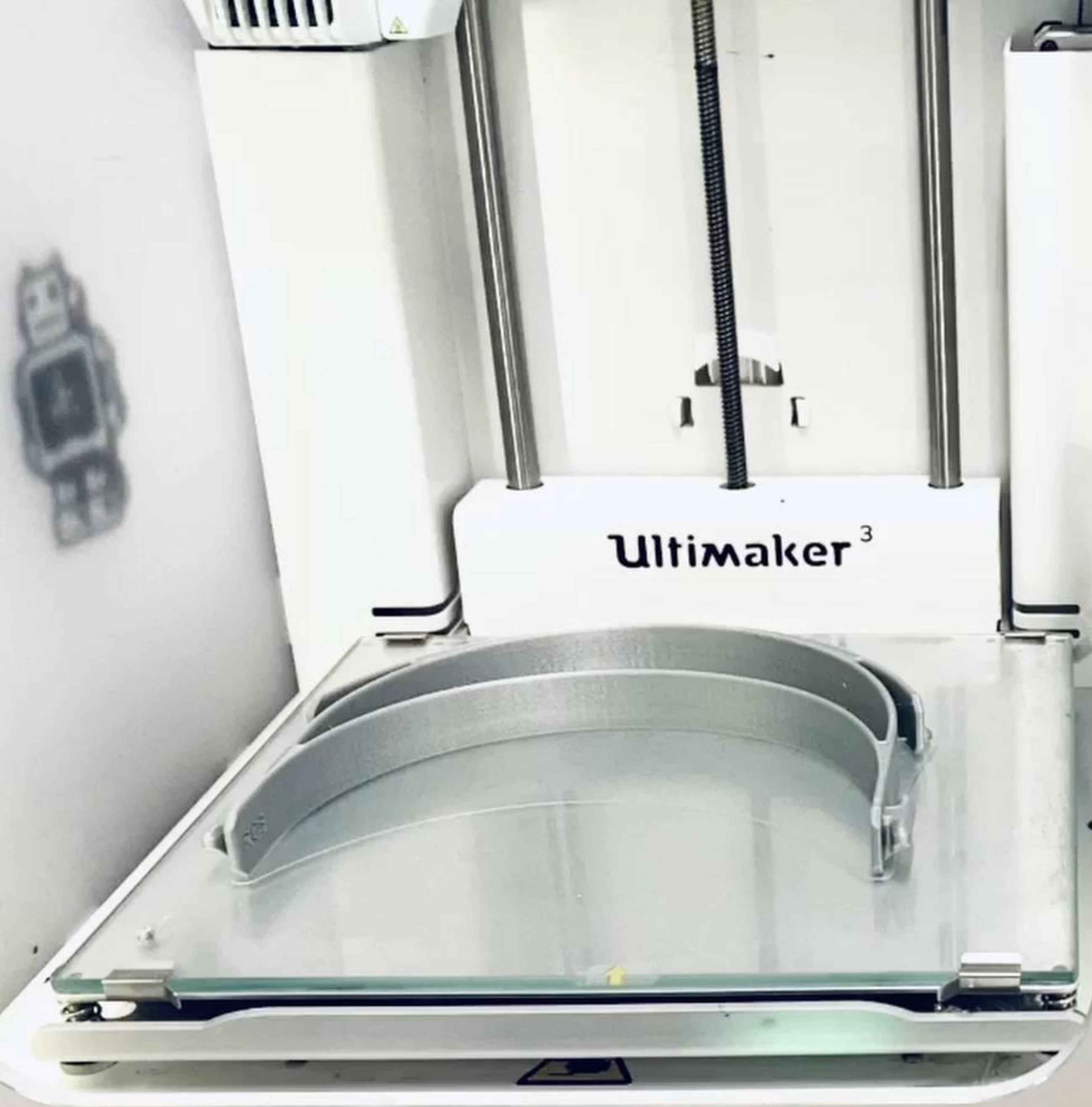
Printed in under 10 minutes

Time saving of at least 1 hour compared to other designs



What did we do? Part 2

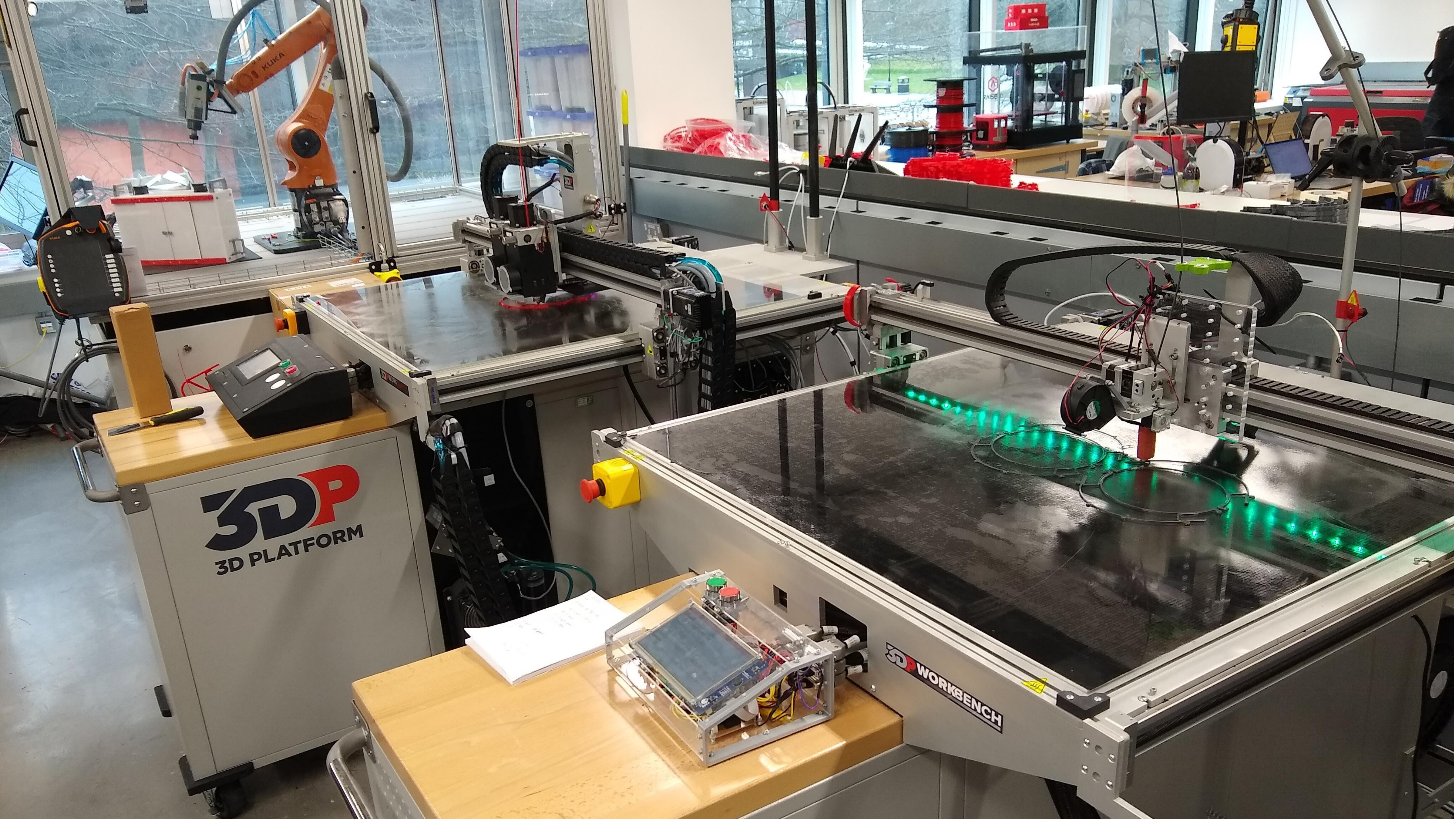




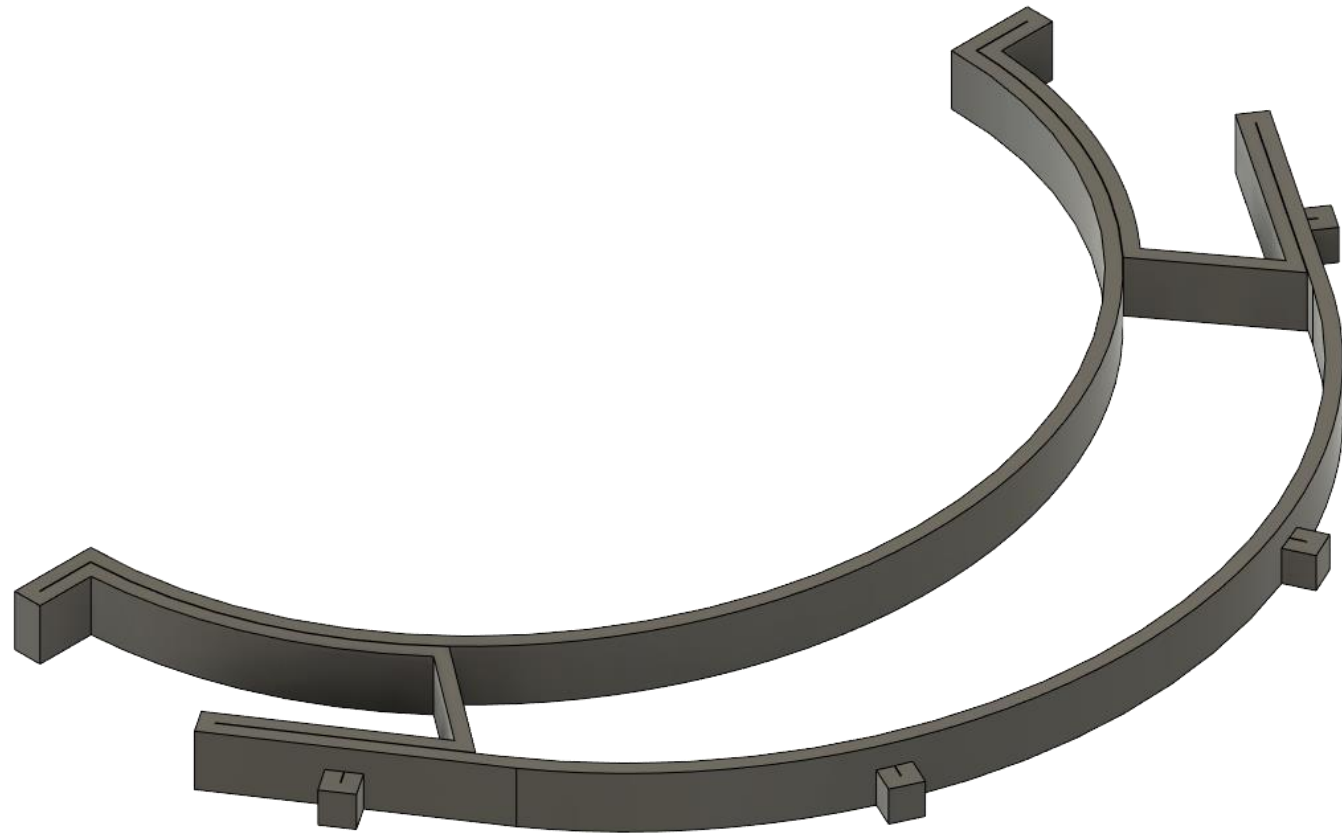
Print finished.
Remove the print from
the build plate.



Print finished.
Remove the print from
the build plate.
19°C



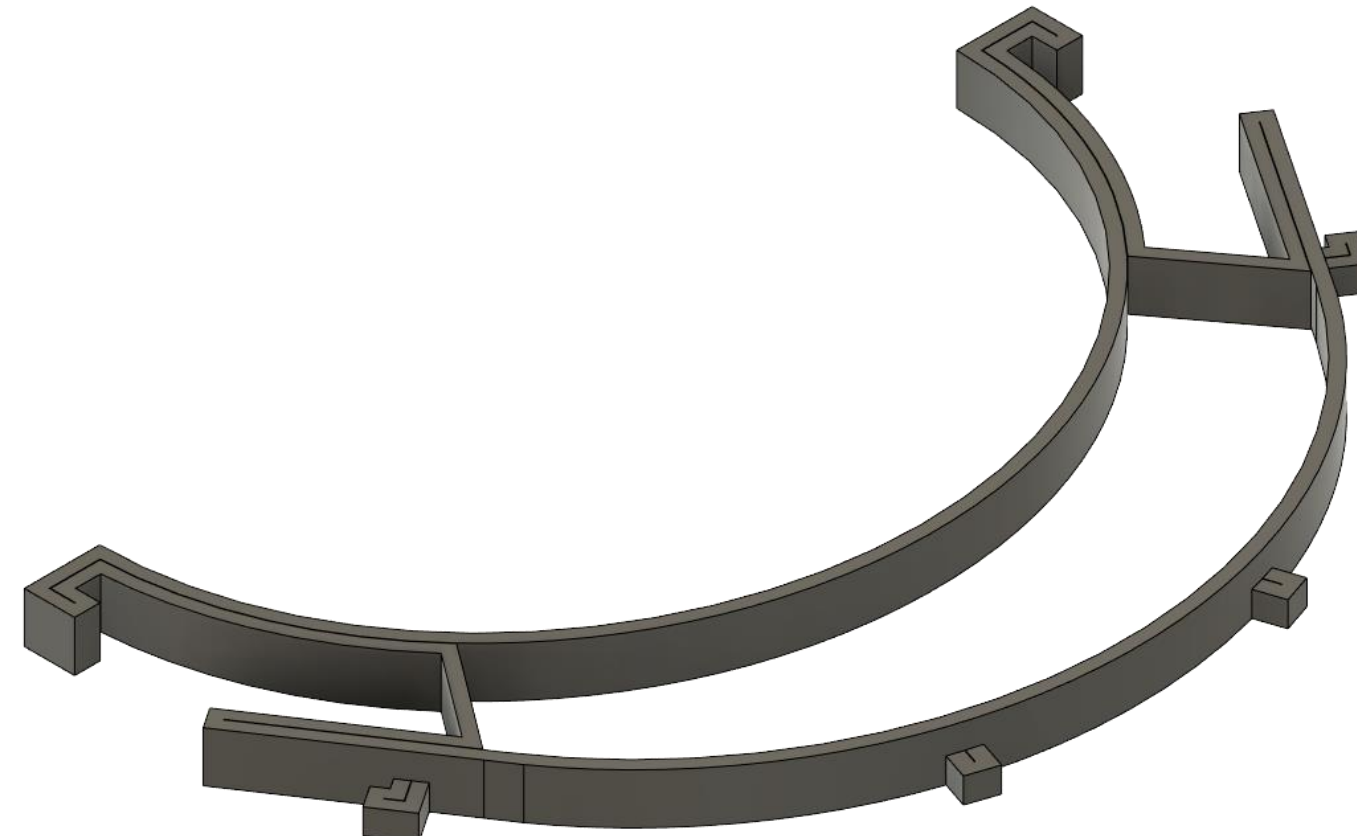
Initial Design Iterations



VERSION 1

Attachment points too small

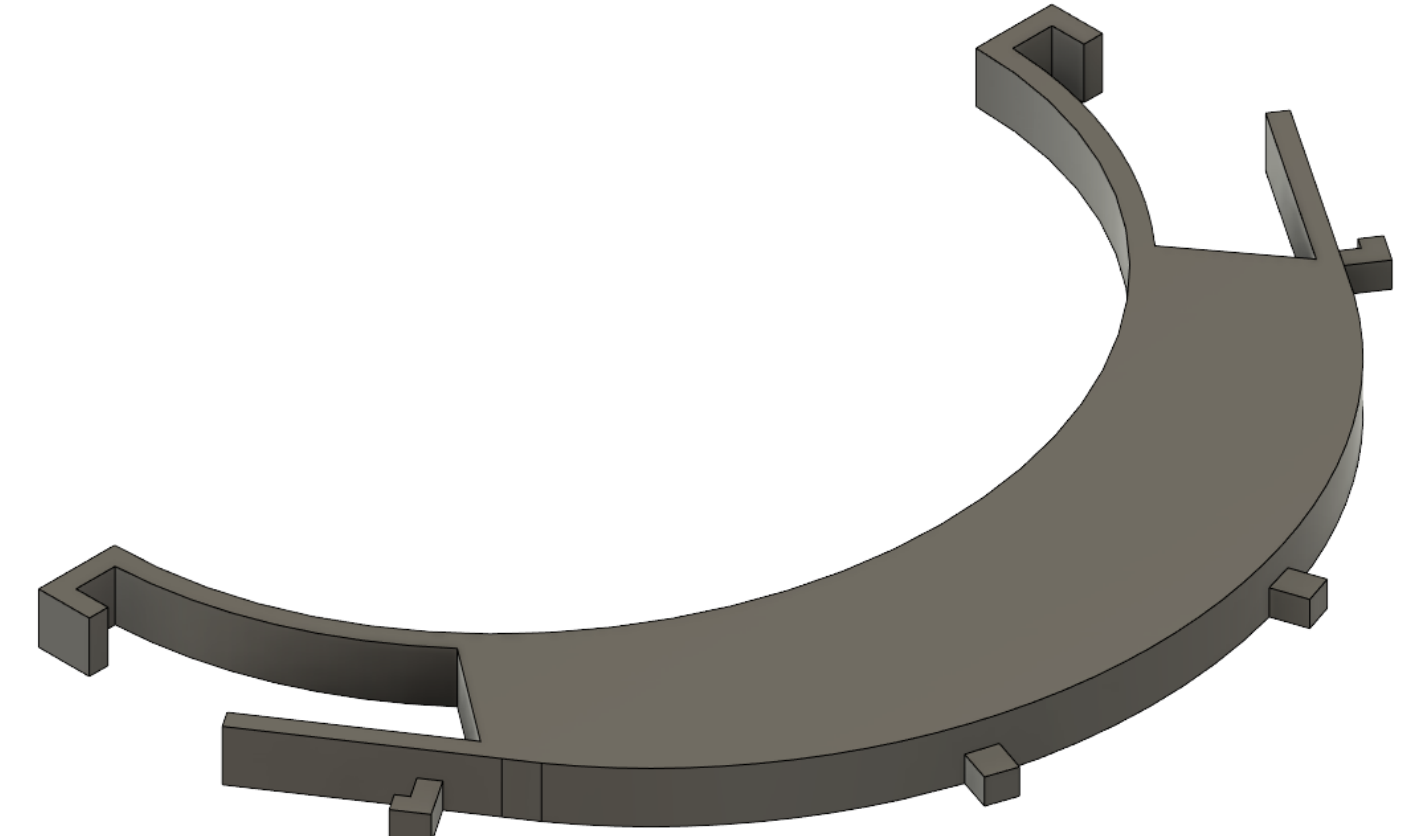
No where for strap to attach



VERSION 2

Added hooked outer attachment
points for visor

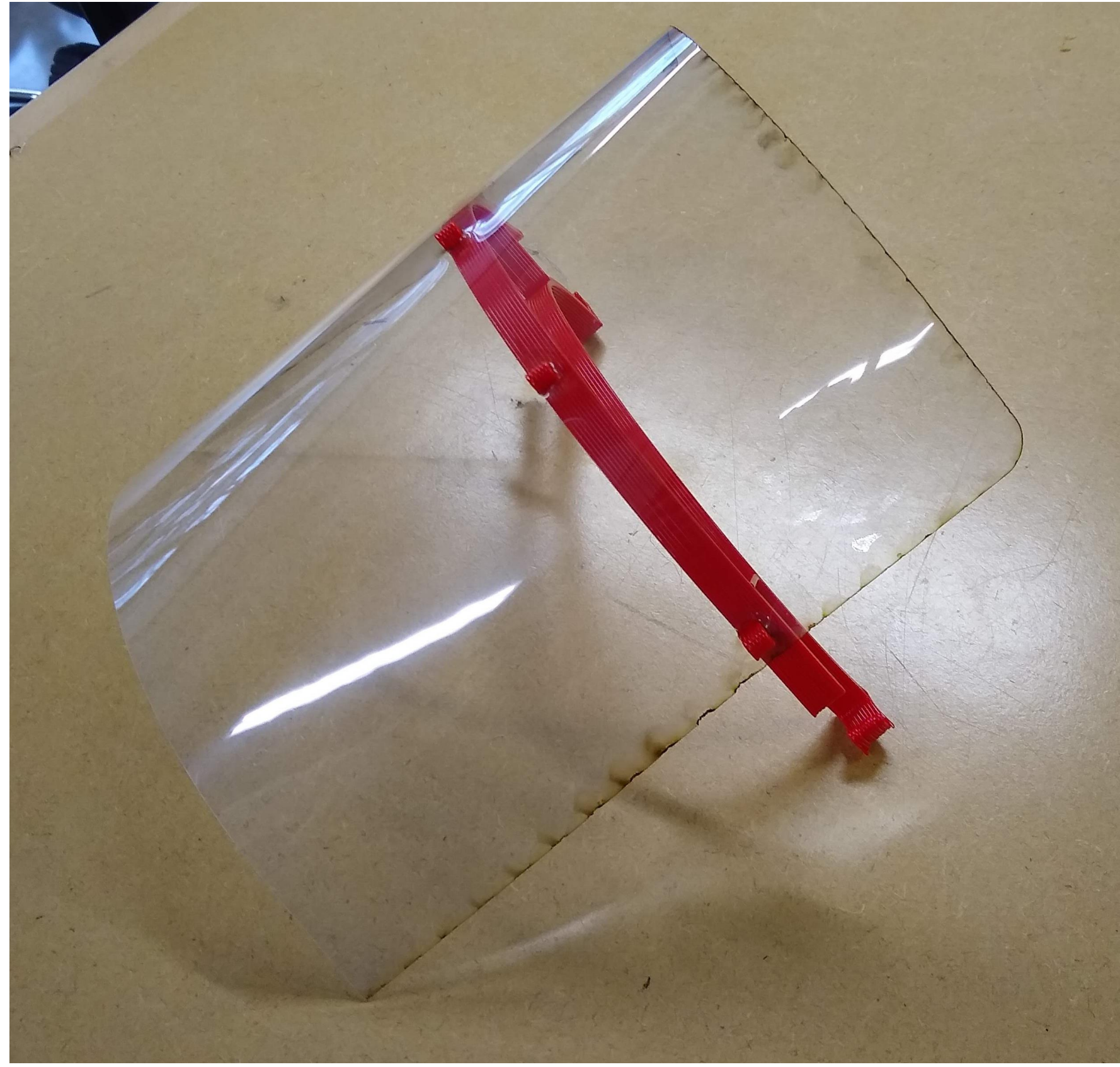
Strap attachment designed

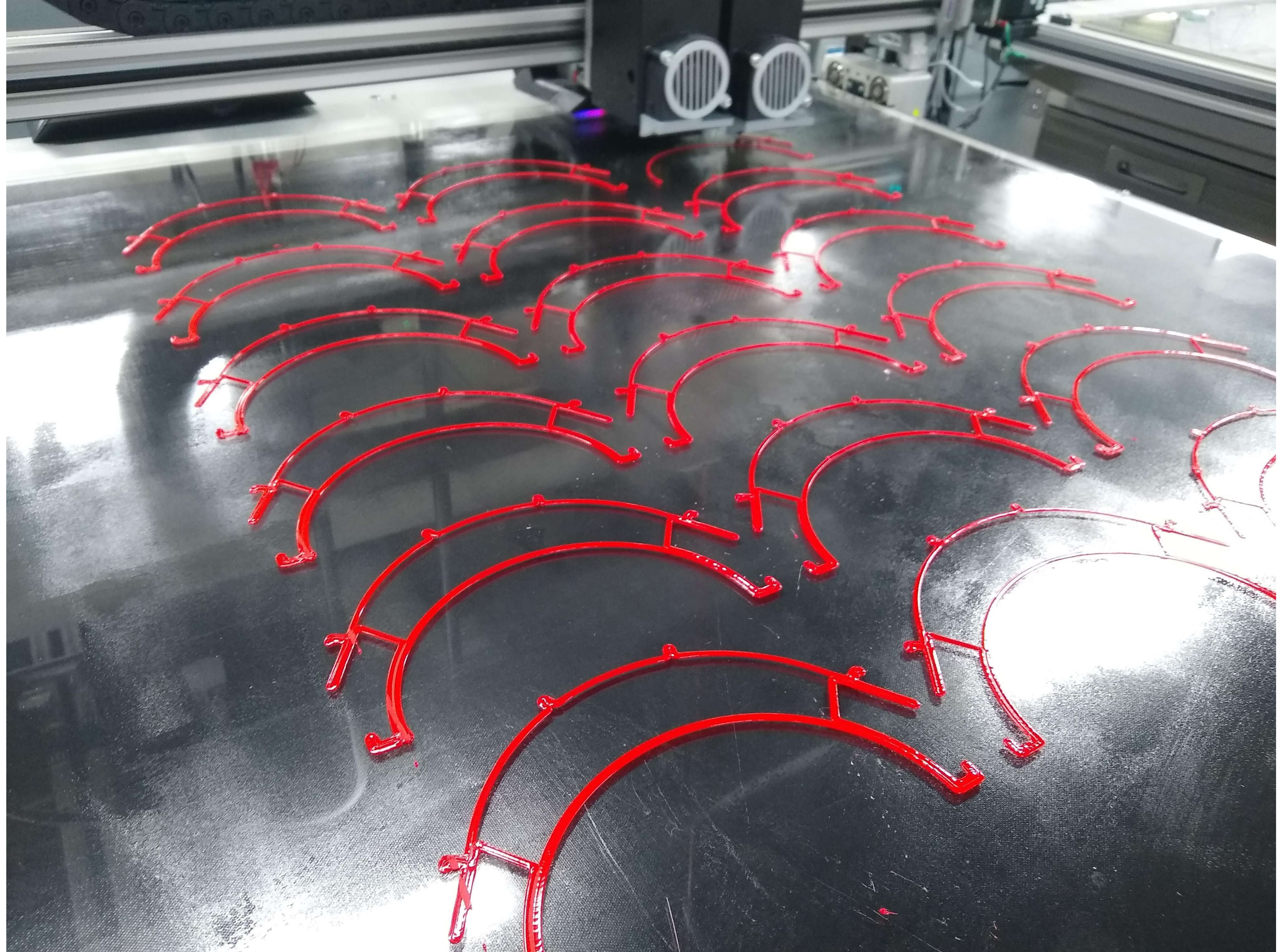


VERSION 3

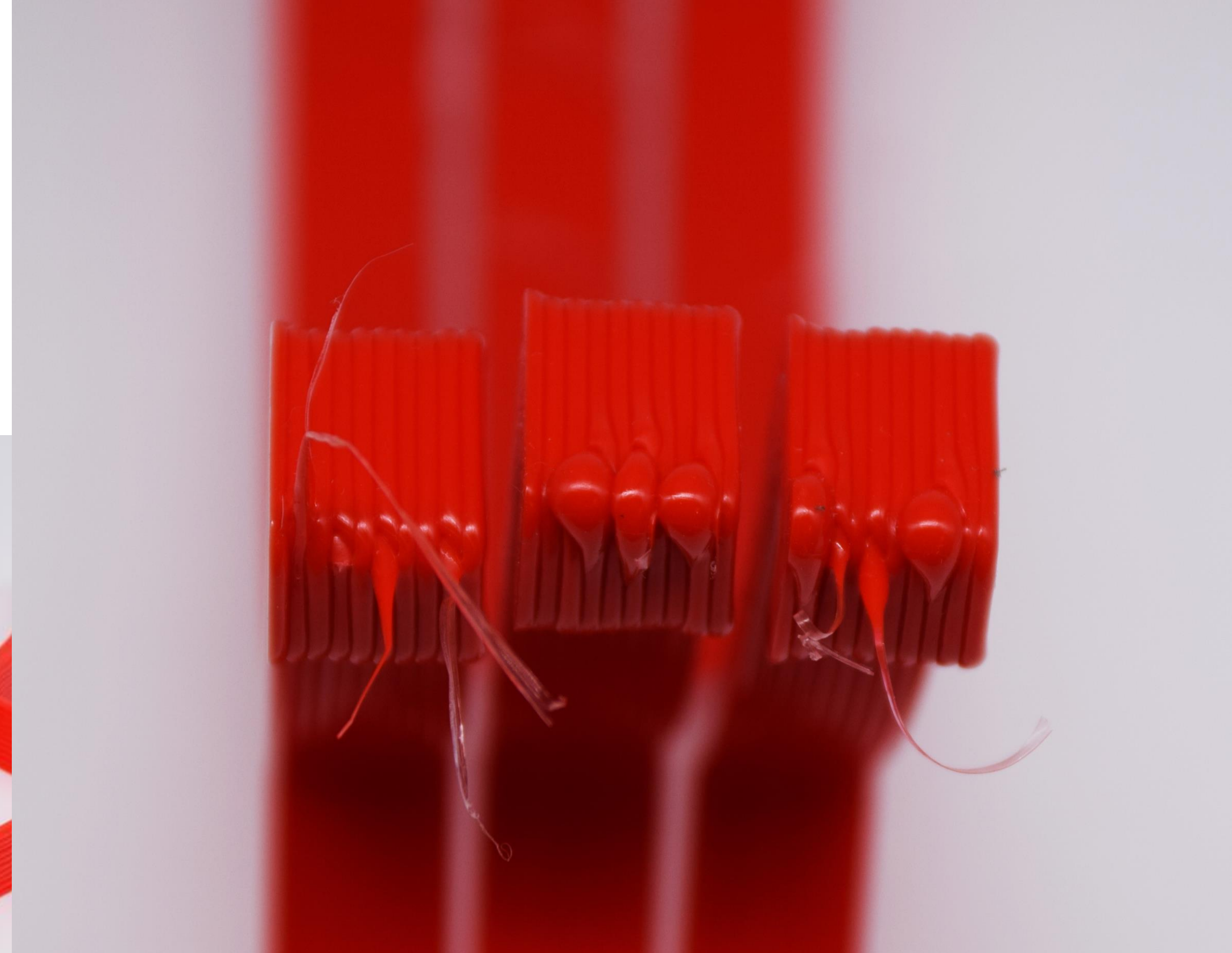
Redesigned for true vase
mode

Version 2

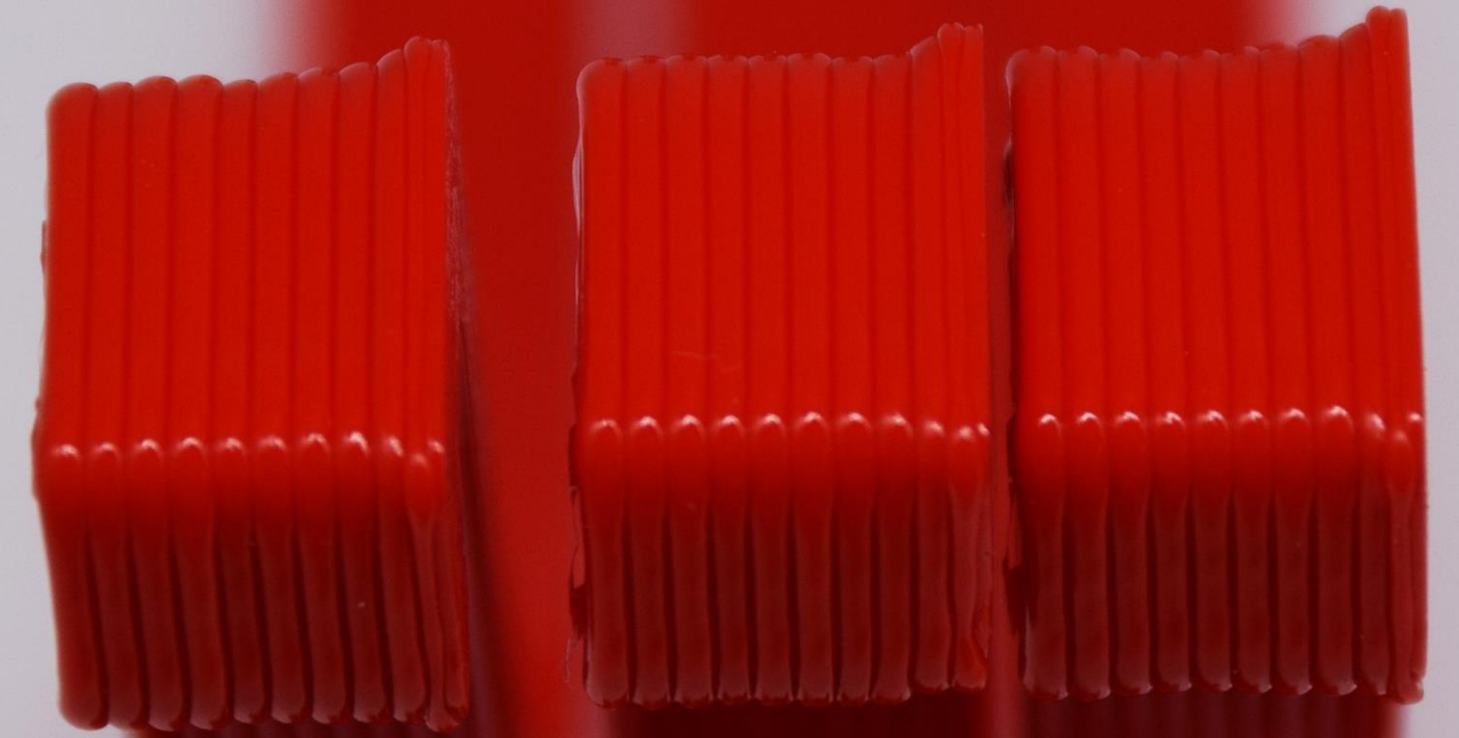
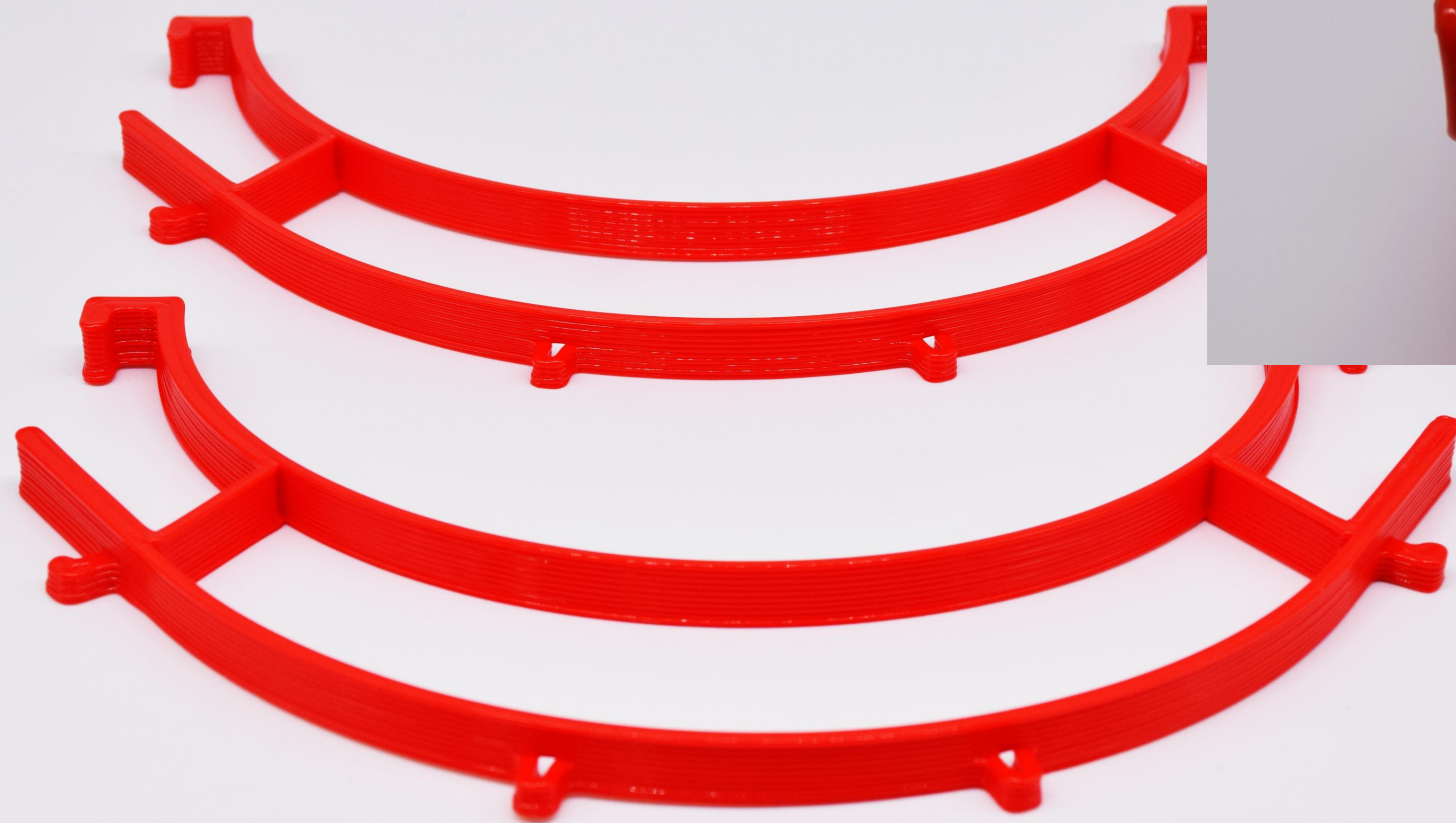




Parallel Printing



Sequential Printing

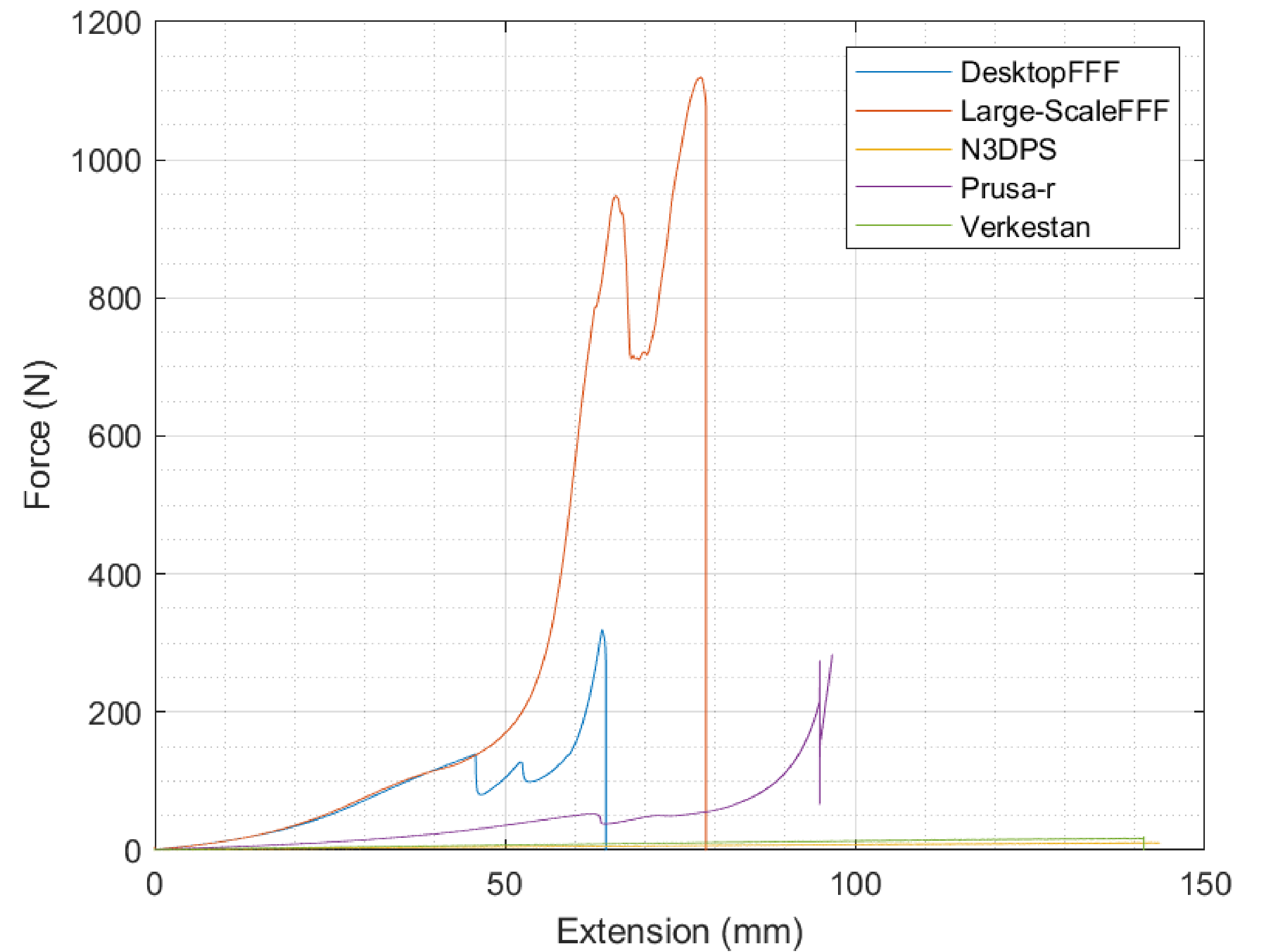
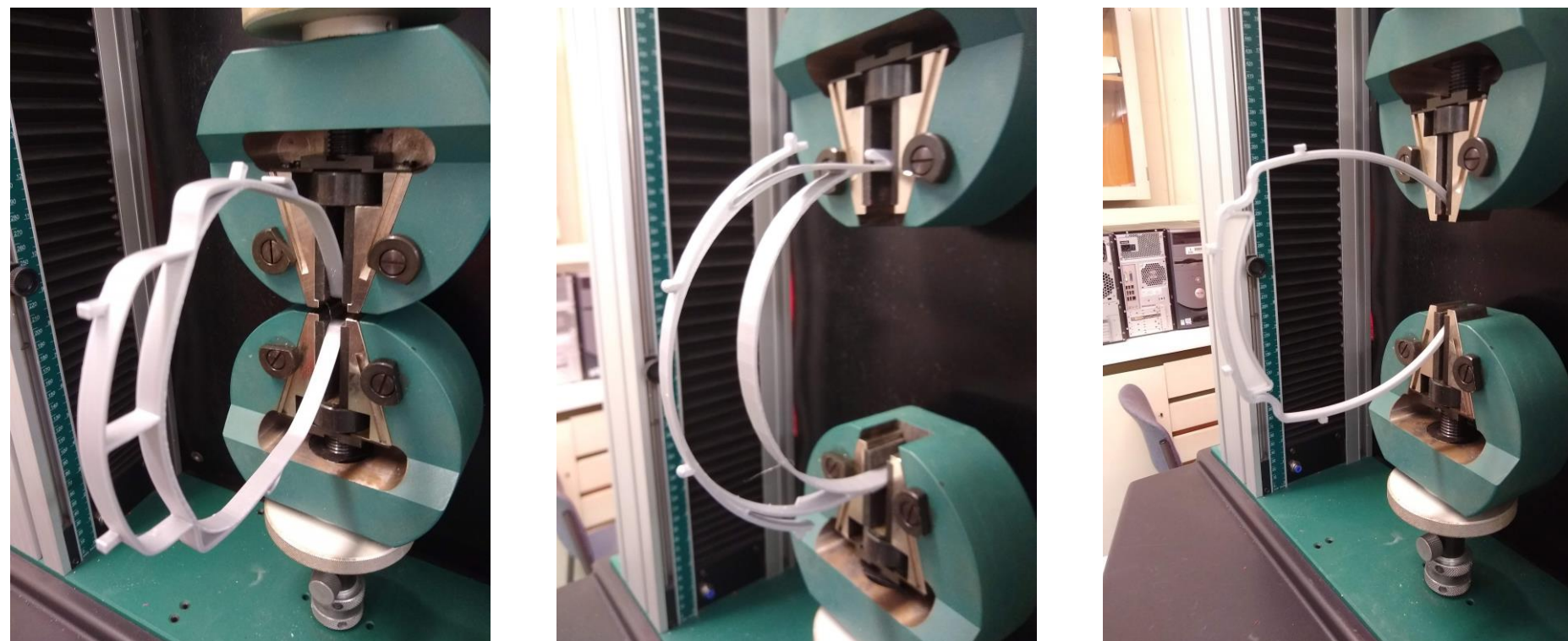
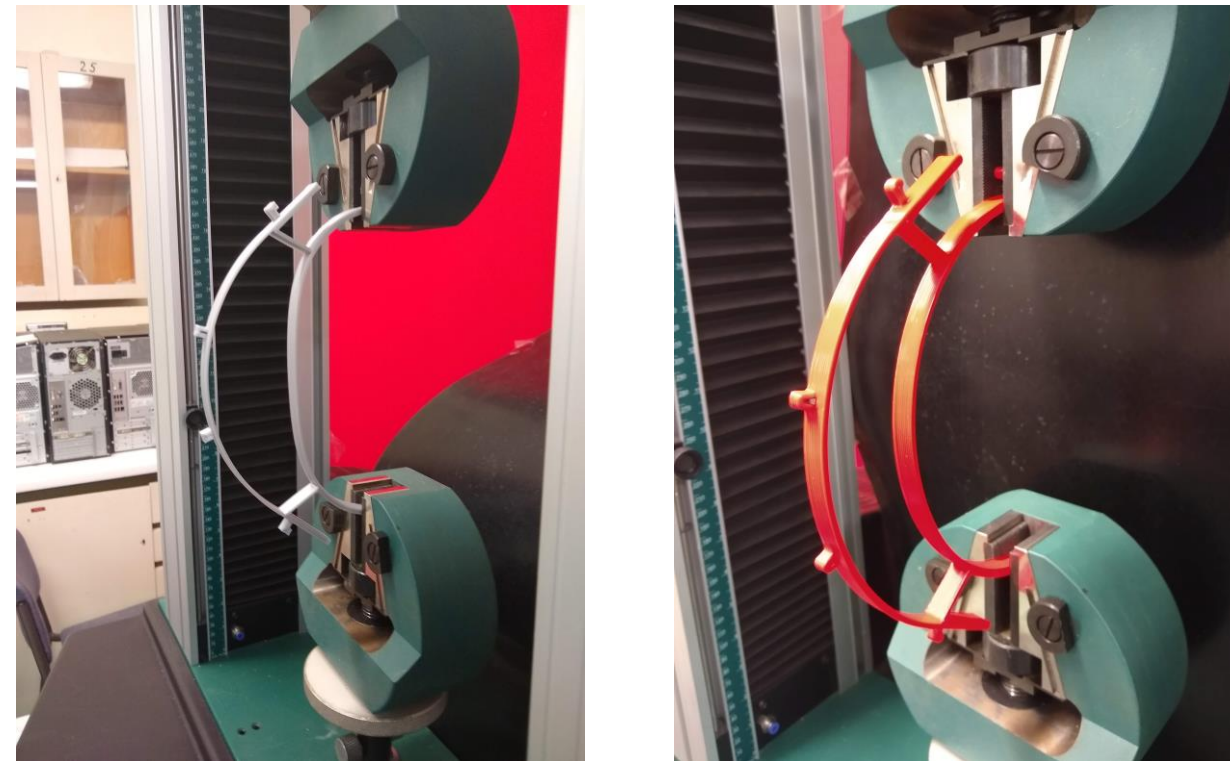


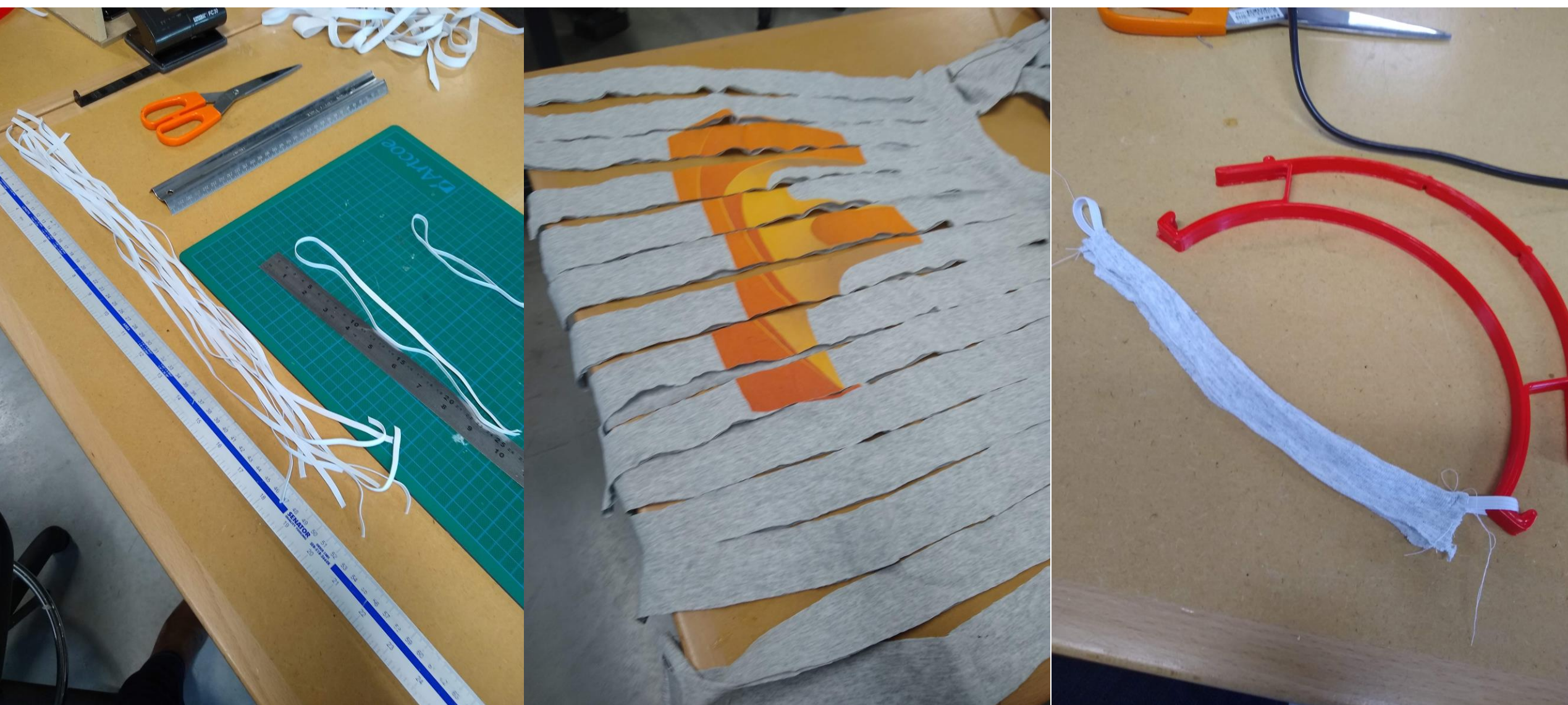
6th April

- Established successful print workflow
- Designed bottom reinforcement piece for large-scale
- Printing top and bottom headband using 3DPs
- Production line set up
- Started distribution to the community free of charge
- Working flat out
- Using A4 report cover sheets with a 4-hole hole punch to create the holes
- Design with BSI for testing



Tensile Testing



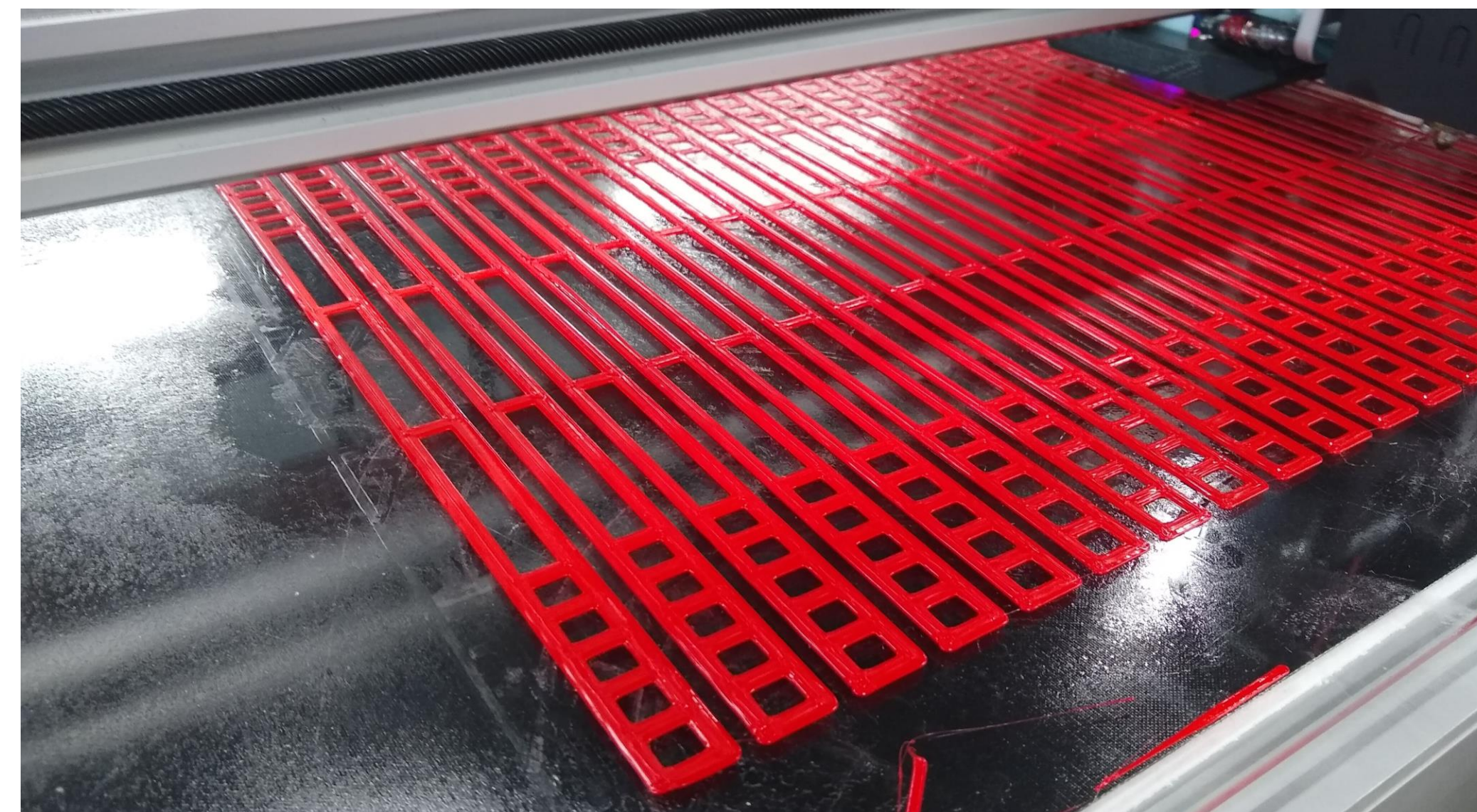


Elastic

Slow to make

Hand skills

Using a sewing machine



3D Printed Strap

Print 64 in 1 hour

Formed hot off the bed into curve

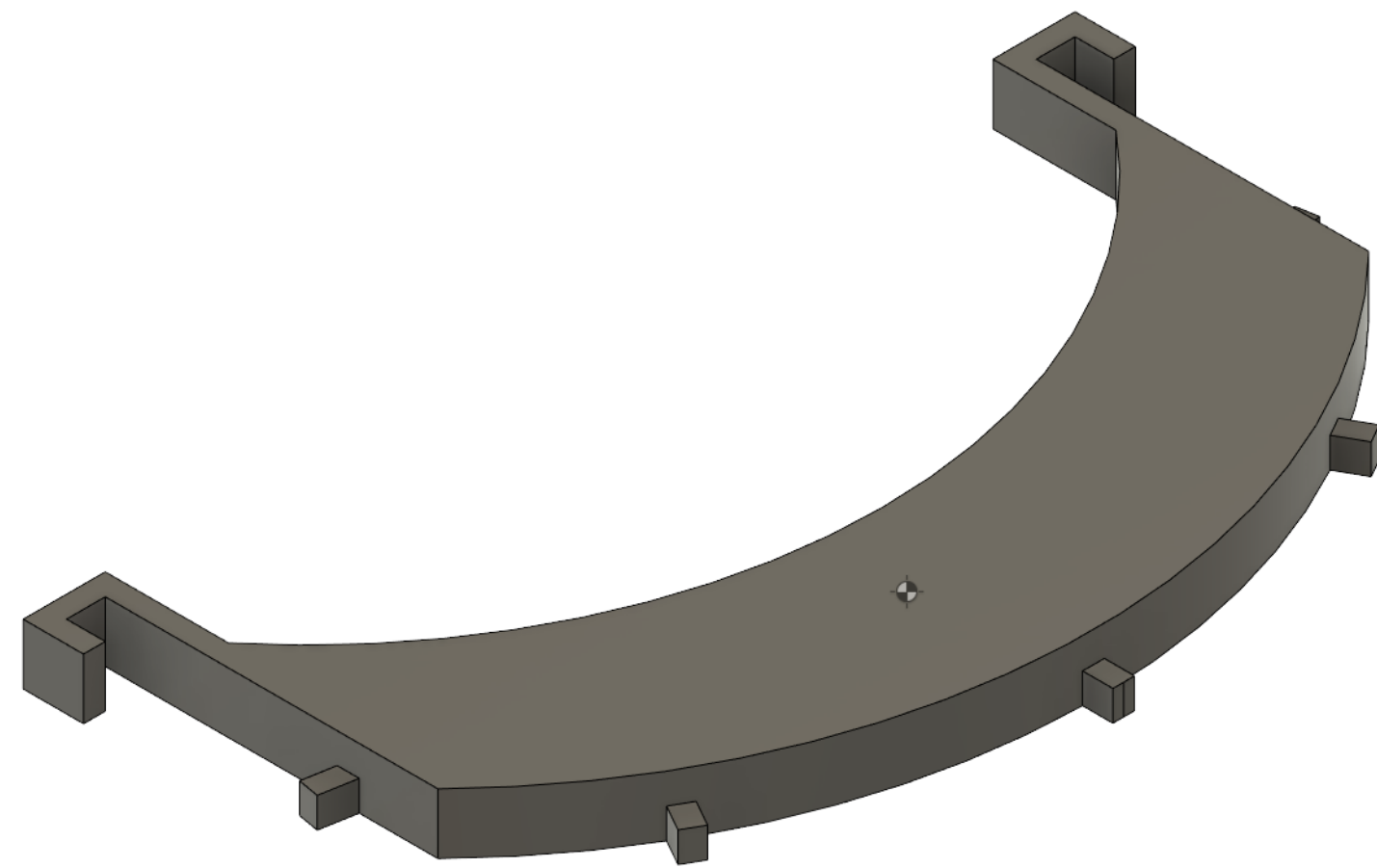
Automated process

BSI Testing

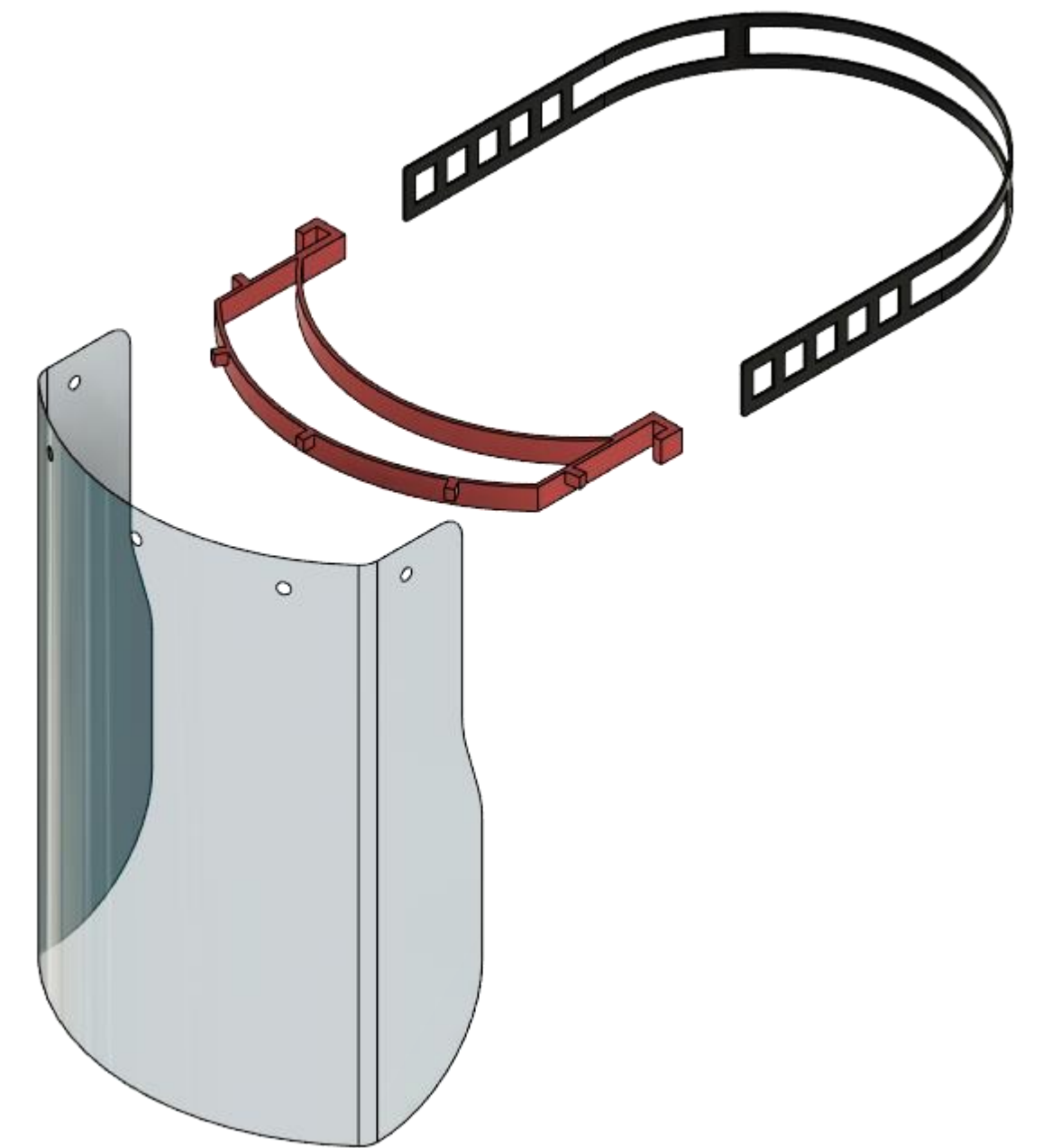
- Our A4 sheet just wasn't big enough
 - Needed to modify the headband to change the location of the visor
- Or
- Come up with a new supplier/solution for the visor



Version 4



COMPLETE RE-DESIGN



NEW FACE SHIELD KIT

Design Changes

- Narrower visor / more wrap
- Bottom reinforcement piece removed
- Longer visor
- 5 attachment points instead of 4
- Reduction in printing material
- Faster to print



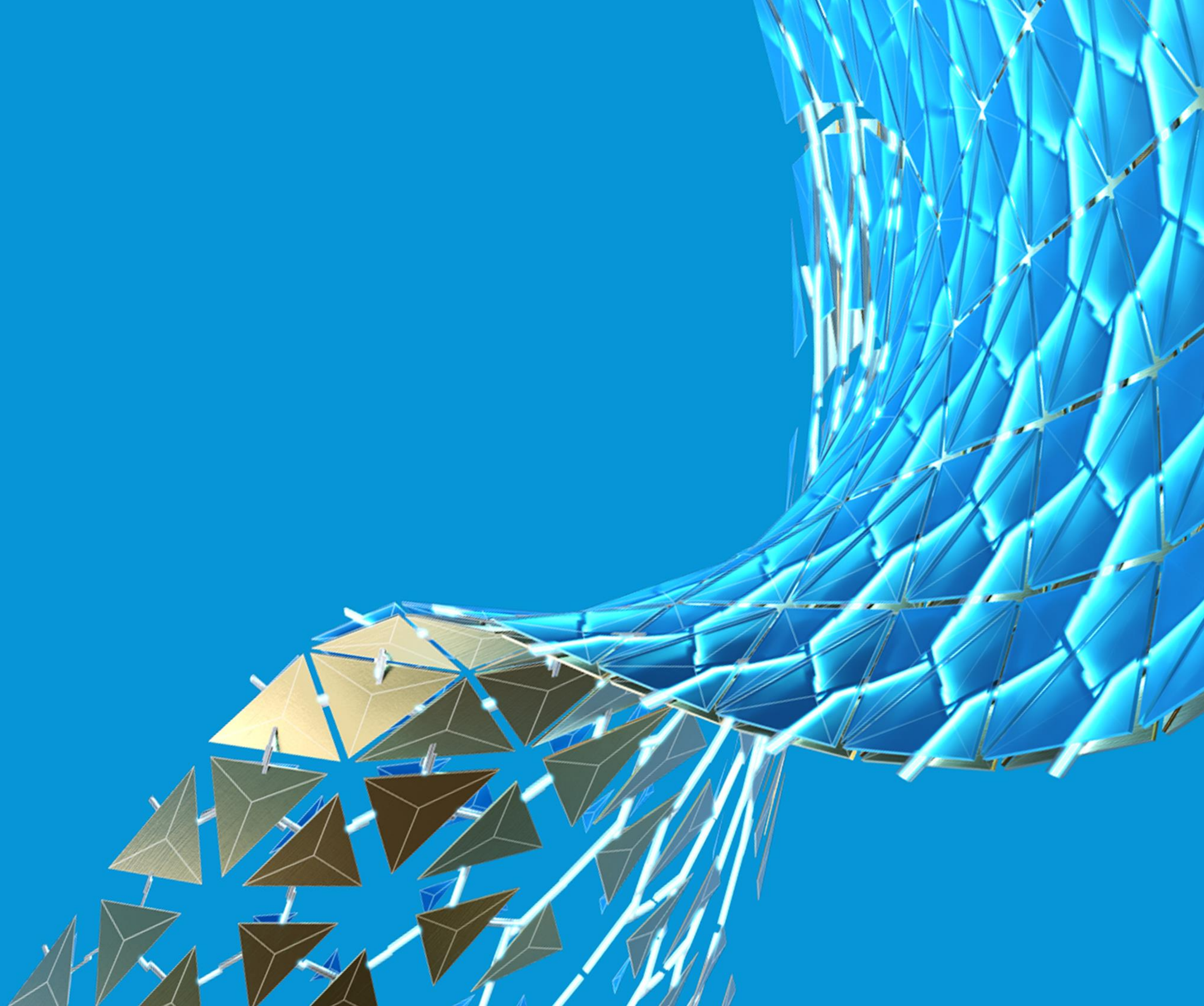
BSI Testing

- Our A4 sheet just wasn't big enough
 - Needed to modify the headband to change the location of the visor
- Or
- Come up with a new supplier/solution for the visor



7667

Conclusions



Summary

OBJECTIVE 1

Learn about the global maker's response to the COVID-19 crisis

OBJECTIVE 2

Learn how Warwick University responded and helped using 3D printing

OBJECTIVE 3

Learn how to print a PPE face shield in under three minutes

OBJECTIVE 4

Learn about large-scale additive manufacturing

Want More?

REACH OUT ON MY SPEAKER / CLASS PAGE

READ MY PUBLISHED JOURNAL PAPER

BISHOP, Elizabeth G.; LEIGH, Simon James. Using Large-Scale Additive Manufacturing as a Bridge Manufacturing Process in Response to Shortages in Personal Protective Equipment during the COVID-19 Outbreak. International Journal of Bioprinting, [S.l.], v. 6, n. 4, p. 281, sep. 2020

<http://ijb.whioce.com/index.php/int-j-bioprinting/article/view/281/pdf>

JOIN ONE OF MY OTHER CLASSES

Stressing Out: Simulation Workspace in Fusion 360

Fusion 360 and 3D Printing: Tips and Tricks for a Successful Workflow



Autodesk and the Autodesk logo are registered trademarks or trademarks of Autodesk, Inc., and/or its subsidiaries and/or affiliates in the USA and/or other countries. All other brand names, product names, or trademarks belong to their respective holders. Autodesk reserves the right to alter product and services offerings, and specifications and pricing at any time without notice, and is not responsible for typographical or graphical errors that may appear in this document.

© 2020 Autodesk. All rights reserved.

