



3D Printing of QA Phantoms

From Conception to Prototype to Application

Justin Gagneur MA, DABR

Outline

- Introduction
- Resin or FDM
- Filament Choices
- Practical Examples

Introduction

- Why should you consider 3D Printing?
 - You'll use less tape
 - Your imagination is the limiting factor
- Look for things that annoy you during QA
- Increase your value to the department

Resin or FDM

- Resin
 - Pro's
 - High resolution
 - Ability to make more complex shapes and structures than FDM
 - Higher print consistency when compared to FDM
 - Con's
 - Cost
 - Resin printers have higher initial and ongoing costs
 - Can use toxic chemicals
 - Requires cleaning after the print
 - UV Curing

Resin or FDM

- FDM
 - Pro's
 - Adequate resolution
 - Cheap
 - Wide variety of filaments to meet your printing needs
 - Accessible (Lots of online resources available)
 - Con's
 - ABS has a strong odor and requires ventilation
 - Bed adhesion can be problematic
 - Parts can fail between layers

Filament Choices

- PLA (Polylactic Acid)
 - Very forgiving
 - Low warpage
 - Sandable &gluable
 - Can use bondo to fill defects
- ABS (Acrylonitrile Butadiene Styrene)
 - Strong
 - Prone to warping
 - Can use acetone to finish the surface
- Polycarbonate
 - Very Strong,
 - Requires very high temperatures to print (~300c)

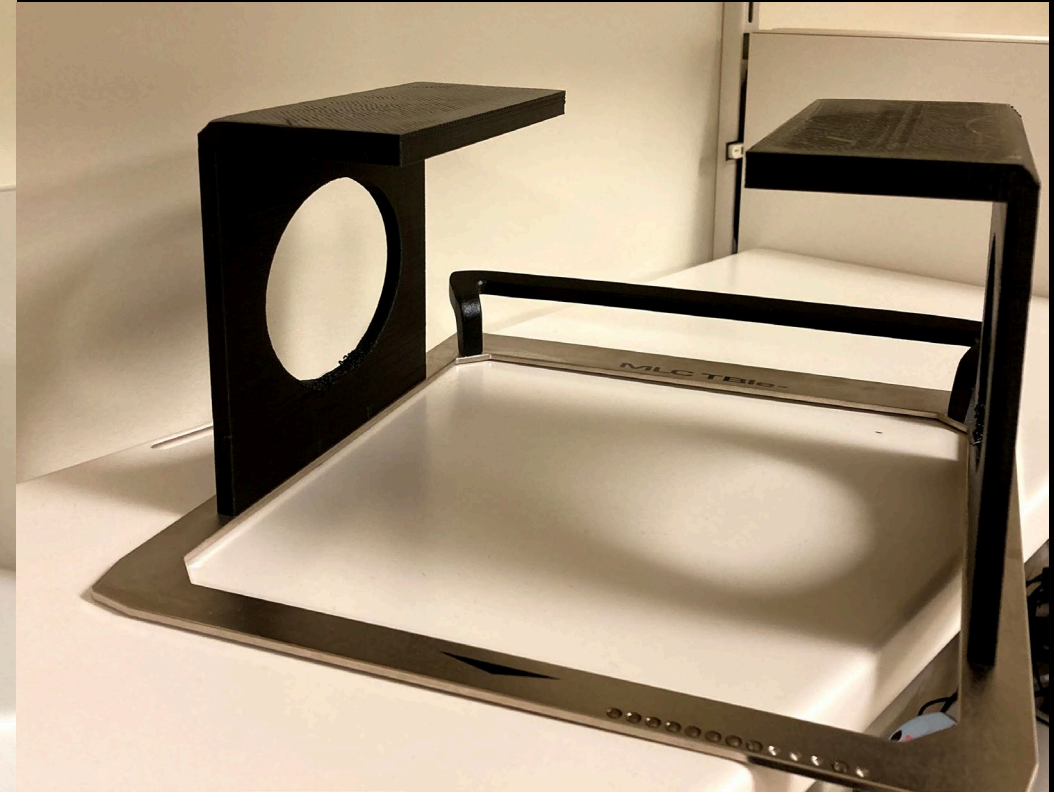
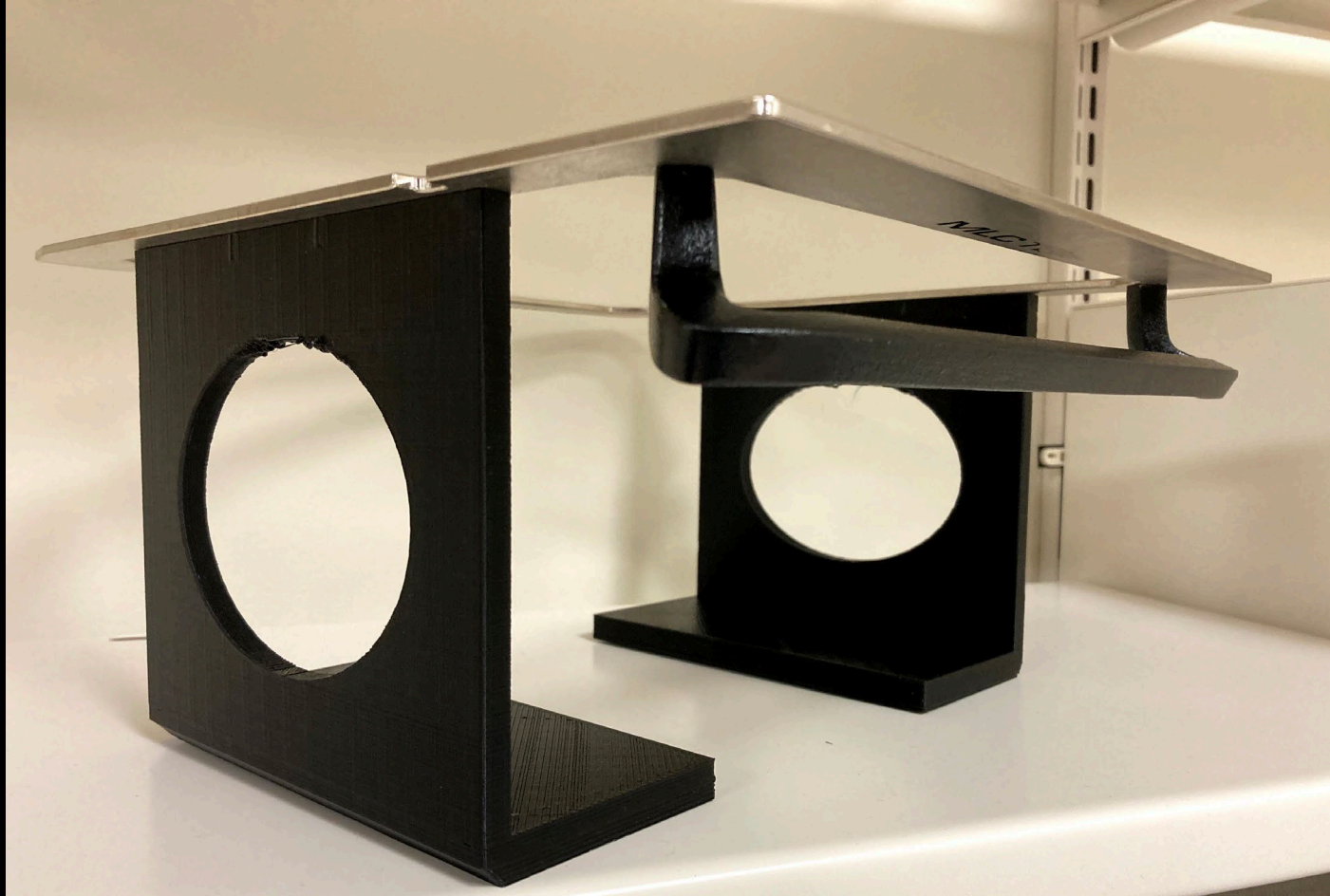
Filament Choices

- TPU (Thermoplastic Polyurethane)
 - Very soft,
 - Inconsistent density when printing,
 - Commercially “Ninja Flex
- BronzeFill (80% PLA / 20% Bronze)
 - Very rough and can damage the printer if the filament is rubbing against any plastic parts
 - Sandable
 - Density around 4g/cc
- LW-PLA (Light Weight PLA)
 - Easy to use
 - Expands 3x at 230c
 - Can be used to speed up prints or make them lighter depending on

TG-51 Lead holder

- Clinical Need
 - TG-51 requires “precise” placement of the 1mm lead foil
 - Using tape is annoying, difficult, and error prone
- Prototyping
 - Distance from collimator head to isocenter is known
 - Can you attach it to the collimator head
 - How do you do that? (Interface mount, accessory mount, custom jig)

TG-51 Lead holder



OSLD Mass annealer

- Clinical Need
 - We want to start annealing OSLD's
 - Technically all you need is a bright light but that could lead to variation in bleaching
- Prototyping
 - How many OSLDs can we anneal at the same time?
 - How many OSLDs do we *need* to anneal at the same time?
 - How do we hold / contain the OSLDs

OSLD Mass annealer



ExacTrac Leads Phantom Holder

- Clinical Need
 - ExacTrac KV image quality needs to be periodically tested
 - X-ray tubes are in a fixed angled geometry with respect to isocenter
- Prototyping
 - How do you securely hold the leads phantom at a 45-degree angle?
 - How do you align the phantom holder accurately?

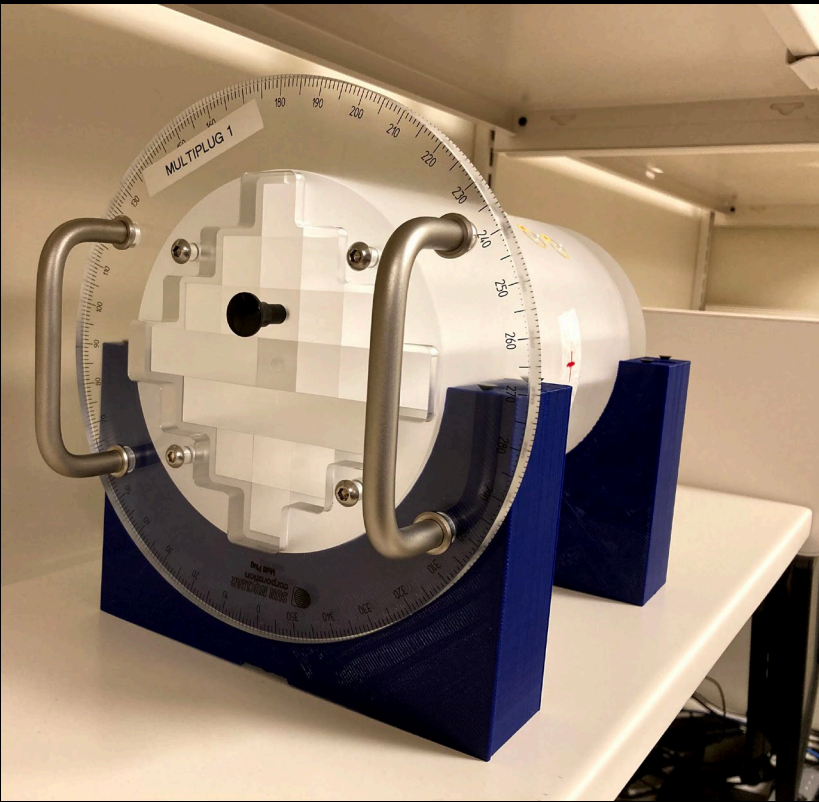
ExacTrac Leads Phantom Holder



Annual End to End

- Clinical Need
 - MPPG 9.a has a requirement for an annual end to end phantom
 - Many commercial products already exist but can we use something we already have?
 - In our case an ArcCheck Multiplug
 - Process should be simple and resistant to errors
- Prototyping
 - How to we securely hold the ArcCheck Multiplug?
 - Can rotational deviations be minimized?
 - It will be setup and taken down multiple times during the E2E process. Can it be set back up in the same position?

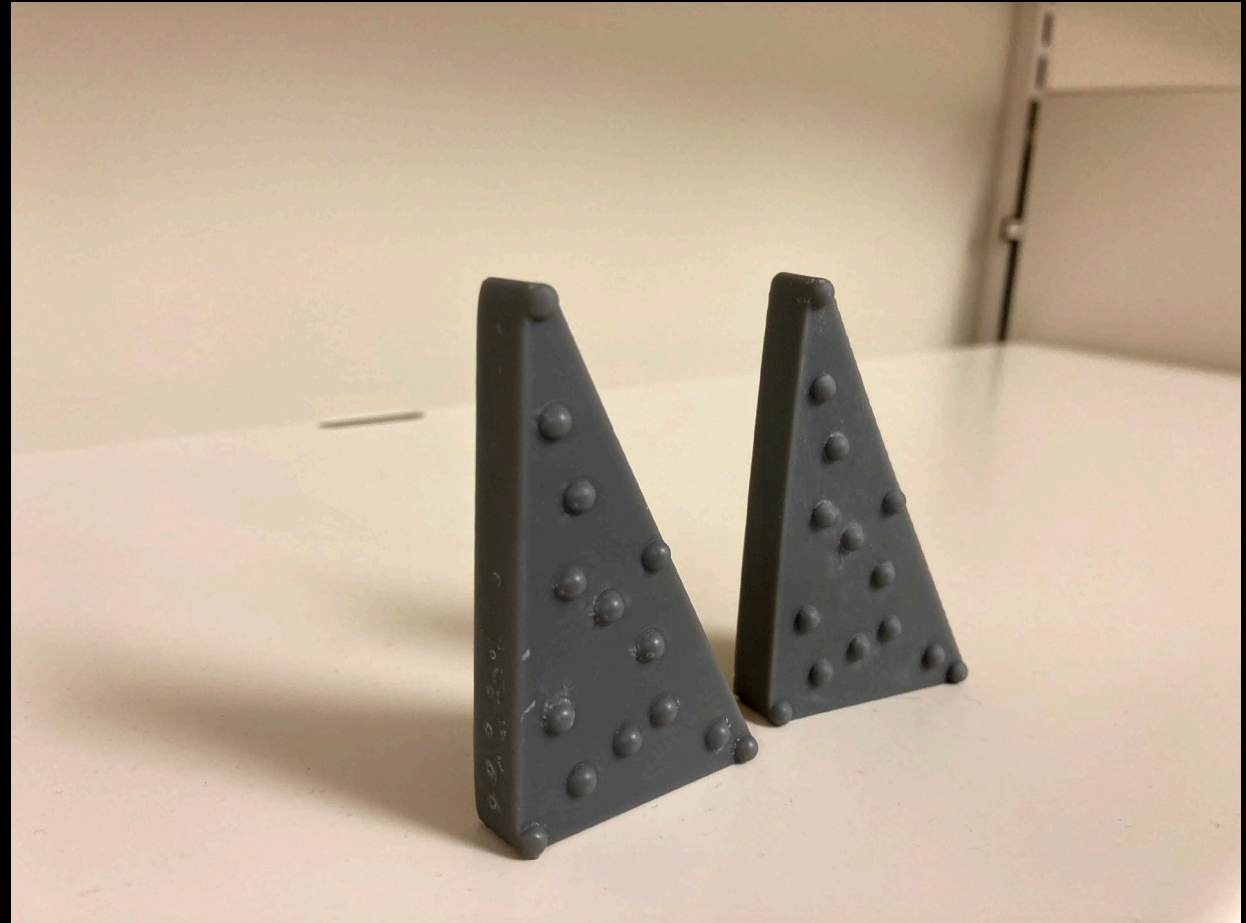
Annual End to End



Surface Imaging QA

- Clinical Need
 - How to test the resolution of a surface imaging system?
- Prototyping
 - Need a high-resolution print for small structures
 - Resin or FDM?
 - What shapes are useful?

Surface Imaging QA



Conclusion

- Map out your needs
- For filament prints be aware of density changes from print to print
- 3D printed phantoms can replace commercially available phantoms
 - Look around at what you have and use 3D printing to meet your needs
- Accept that failure and iteration are a part of the process

References

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- Bieniosek, M.F., Lee, B.J. and Levin, C.S. (2015), Technical Note: Characterization of custom 3D printed multimodality imaging phantoms. Med. Phys., 42: 5913-5918. <https://doi.org/10.1118/1.4930803>