

Additive Manufacturing Technology and Trends

Rapid Software Development for Slow 3D Printers

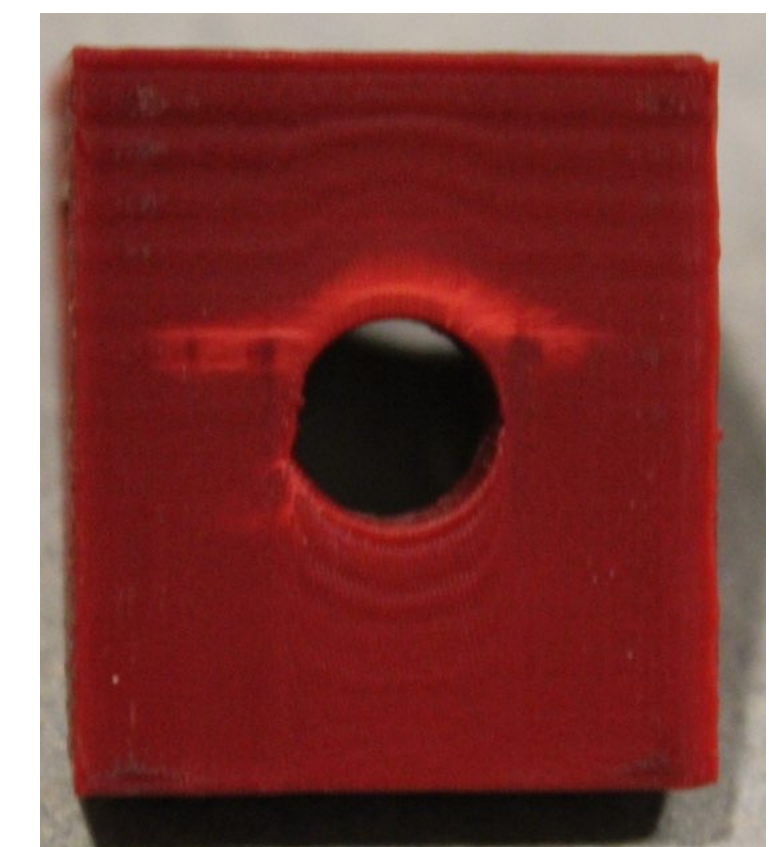
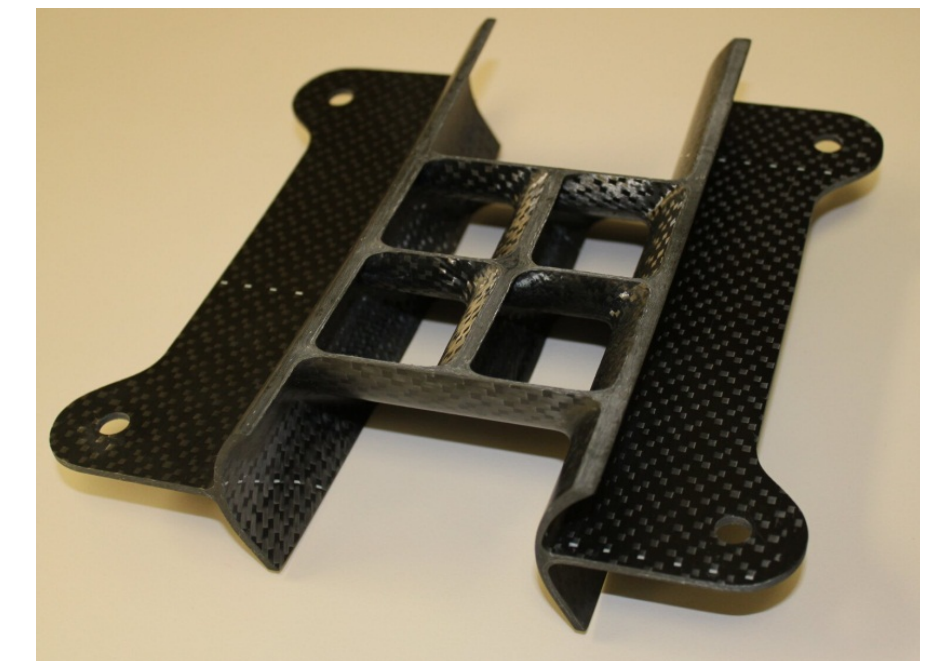
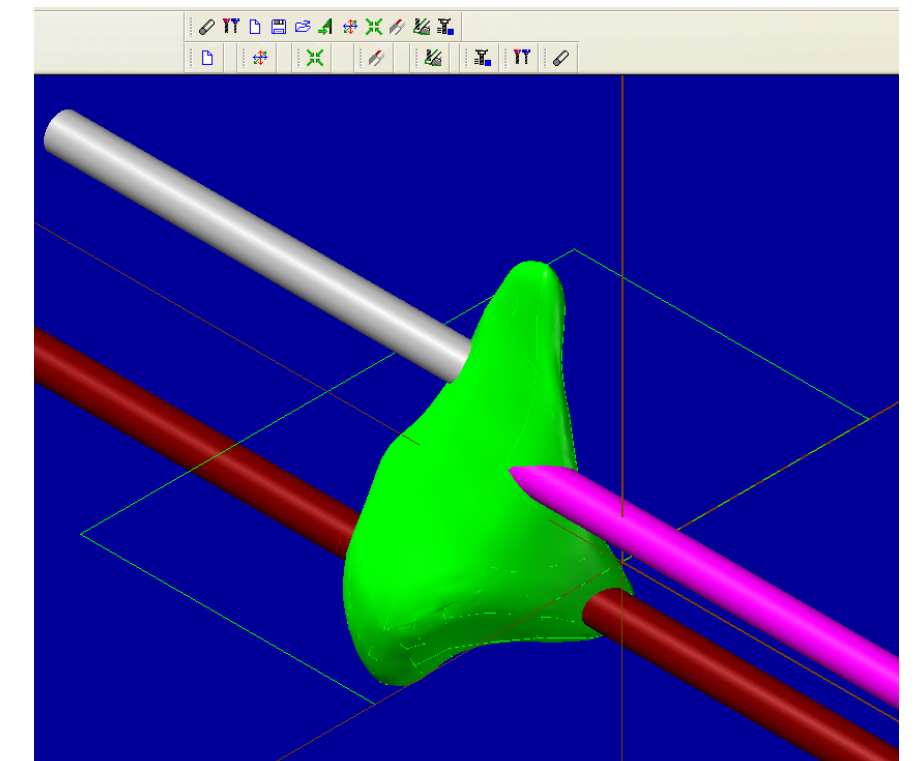
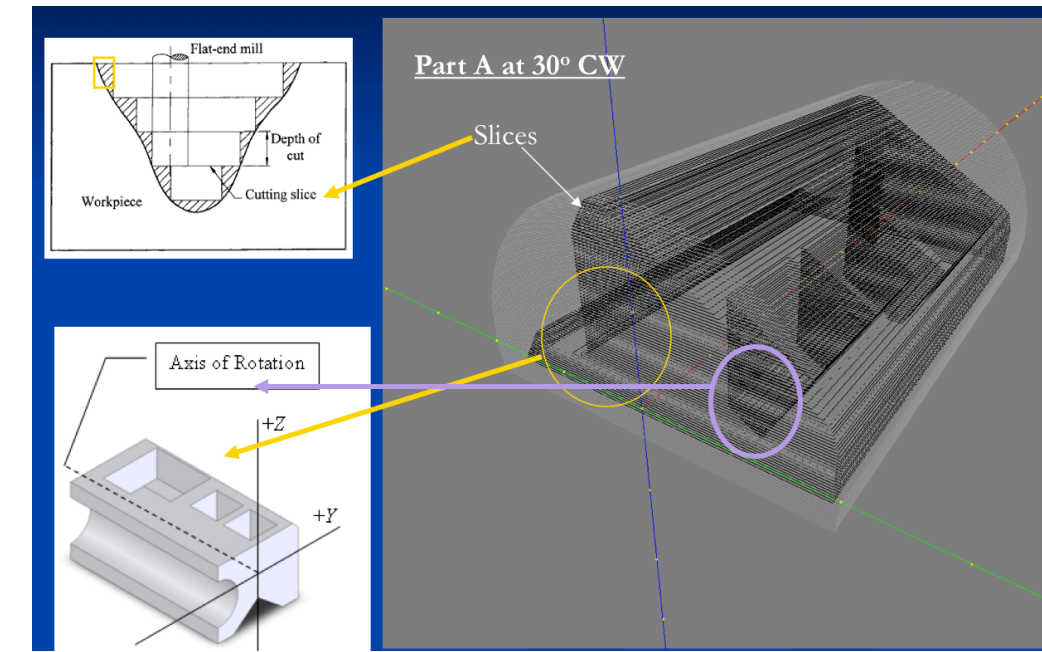
6/24/22

Instructors:

1. Alex Raymond Renner: arenner@iastate.edu
2. Michael Holm: mdholm@iastate.edu

Alex's Related Previous Work

- BS in Mechanical Engineering
- MS in Industrial and Manufacturing Systems Engineering (IMSE)
- Industrial Experience
- Mechanical Engineering PhD Student, HCI Co-Major
- Research interest: help novice users reduce or remove defects before 3D printing parts



Michael's Related Previous Work

- BS in Mechanical Engineering
- Concurrent Grad student
- Danfoss 3D printing
- PrISUm
- Research interest:

3D Printer “expert”

- Someone who rarely knows what they’re 3D printing,
- Someone who can’t wait to take something apart even if it isn’t broken and learns something every time they do so
- Someone who is willing to say “3D Printing is just as much of an art as it is a science”
- Someone who has used and maintained some 3D printers long enough to be asked for advice on how to prepare, print, or improve 3D print quality
- Someone who has spent as many hours running 3D printers as he or she has spent researching them, reading emails forwarded with the subject line “have you seen or heard about this ... 3D printing ...”, and teaching anyone who will listen to what I think I know about the subject
- *Not someone who says they’re a 3D printer expert*

Lecture ~~Attendance~~ Participation Guide

1. What is 3D Printing have to do with the VRAC and HCI Graduate Program?
2. Where can you go to get training and certification to use 3D printers?
3. When should someone use a 3D printer?
4. Why are we doing a “Deep Dive” into 3D printing?
5. How does your degree relate to 3D printing?

Additive Manufacturing Technology and Trends

MCA Session Topic: Background

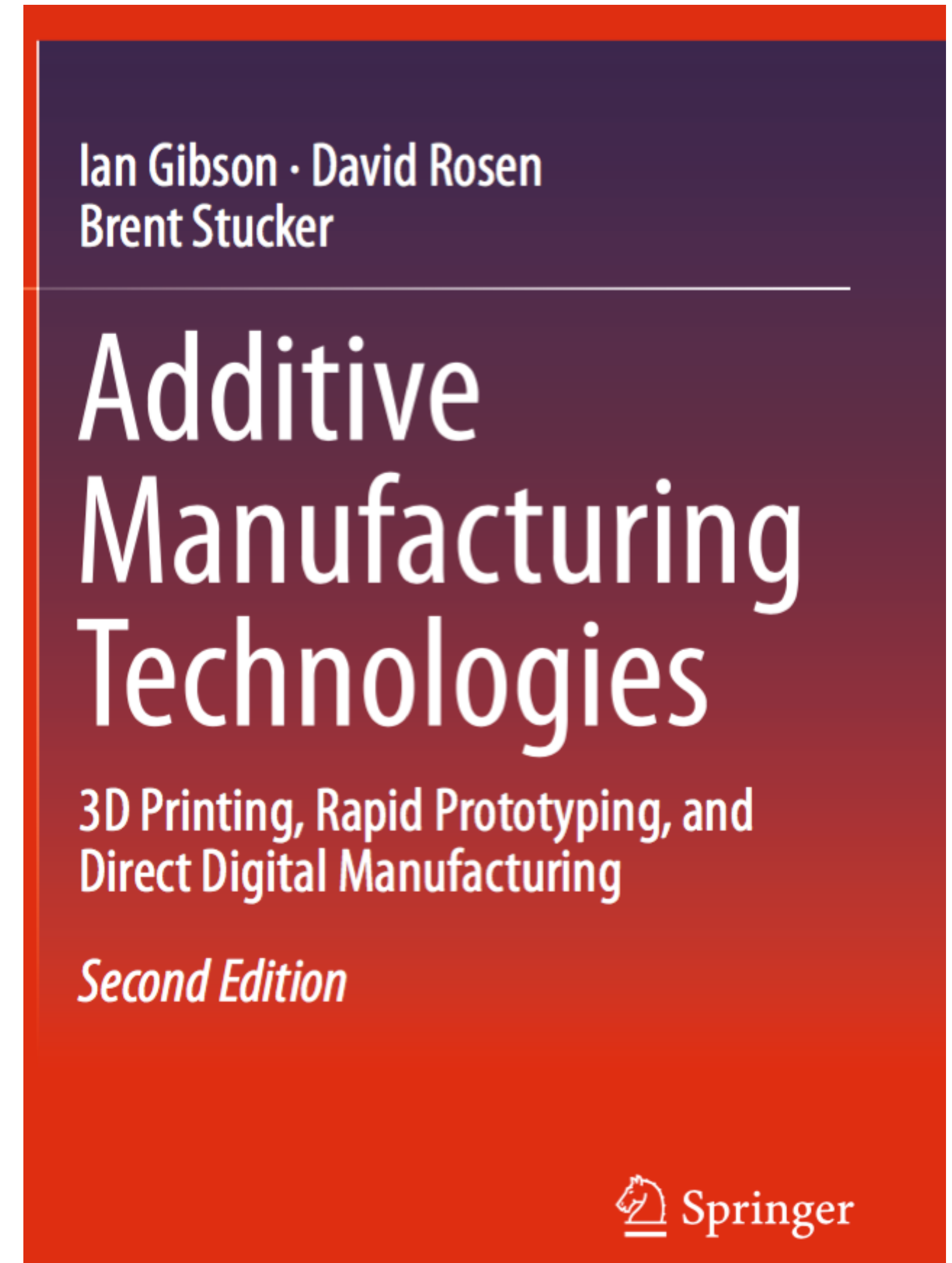
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Background: Terminology

- Additive Manufacturing (AM): Category
- Rapid Prototyping (RP)
- 3D Printing
- Direct Digital Manufacturing



“Additive Manufacturing”: Textbook Definition

- *Additive Manufacturing is defined by a range of technologies that are capable of translating virtual solid model data into physical models in a quick and easy process.*
- *The data are broken down into a series of 2D cross-sections of a finite thickness.*
- *These cross-sections are fed into AM machines so that they can be combined, adding them together in a layer-by-layer sequence to form the physical part.*
- *The geometry of the part is therefore clearly reproduced in the AM machine without having to adjust for manufacturing processes, like attention to tooling, undercuts, draft angles, or other features.*
- *We can say therefore that the AM machine is a What You See Is What You Build (WYSIWYB) process that is particularly valuable the more complex the geometry is.*
- *This basic principle drives nearly all AM machines, with variations in each technology in terms of the techniques used for creating layers and in bonding them together.*

*Gibson, Ian, David W. Rosen, and Brent Stucker. Additive manufacturing technologies. New York: Springer, 2010.

What's Additive Manufacturing

- *Term for machines that bond small “segments” of material together to create a 3D part*
- Term used for both RP and 3D printing
- Industry standard term (ASTM F2792) used for the technology, processes, academic research, industrial systems
- Technically this term could refer to the Additive Rapid Prototyping and 3D Printing systems
- Textbook definition...





America Makes

- *Fostering a highly collaborative infrastructure for the open exchange of additive manufacturing information and research.*
- *Facilitating the development, evaluation, and deployment of efficient and flexible additive manufacturing technologies.*
- *Engaging with educational institutions and companies to supply education and training in additive manufacturing technologies to create an adaptive, leading workforce.*
- *Serving as a national Institute with regional and national impact on additive manufacturing capabilities.*
- *Linking and integrating U.S. companies with existing public, private, or not-for-profit industrial and economic development resources, and business incubators, with an emphasis on assisting small- and medium-sized enterprises and early-stage companies (start-ups).*

<https://www.americamakes.us/about/overview>

President Obama Announces...



a New Manufacturing Innovation Hub



“Rapid Prototyping” (RP)

- Rapid – (adjective) marked by a fast rate of motion, activity, succession, or occurrence, synonym: see FAST
- Prototype – (noun) a first full-scale and usually functional form of a new type or design of a construction (as an airplane)
- Textbook for RP :
 - Gibson, Ian, David W. Rosen, and Brent Stucker. Additive manufacturing technologies. New York: Springer, 2010.

Rapid Prototyping Machines



Zcorp 3D Printer



Stratasys (FDM)



Stratasys (PolyJet)

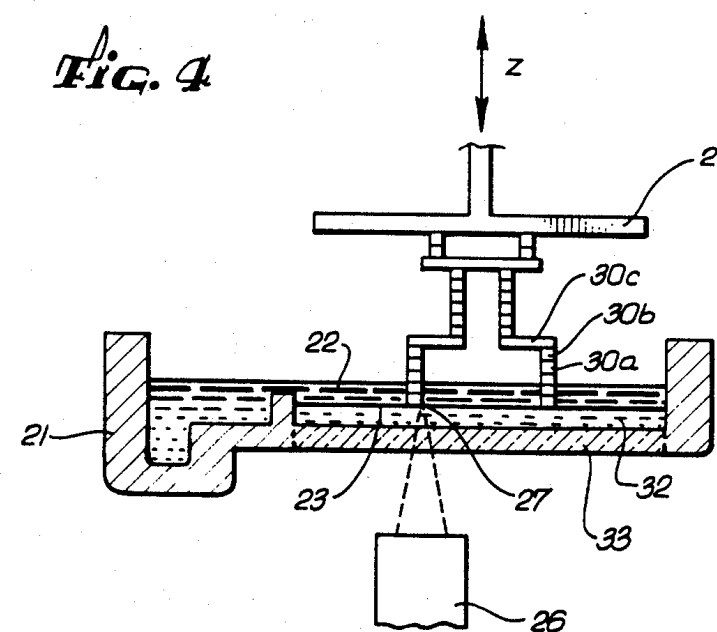
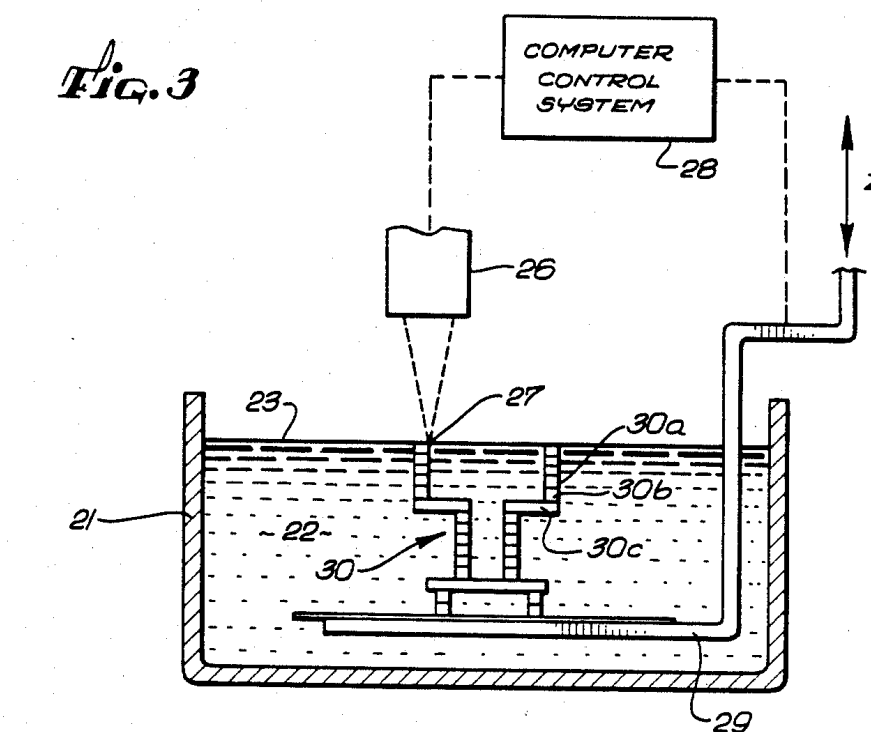


EOS (SLS)

What's Rapid Prototyping (RP): History Lesson

- 1986 Charles Hull (Convex Hull...)
- StereoLithography
- Zcorp "3D Printer"
- Fused Deposition Modeling (FDM) patent (Stratasys)

U.S. Patent Mar. 11, 1986 Sheet 2 of 4 4,575,330



U.S. Patent Aug. 23, 1994 Sheet 6 of 6 5,340,433

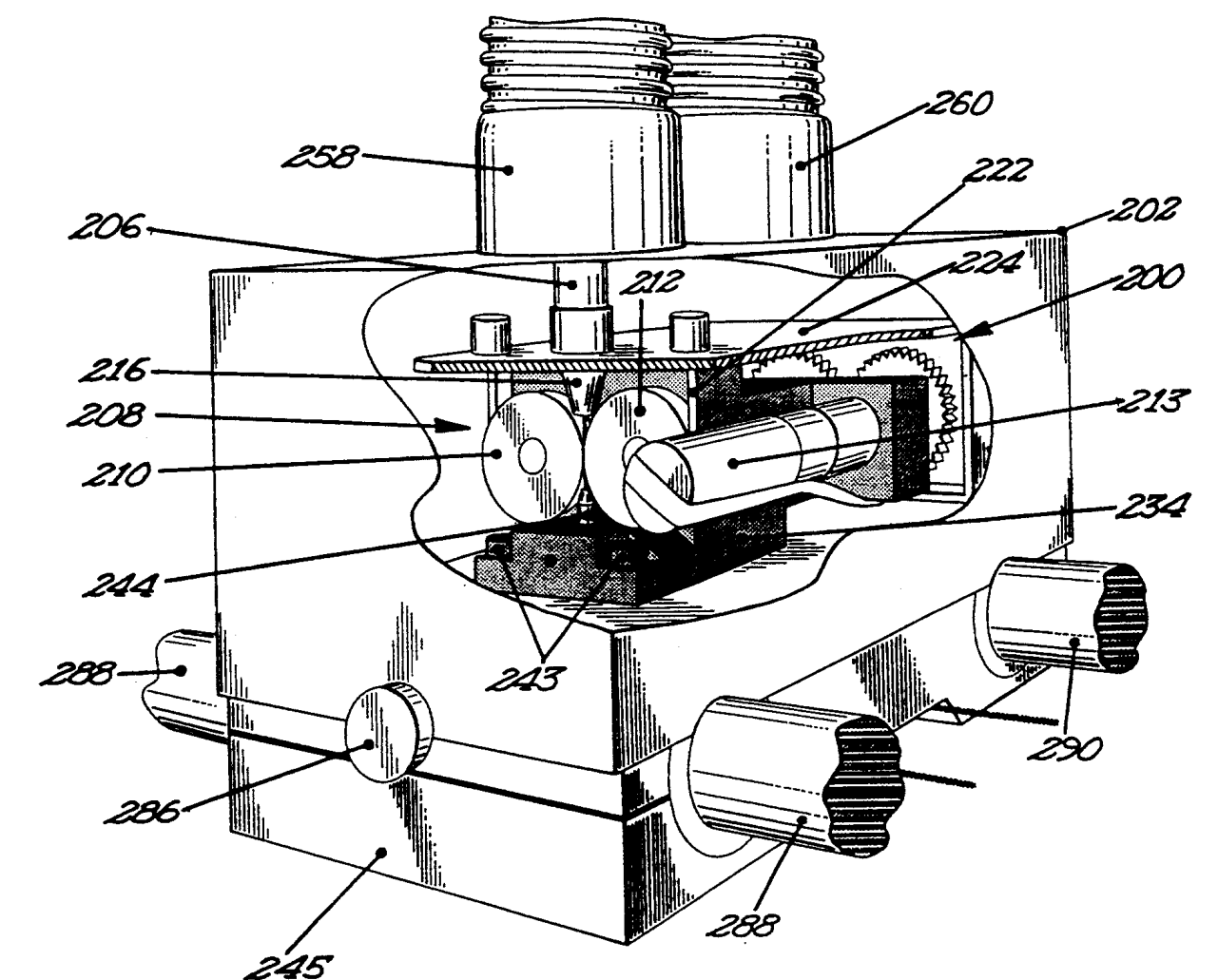
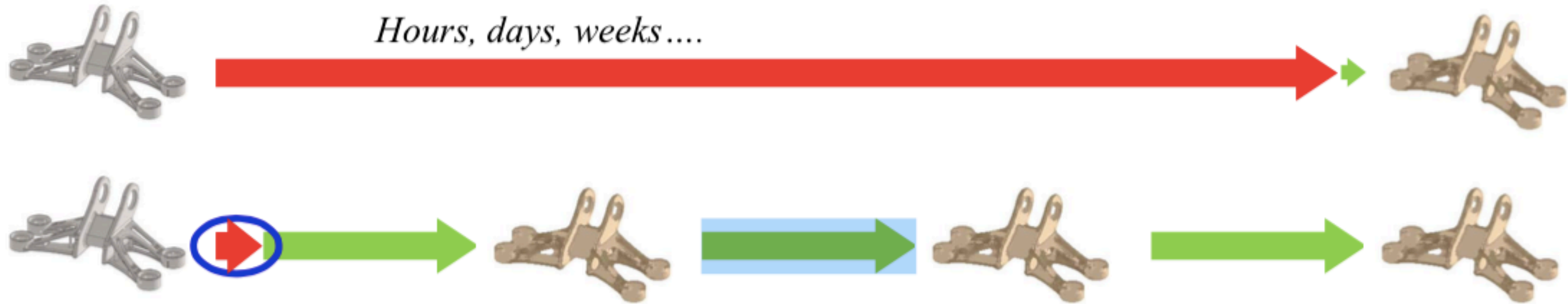


Fig 17

“Rapid Prototyping”

- Most RP/AM systems make models (but this is slowly changing...)
- RP/AM systems create MODELS that convey form, sometimes fit and less often functional characteristics of a design
- *A Functional model is a Prototype*
- What do we require?
 - Something to look at...
 - Something to assemble with other parts... – Something to test...
 - Something to replace a production part...

When to Rapid Prototype



Which is "rapid"?

Which is "better"?

How many did you want?



Form -> Fit -> Function

- Form, as we define it, is the ability of a prototype to convey the design appearance and/or general size and shape of the part.
- – Verification of the design intent – Aesthetics
 - Ergonomics
 - Marketing
- – Promote discussion on Df(x)

Form -> **Fit** -> Function

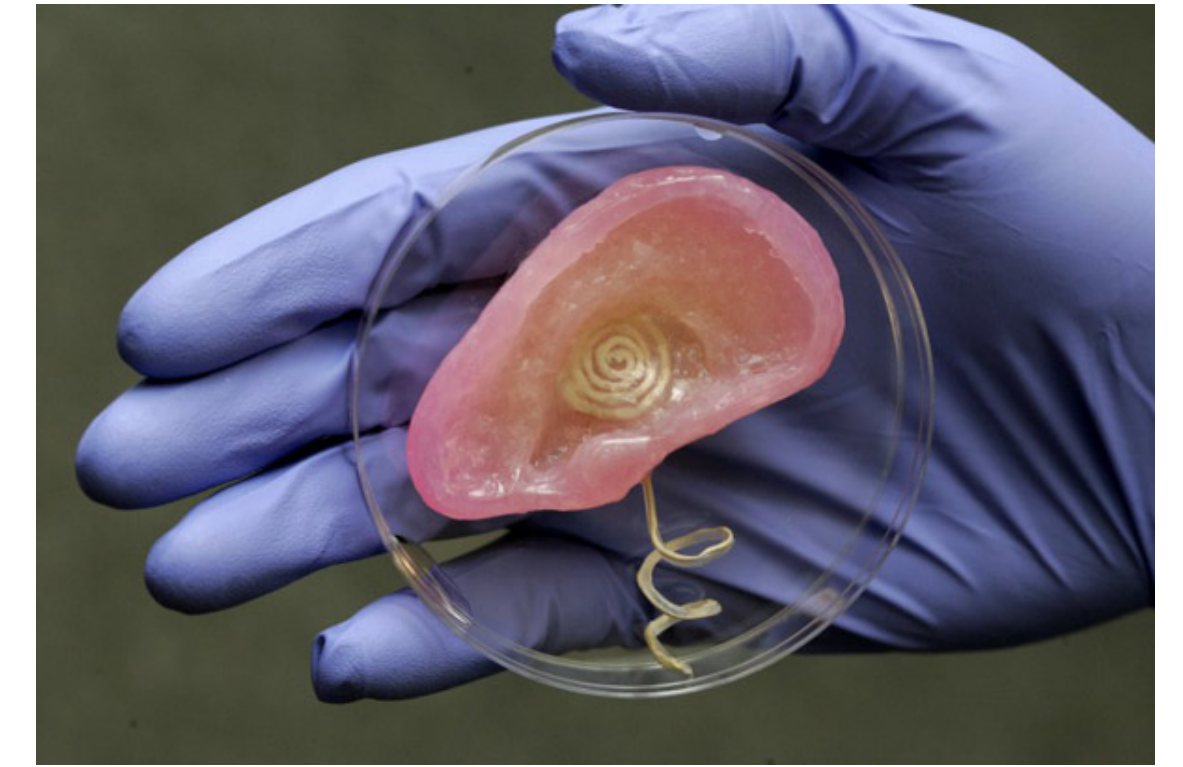
- A prototype that is built for fit will need to more accurately present the size and shapes of the design features.
- – Inspect the general size of the part
- Verify part and feature dimensions
- Assemble with other parts (RP or otherwise)

Form -> Fit -> **Function**

- A first “part”: that can be tested for performance under the conditions for which it is designed.
- – Thermal, Structural Integrity – Fatigue and Failure testing
 - Cycles to failure
 - Dynamic performance

3D Printing Myths

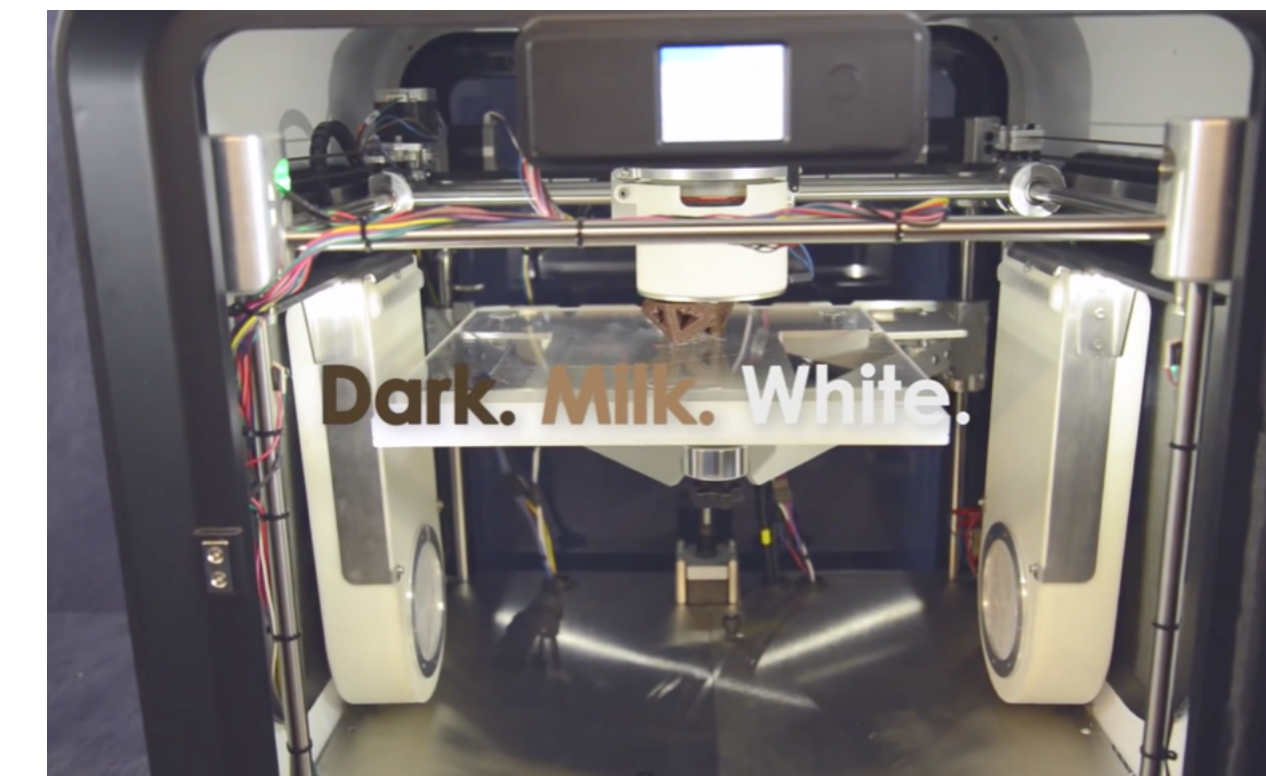
BAAMCI at IMTS 2014
BIG AREA ADDITIVE MANUFACTURING



○ Confirmed, Plausible, or Busted?

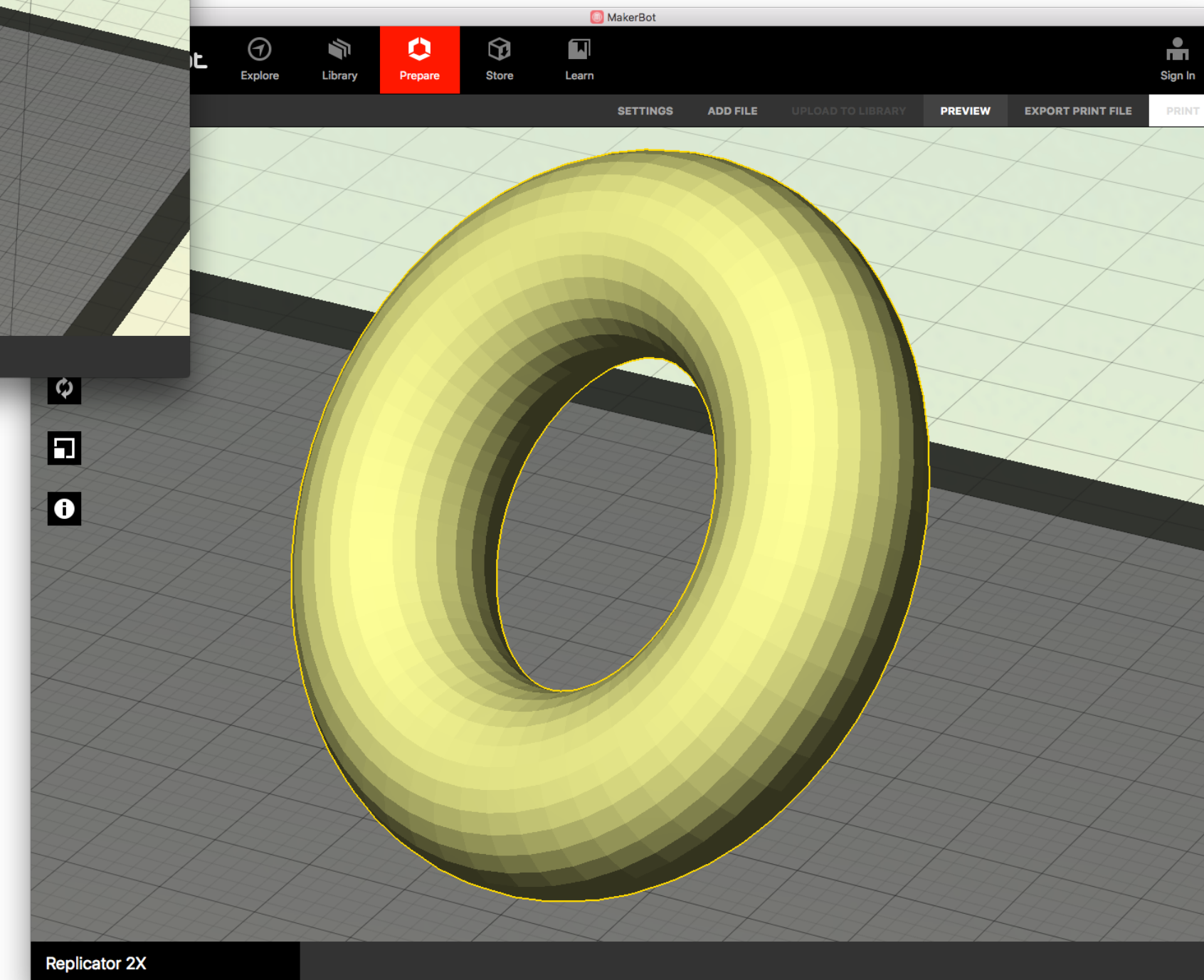
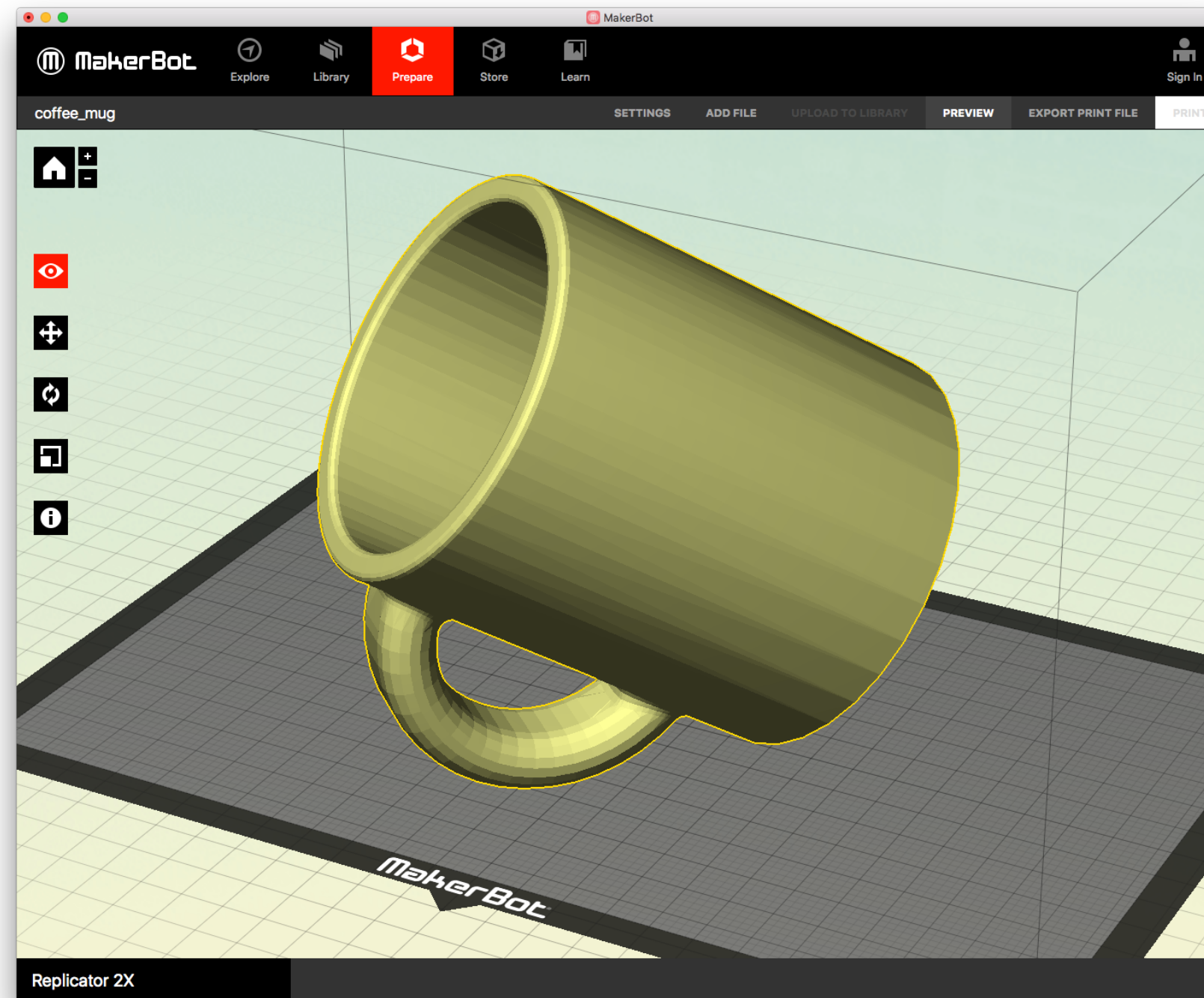
○ You can make Additive Manufactured substitutes for:

- Human Organs?
- Prosthetics?
- Cars and other large products?
- AeroSpace Parts?
- Guns?
- Jewelry?
- Candy?



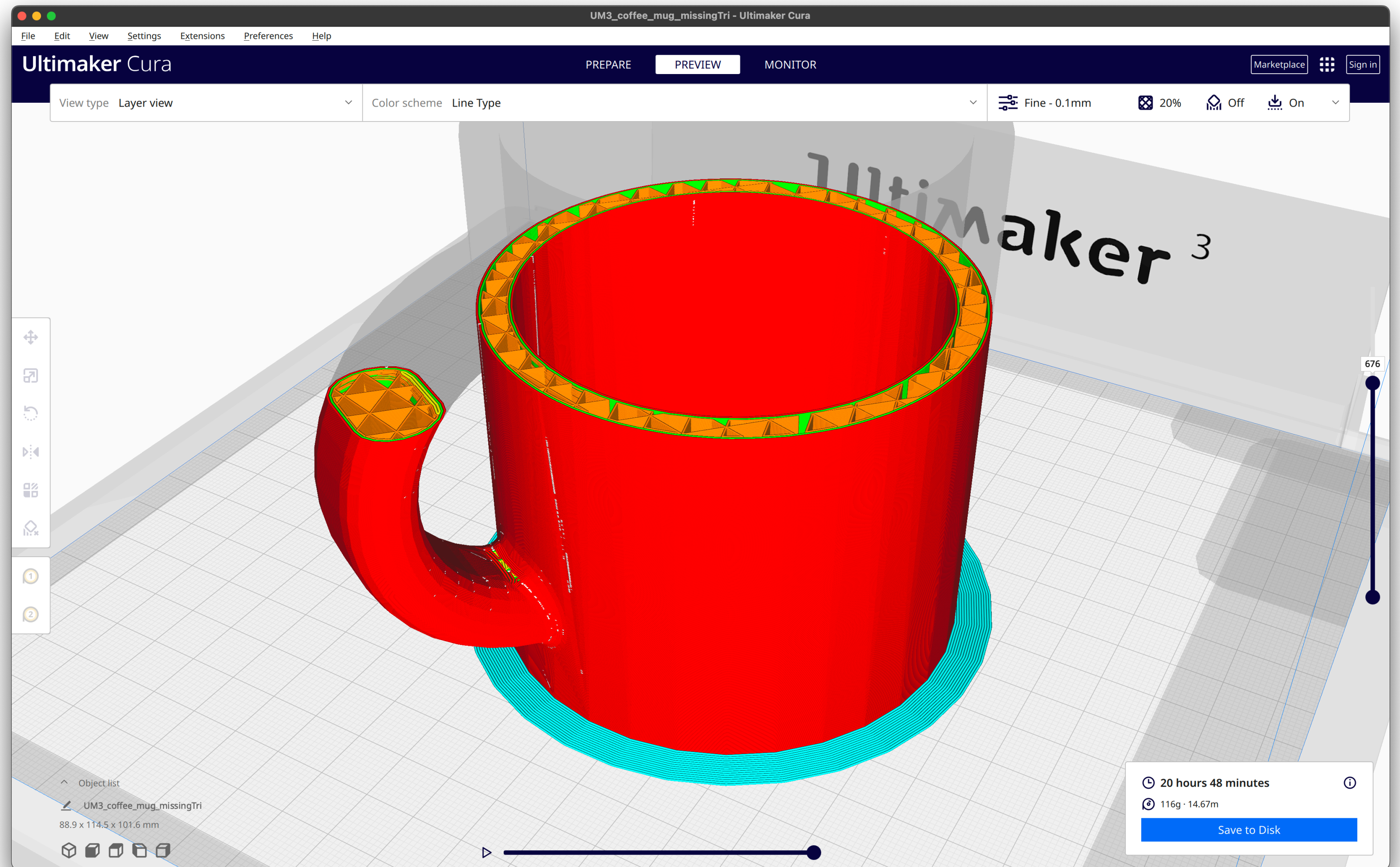
MCA Session 1, In-Class Activity

- Create a Coffee Mug and a Donut in the CAD software of your choice
- Save As or Export the 3D model as an STL file
- Explore the available options when saving as an STL
- Import the STL into Ultimaker Cura and/or PrusaSlicer
- Compare to deprecated MakerBot Desktop software import



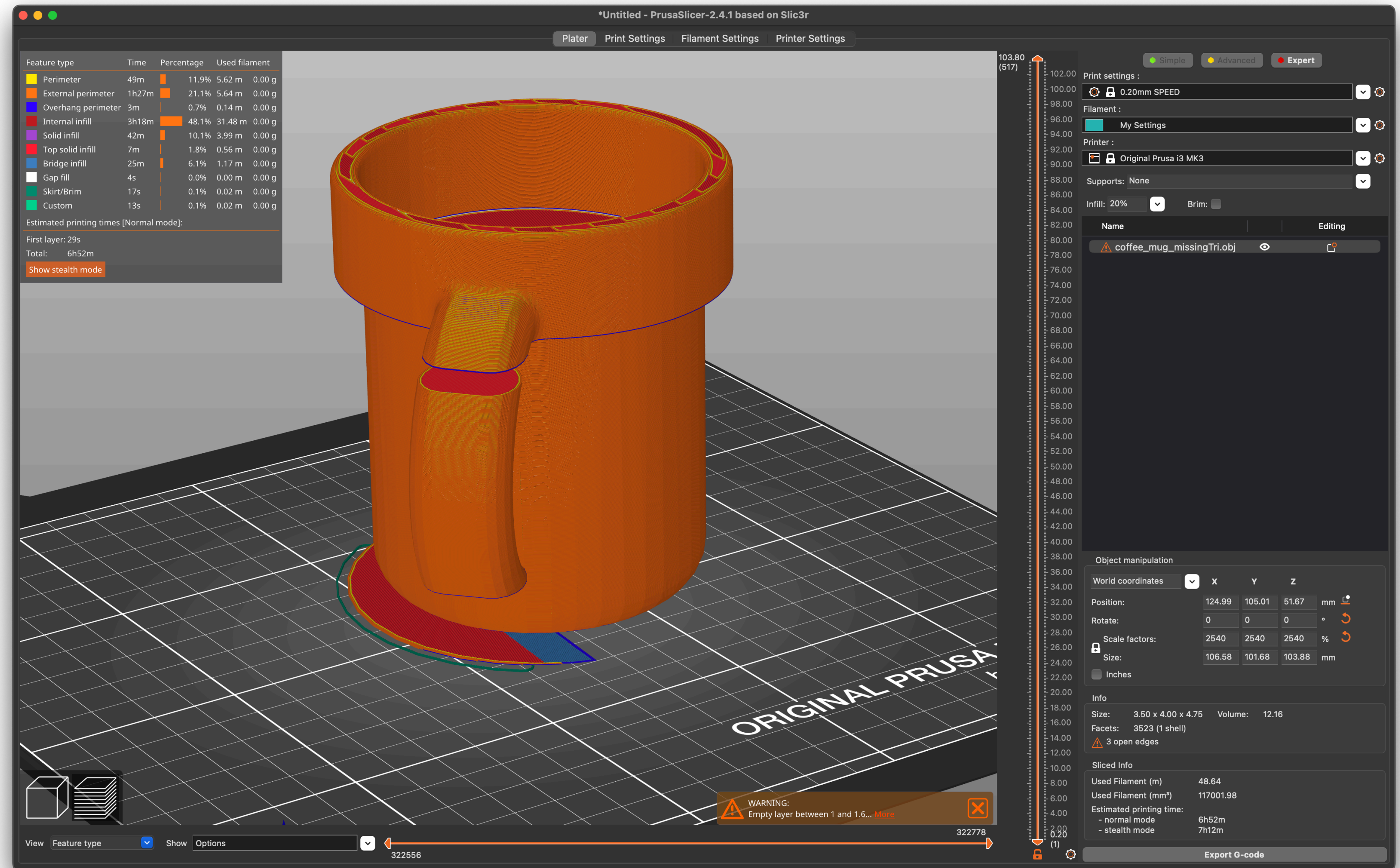
MCA Session 1, In-Class Activity

- Cura “fixes” missing facets



MCA Session 1, In-Class Activity

- PrusaSlicer doesn't try because it shouldn't



MCA Session 1, In-Class Activity

- MakerBot Desktop assumed the model was made for 3D printing
- Which software application helped the user?

