Design for Consumer Level 3D Printing

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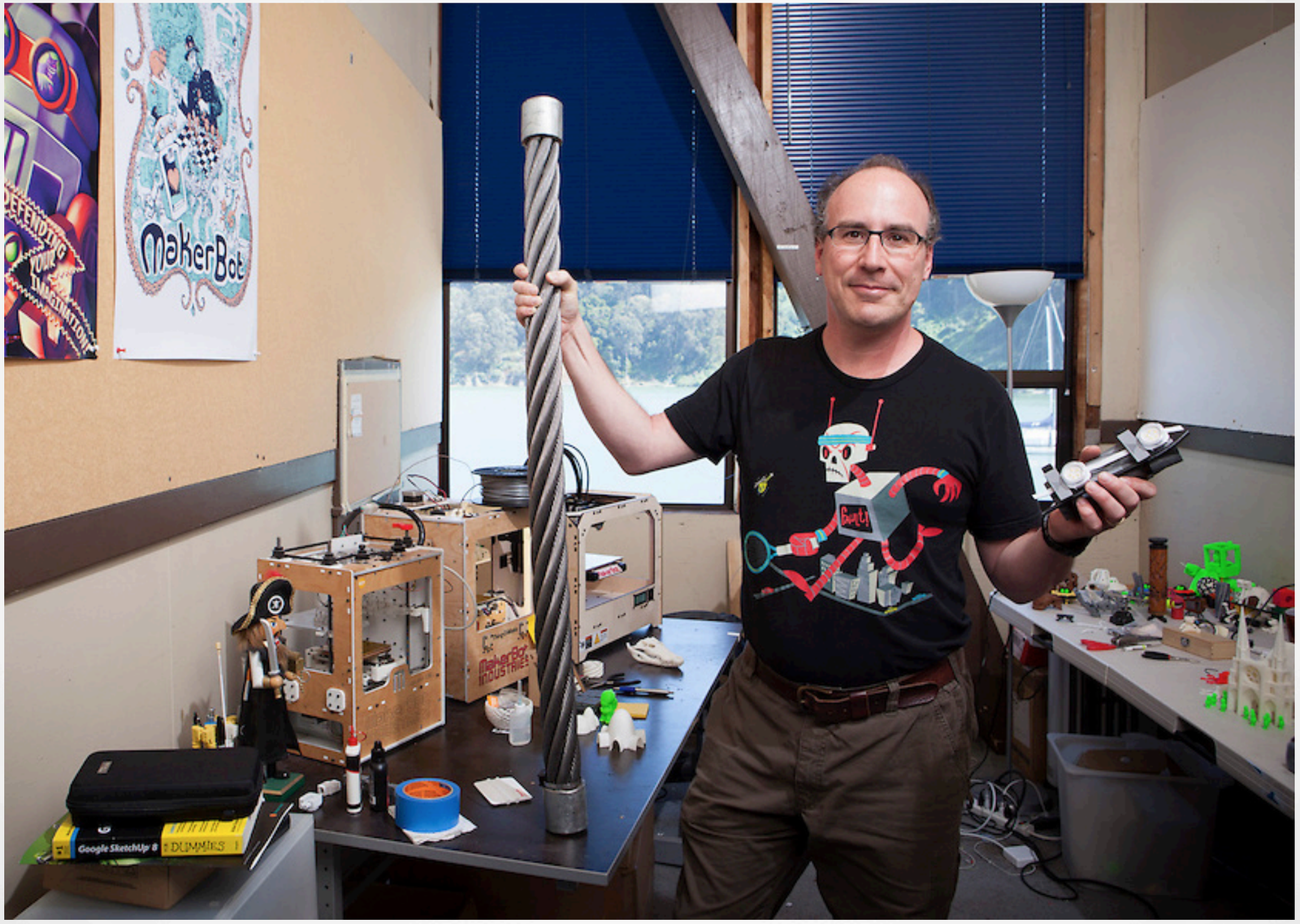
Agenda

- Introduction
- Goals
- How inexpensive 3D printers work
- Constraints and design tips
- Tools

Introduction



User testing

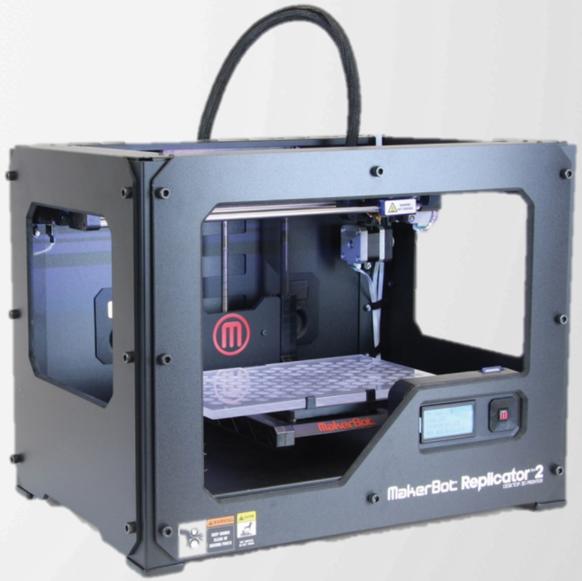
User testing

Goals

- Learn how to design parts that print well on inexpensive 3D printers:
  - Stronger
  - More attractive
  - Quick to print
  - Reduced post-processing
- Learn about tools to help with 3D printing

Background

- 3D printing is not new
- Before, transparent design rules to support prototyping
- Now, reduction in cost means fabrication is main use case
- Realizing the benefits of 3D printing requires designing for the technology

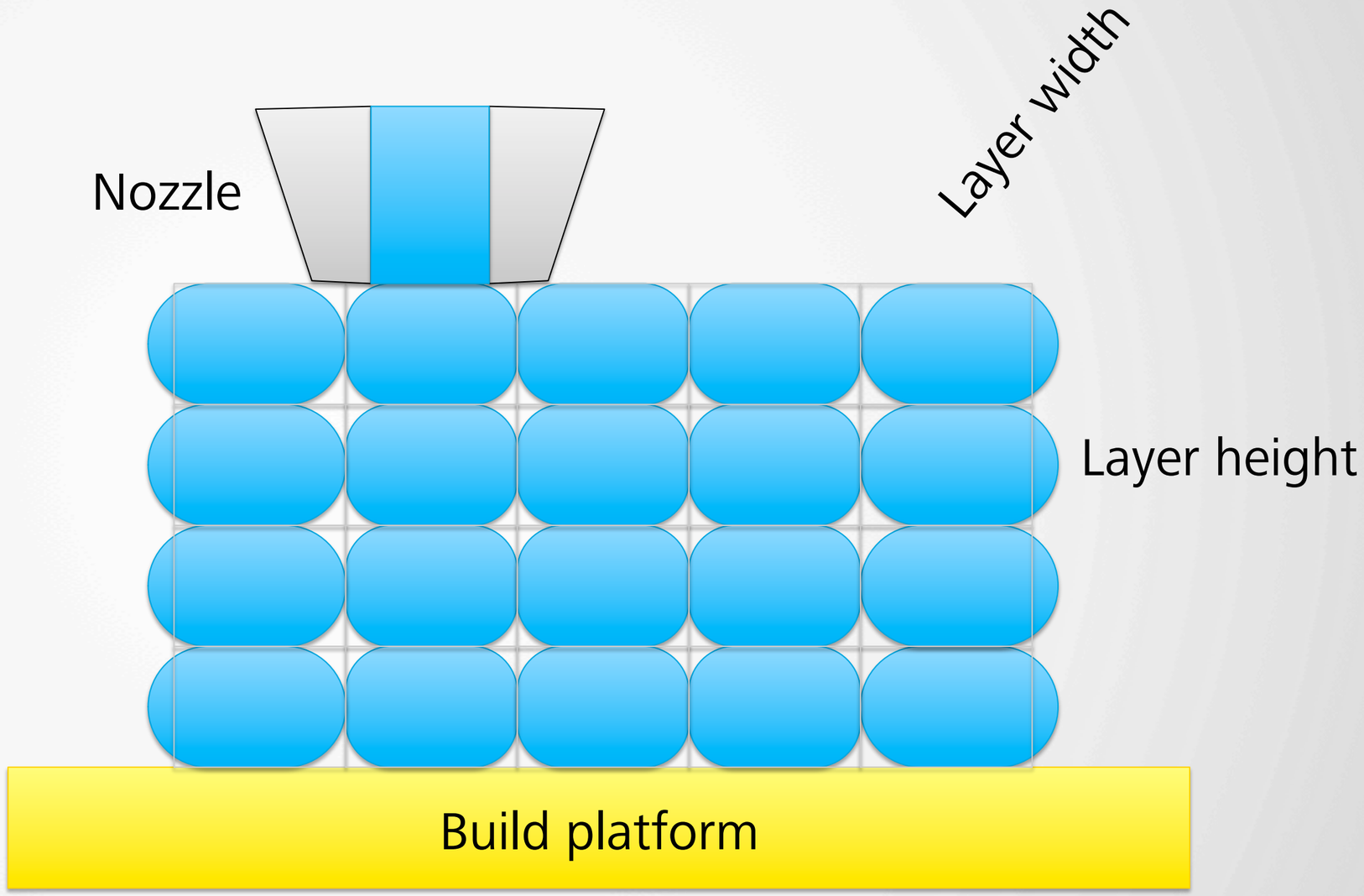


Parts for use: the emerging 3D printing use case

How inexpensive 3D printers work

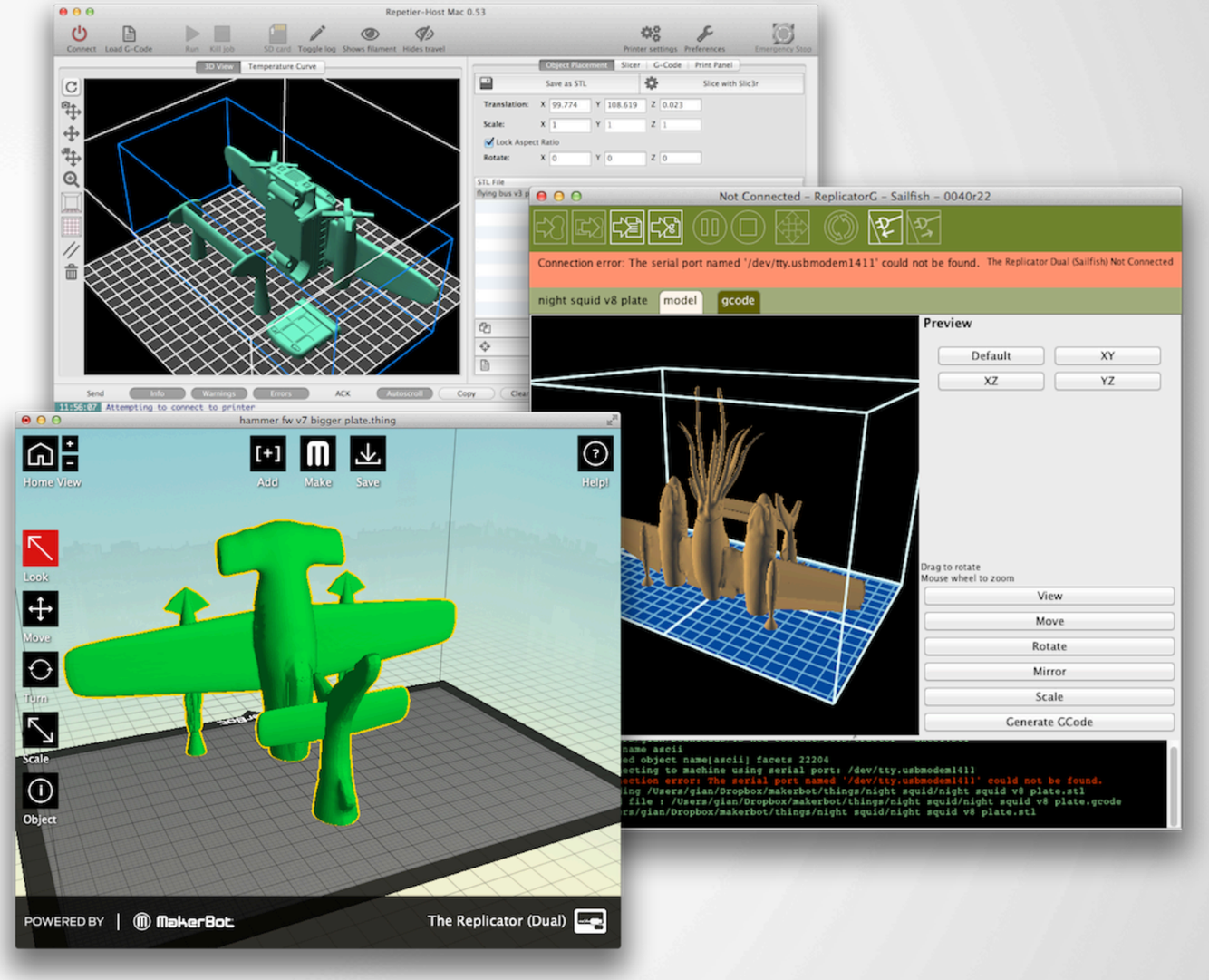
How fused filament fabrication works

- Melted filament is extruded through
- First layer sticks to the build platform
- Subsequent layers bond to the previous ones
- Mathematical model determines key relationships and results



3D printer control software

- Convert model to toolpath
- Key interface between your design intent and the printer
- Many key parameters are embedded in this software
  - Layer width
  - Layer height
  - Support generation
  - Speed
- Quality of meshes impacts the software



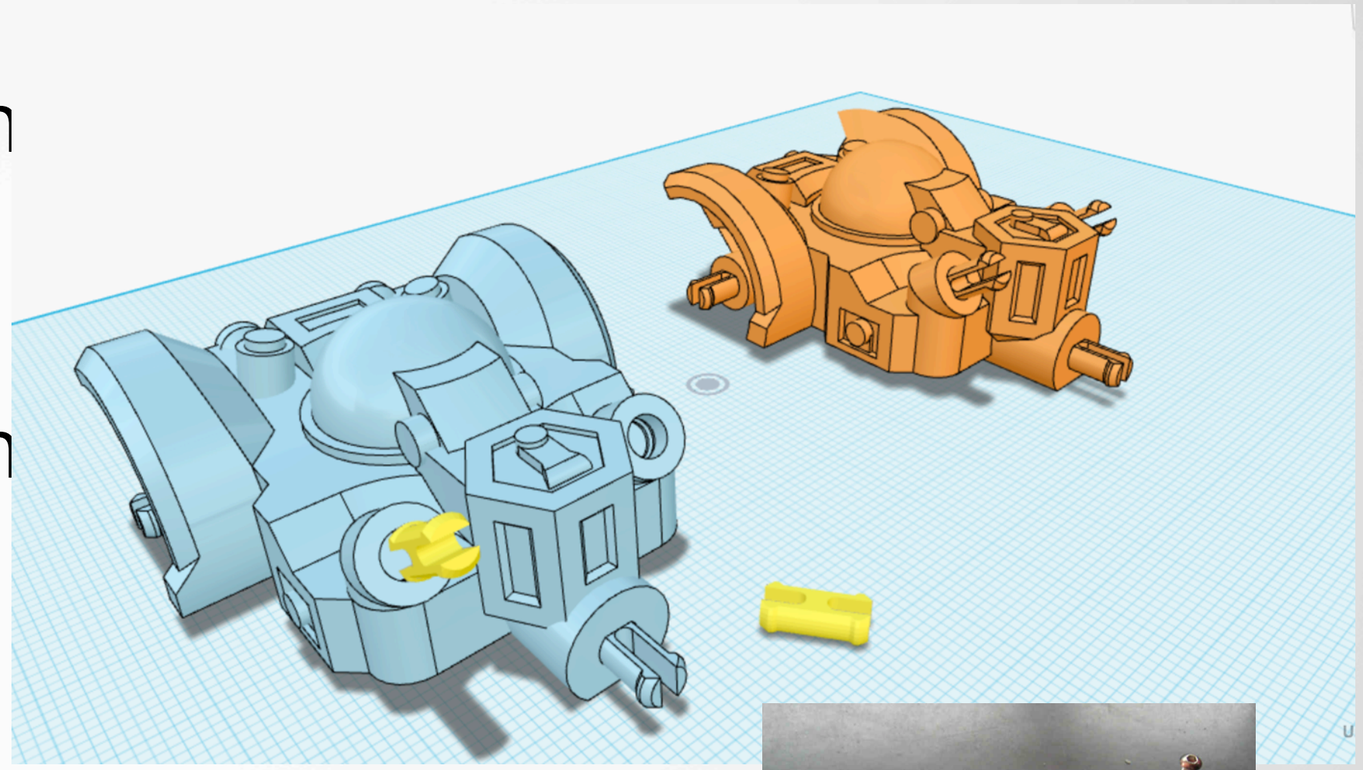
Design tips for consumer level 3D printing

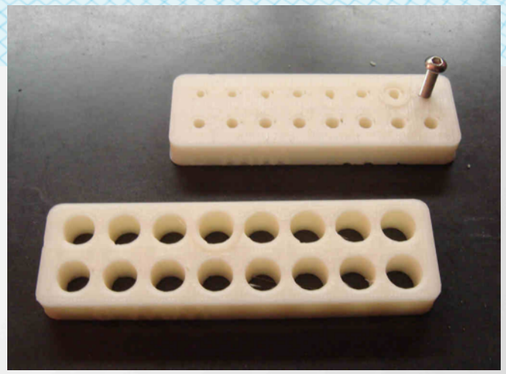
Design tips for best results

- Allow for tolerances
- Make walls thick
- Avoid overhangs
- Manage disconnected overhangs
- Make use of bridging
- Ensure flat base
- Print in place
- Connectors
- Use strong dimension of the print
- Divide into multiple parts
- Working with soluble support
- Minimize support
- Make good meshes
- Repair meshes

Allow for tolerances

- Ensure that you are leavin gaps between moving parts
- Isolate key parts with tigh tolerances
- 0.5mm for free motion, 0.25mm for friction fit
- Test and calibrate!

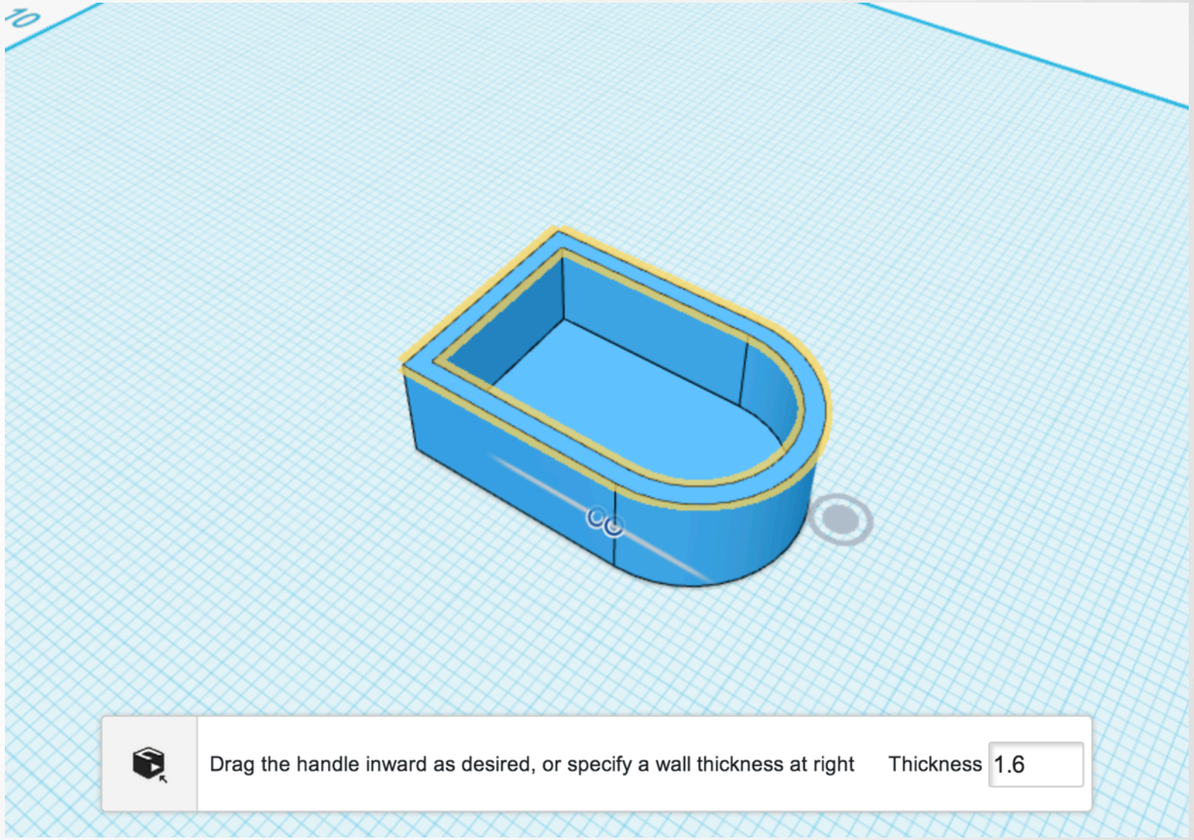




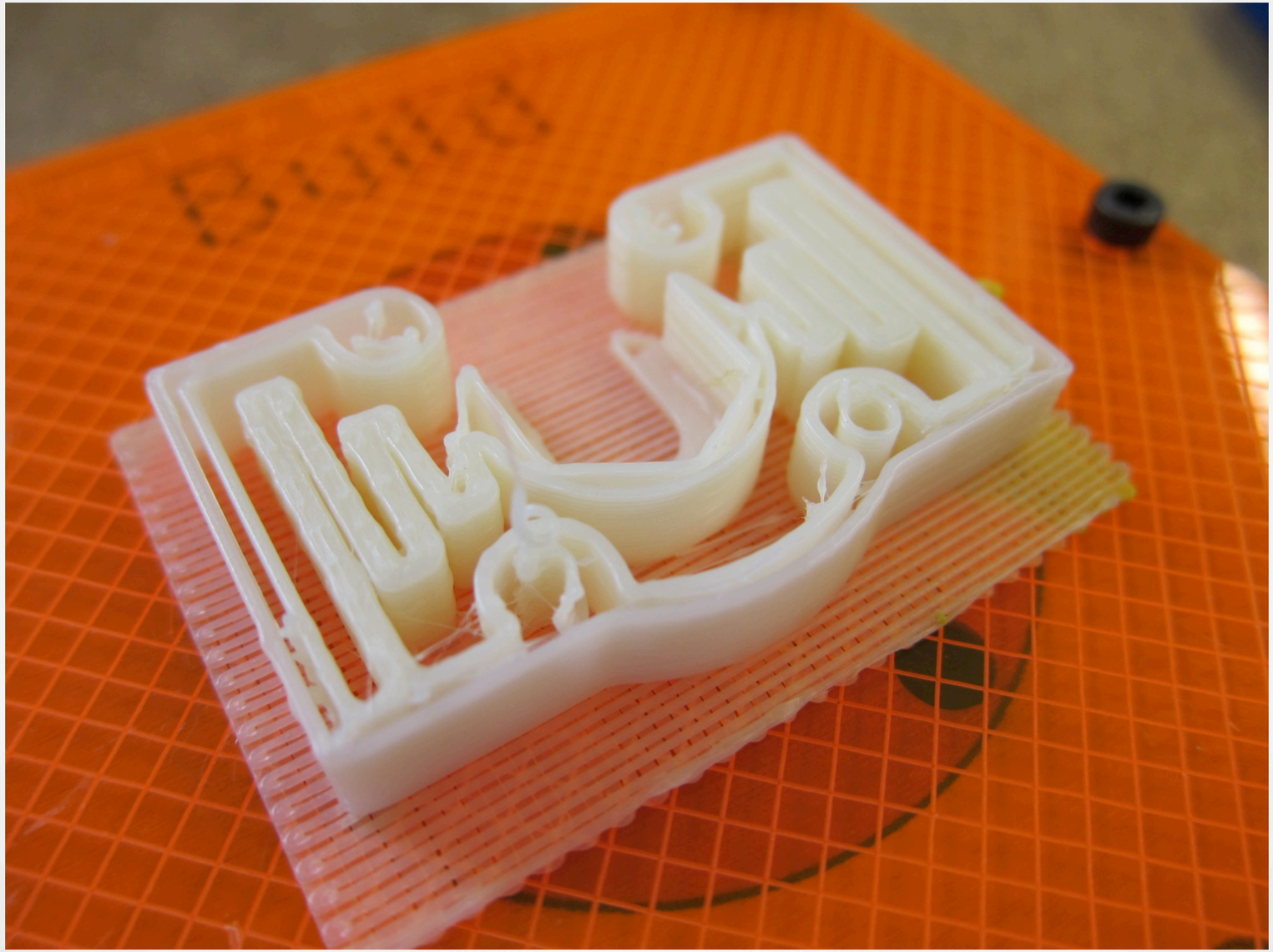
Allow for tolerances – pins & wheels

Make walls thick

- Make narrow walls an exact even multiple of layer width, if this is less than # of shells
- Avoid the dreaded “double wall” problem
- Get the layer width from slicer parameters

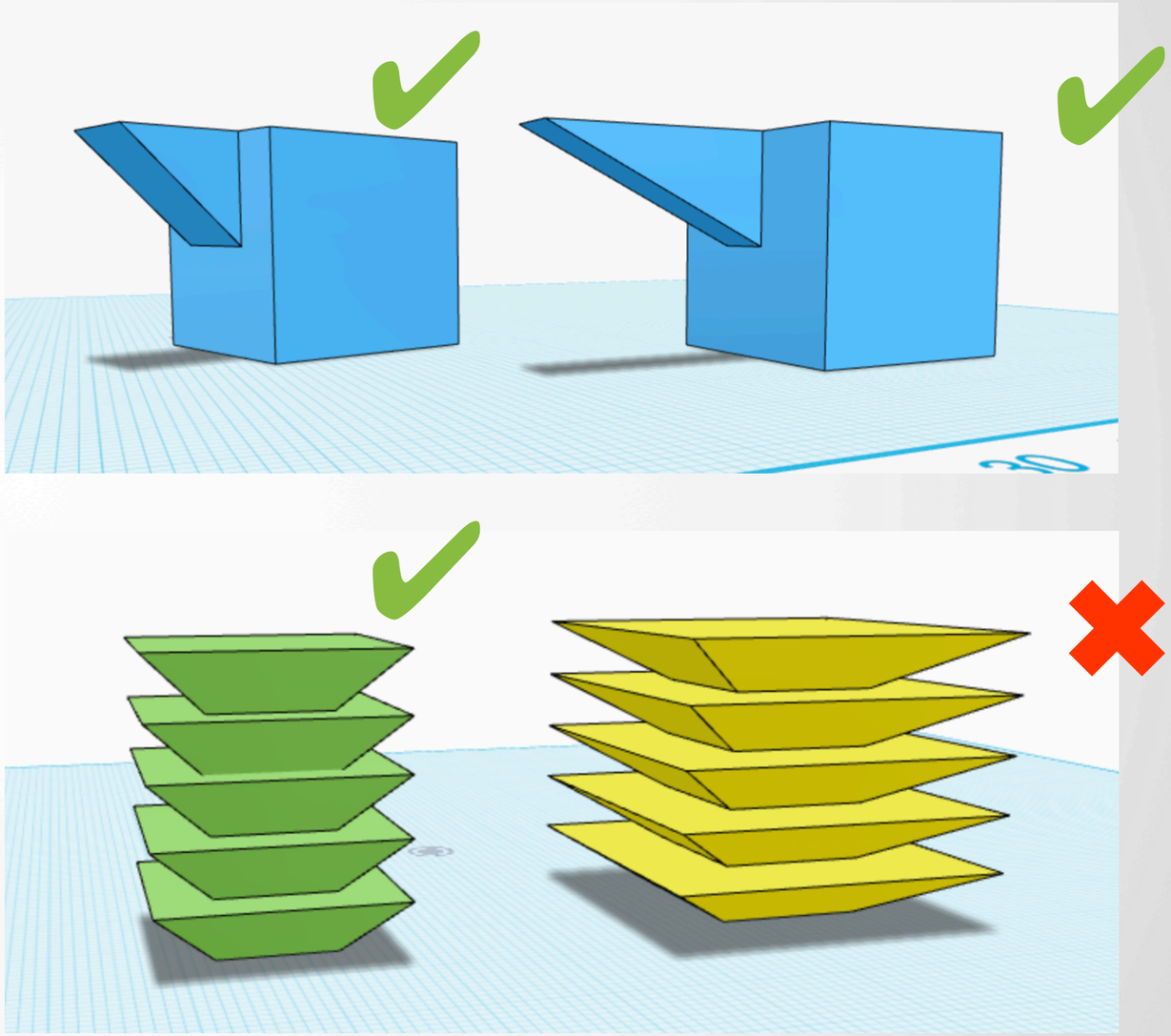


The dreaded “double wall”

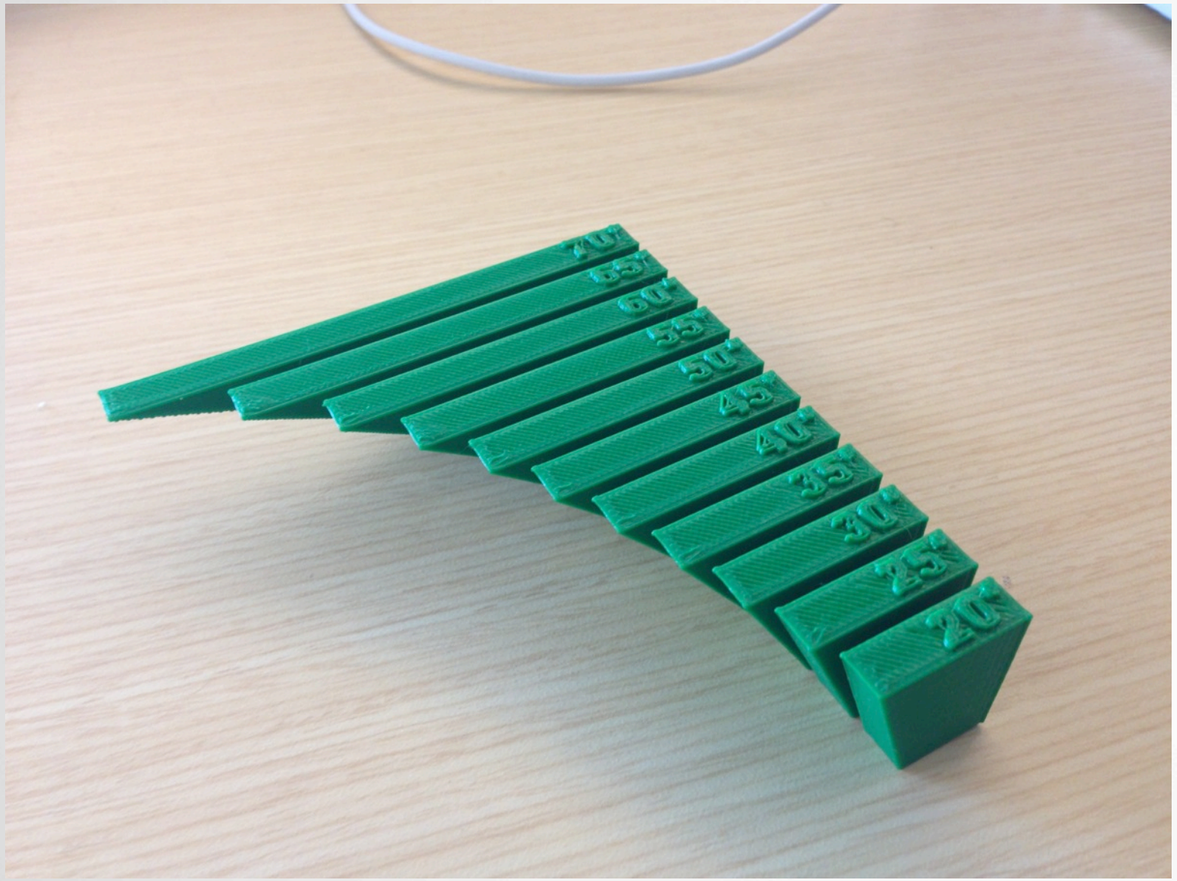


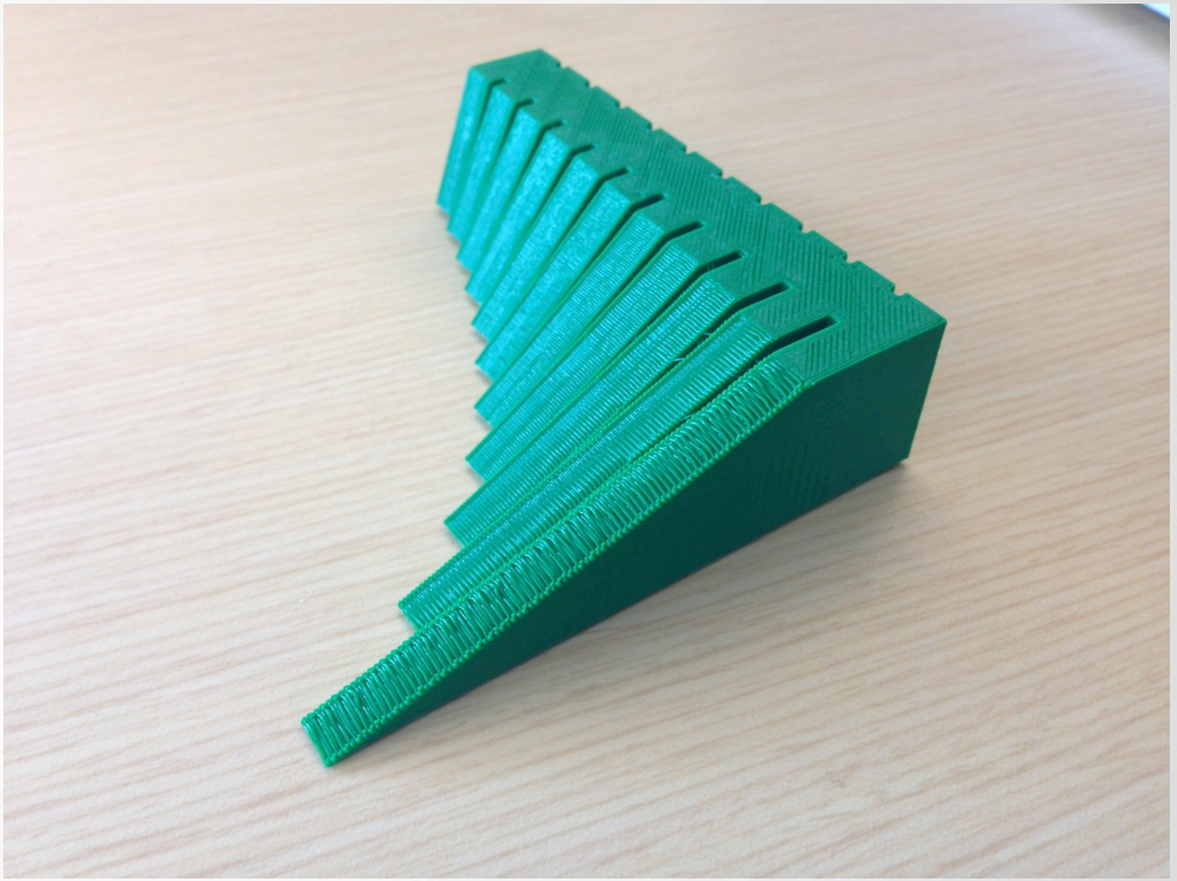
Avoid overhangs

- Keep unsupported overhangs to 45 degrees or less off the vertical
- Exception: if they are narrow salients, overhangs of up to 70 degrees are possible
- Of course, support is available – but use it intelligently!



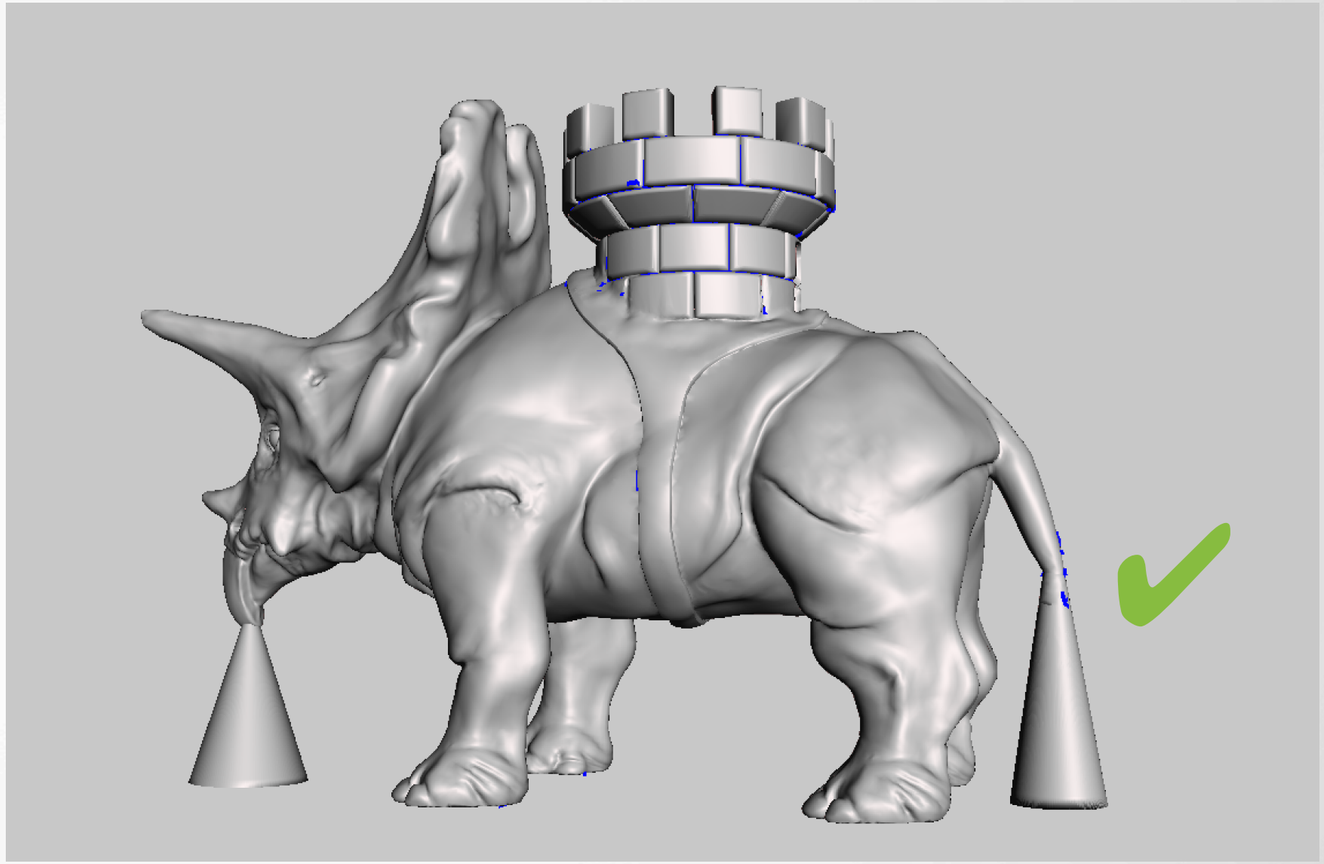
Overhang test piece





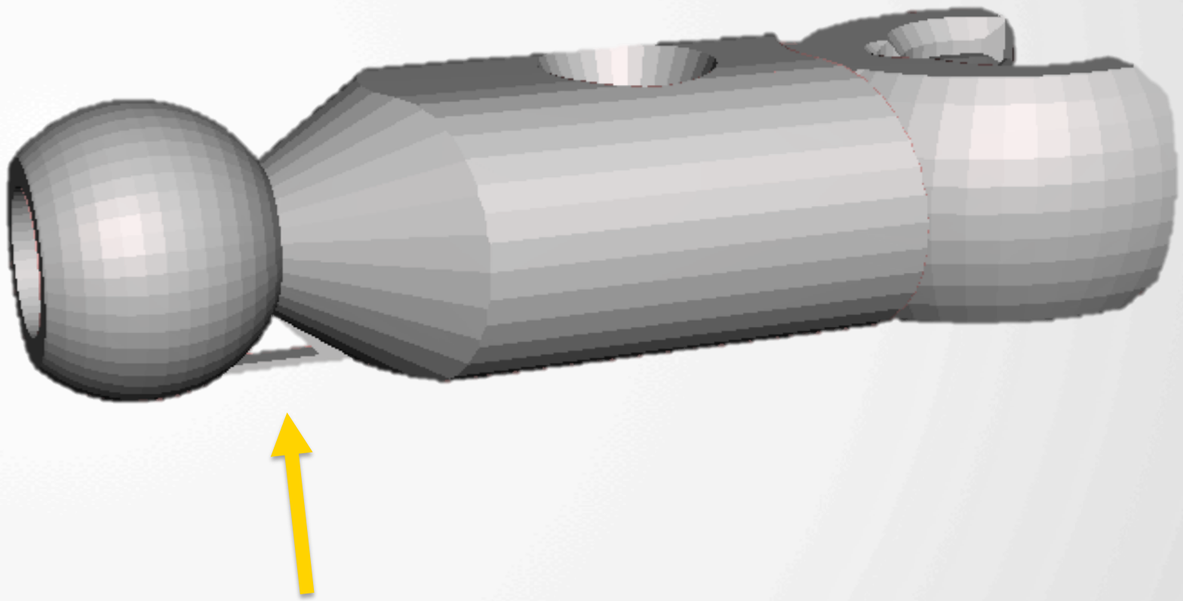
Manage disconnected overhangs

- If possible, make sure that overhangs are connected to main object, even when using support
- Use “helpers” to stabilize disconnected overhangs



Use breakaway supports to stabilize isolated parts while printing

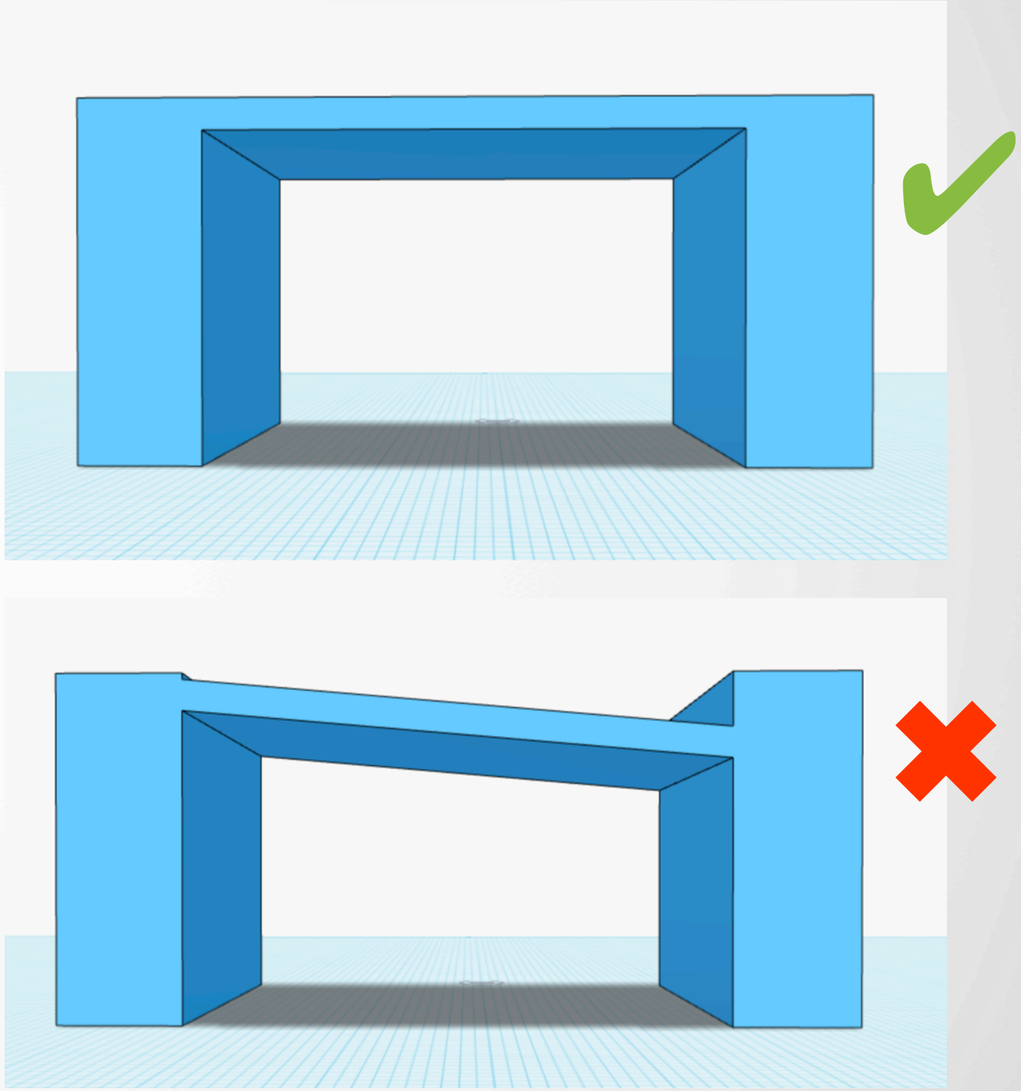
- Thin strips anchor the part
- Will break away under normal use
- Dramatic increase in print success rate!



Finished product…

Make use of bridging

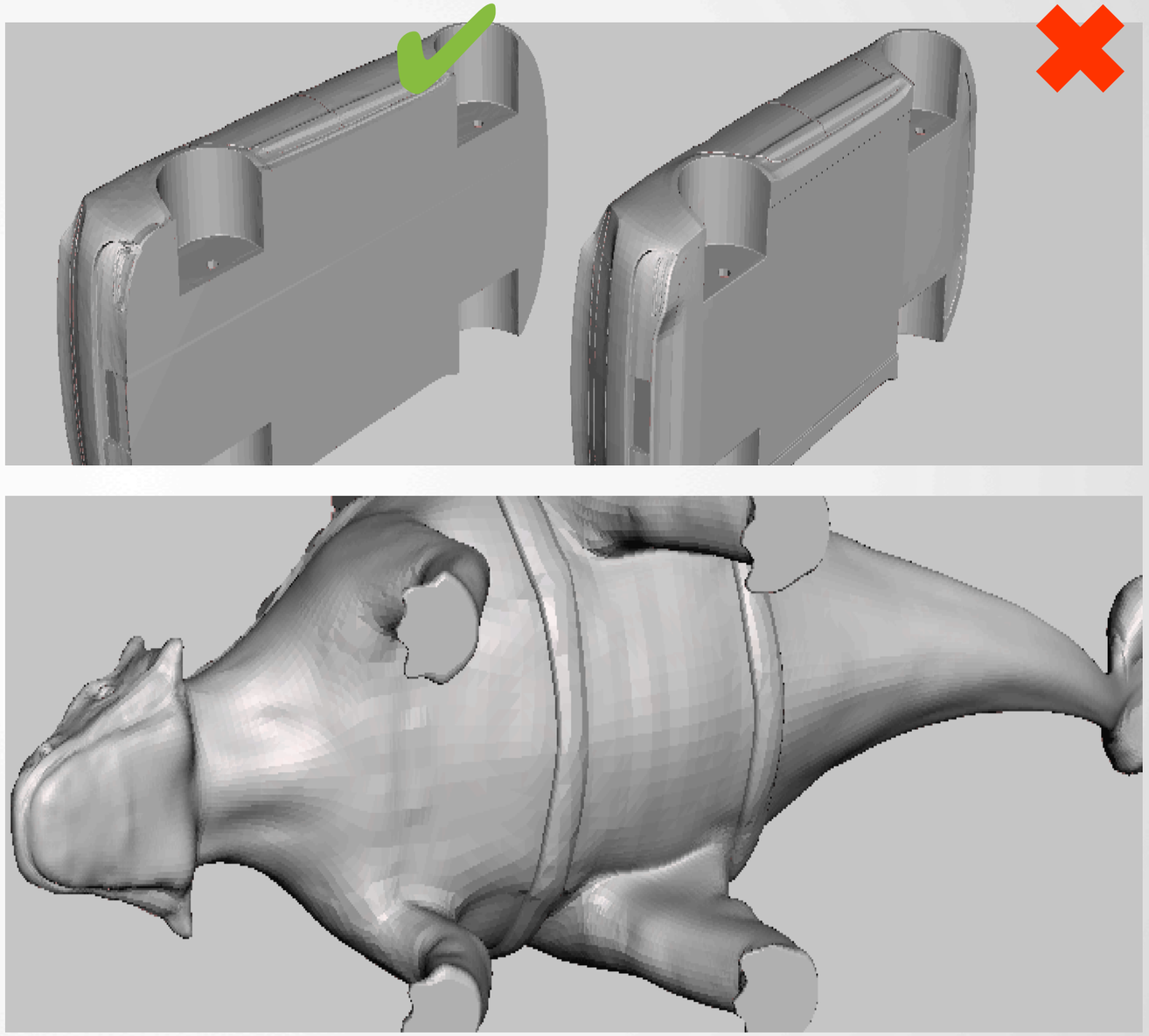
- Level spans anchored at both ends can be bridged without support
- Make sure that unsupported spans are flat to allow bridging to work



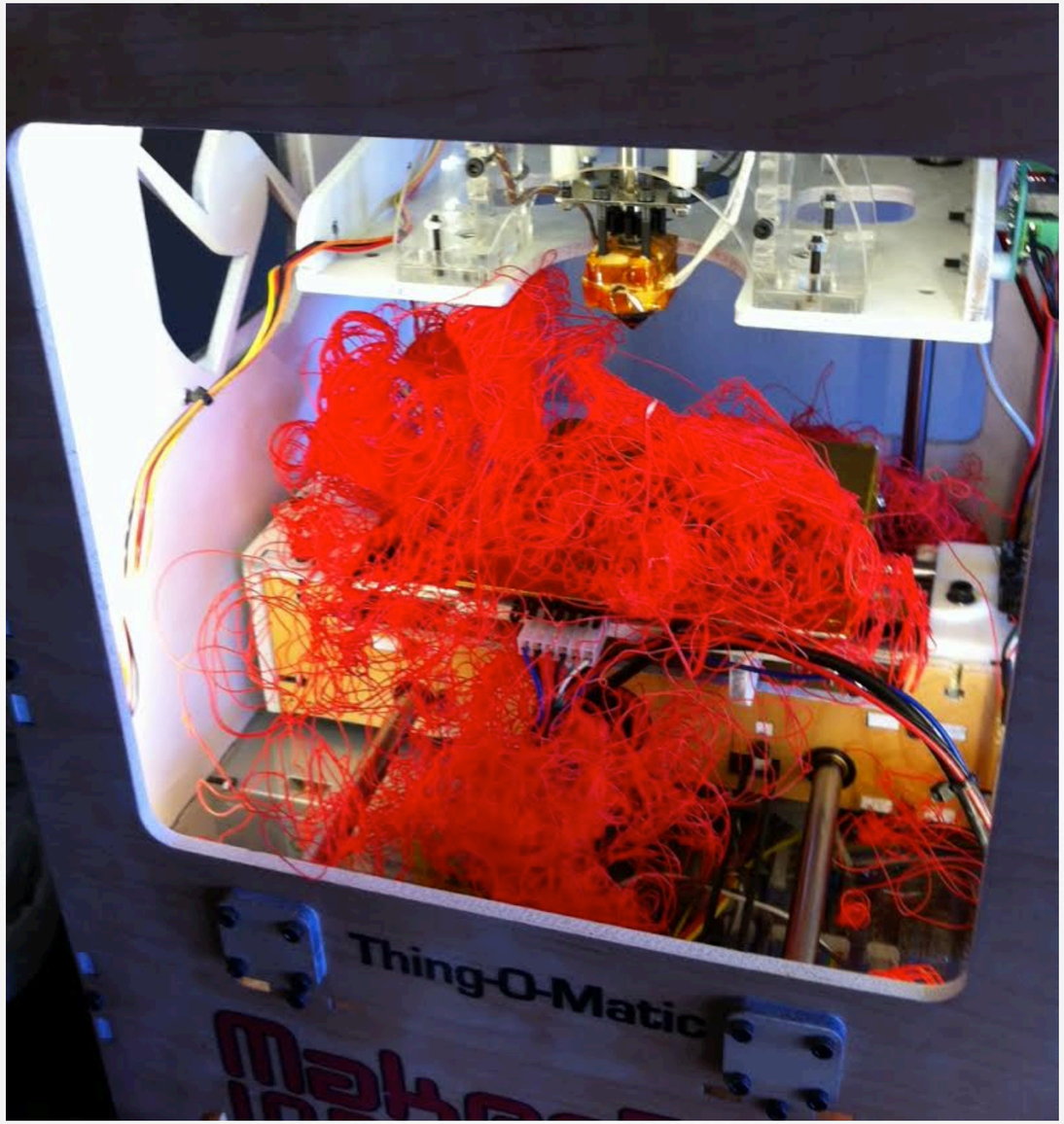
Advanced bridging

Ensure flat base

- Always provide a flat area of contact with the build platform
- Anchors the work piece and keeps it stable
- Even subtle raised features will cause problems

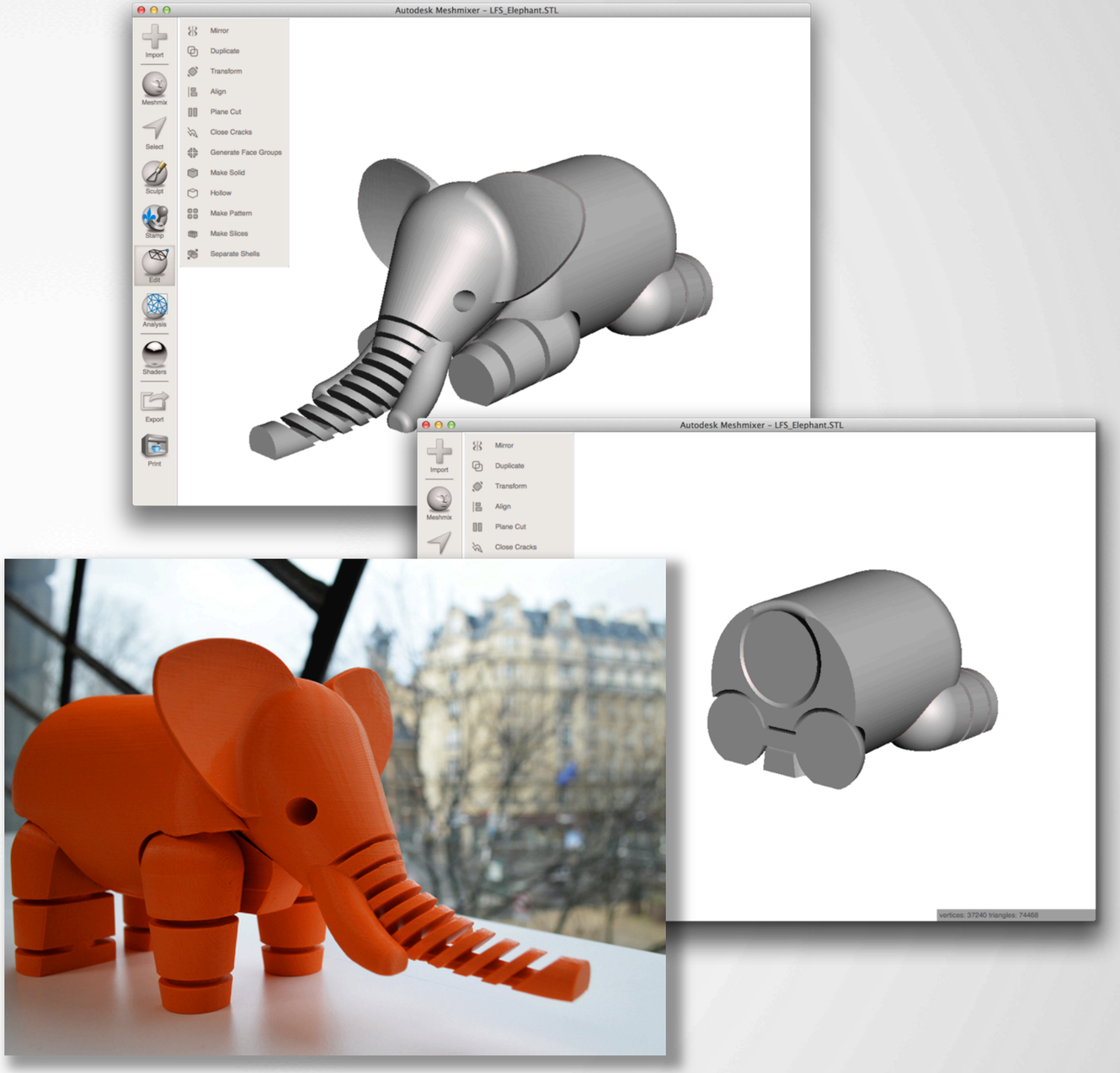


When prints don’t stick



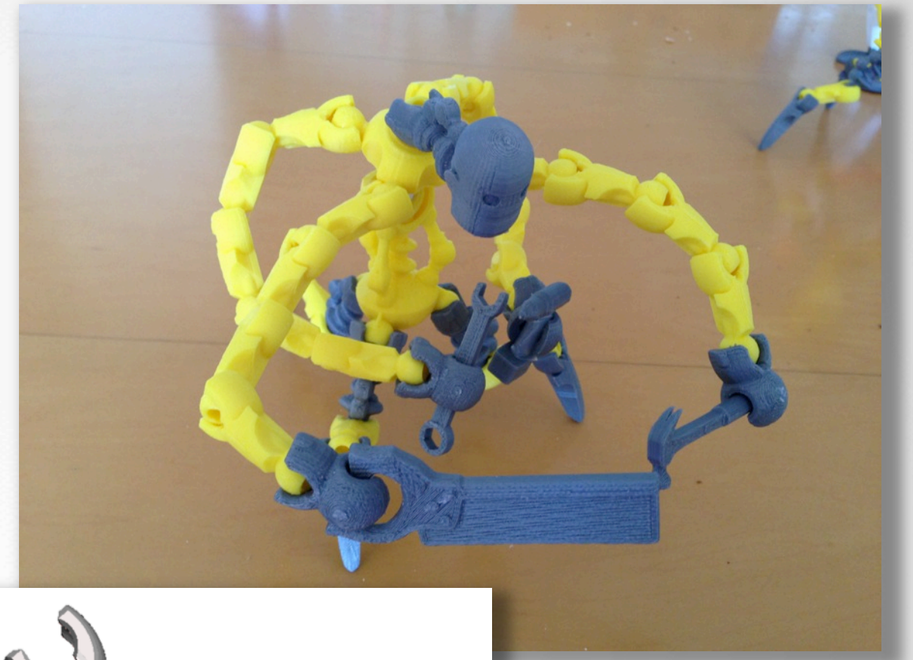
Print-in-place

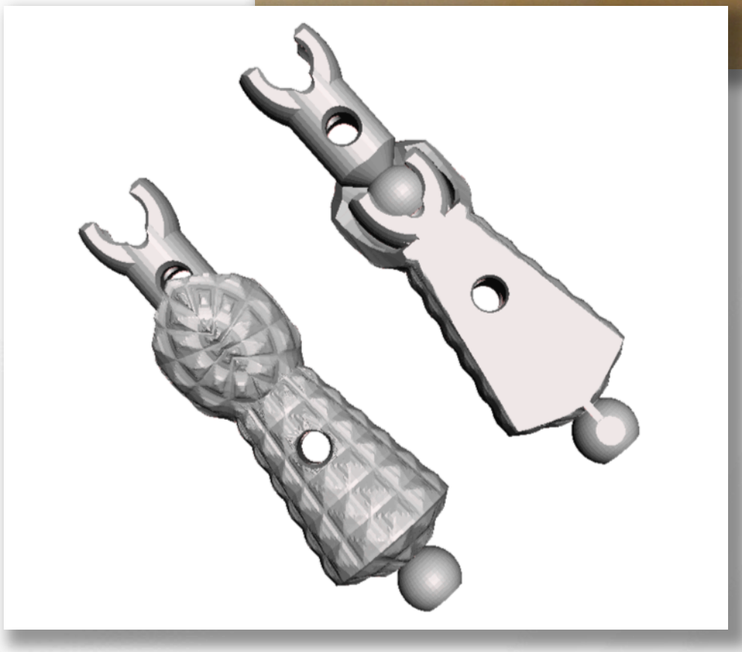
- Classic “wow” factor technique!
- Keep in mind
  - Clearances
  - Bridging
  - Overhangs
- Difficult to do friction fit



Connectors

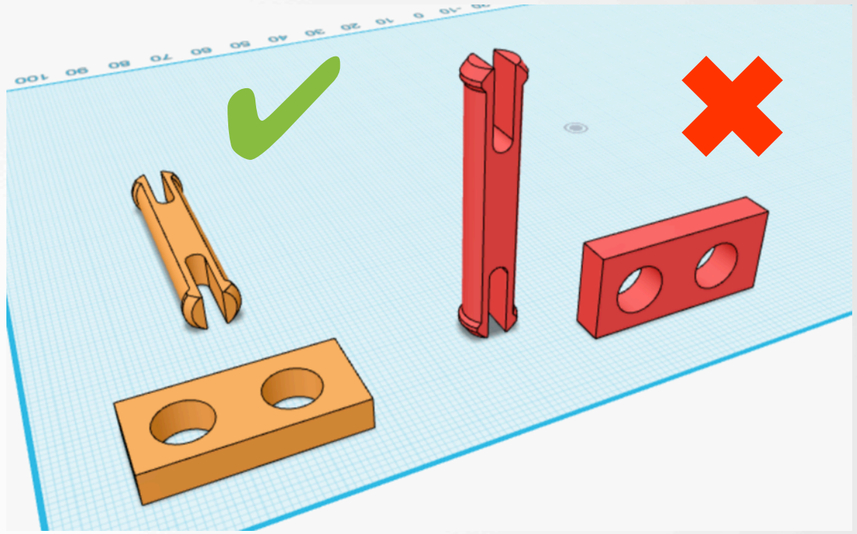
- Robust and reliable snap connectors let you make complex designs with a minimum of post-processing
- Connectors should take into account material characteristics:
  - Flex
  - Wear

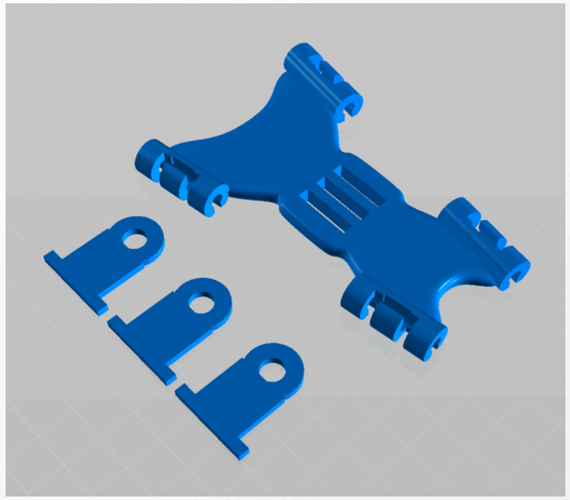


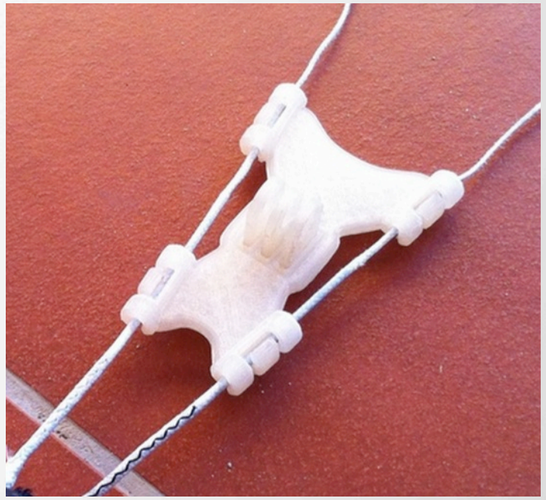


Use strong dimension of the print

- Orient your parts so that the greatest stress is perpendicular to the direction of the filament
- Create multiple parts if necessary so that all are strong

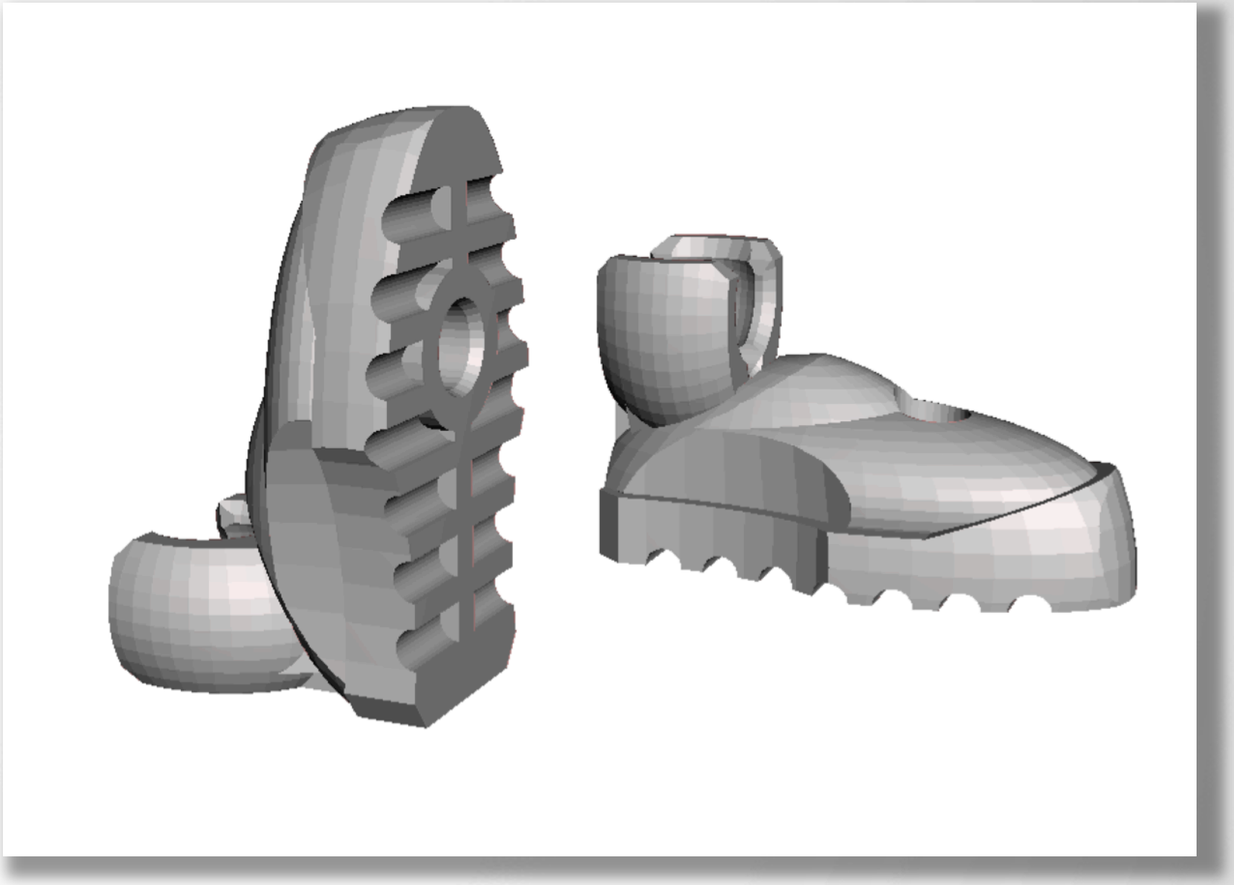




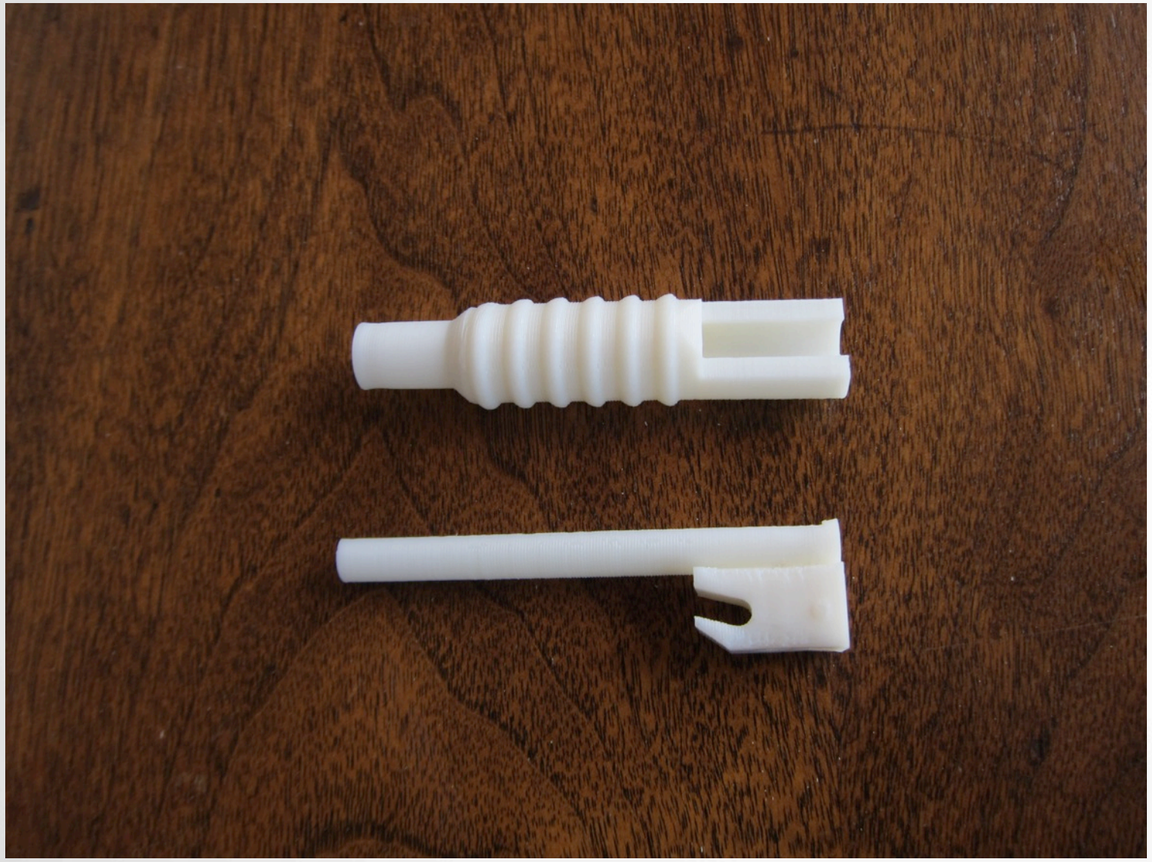


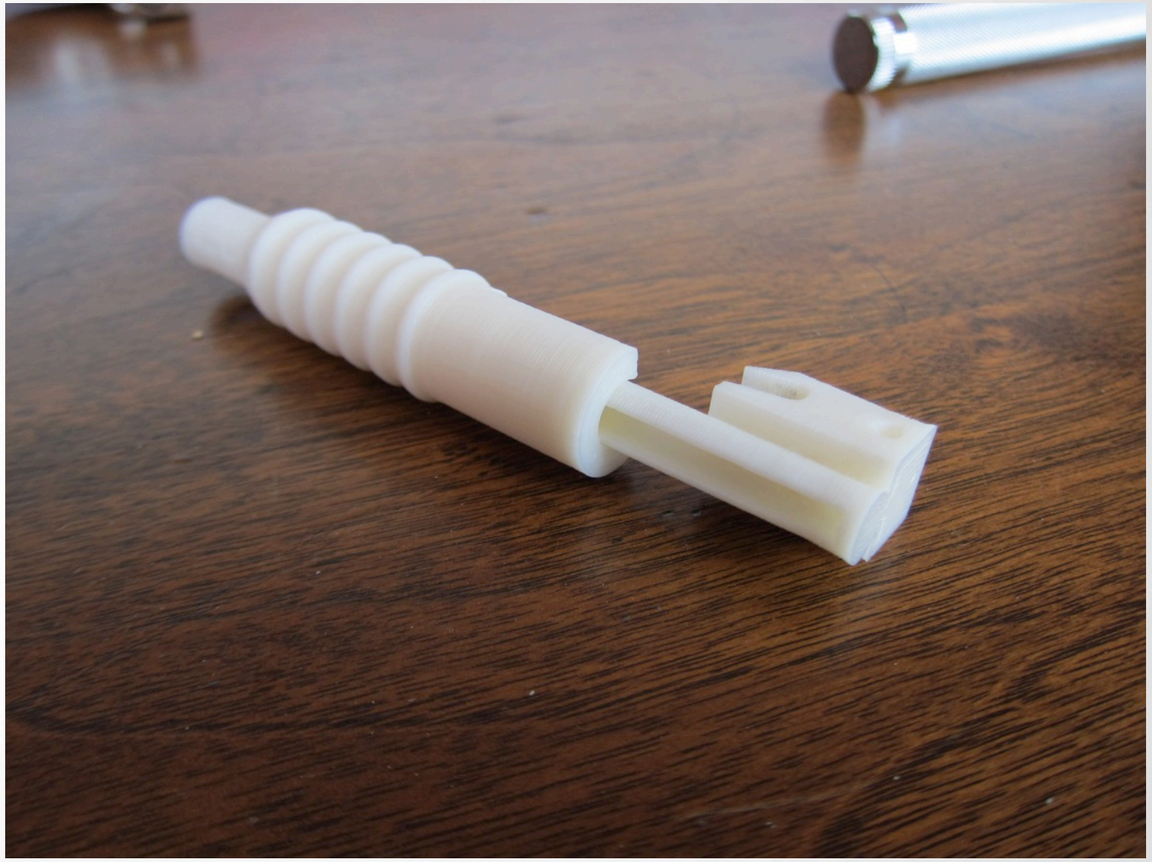
Orient parts to optimize strength

- Socket on the back of the foot will be subject to most stress
- Printing it with the socket flat to the print bed makes it strongest



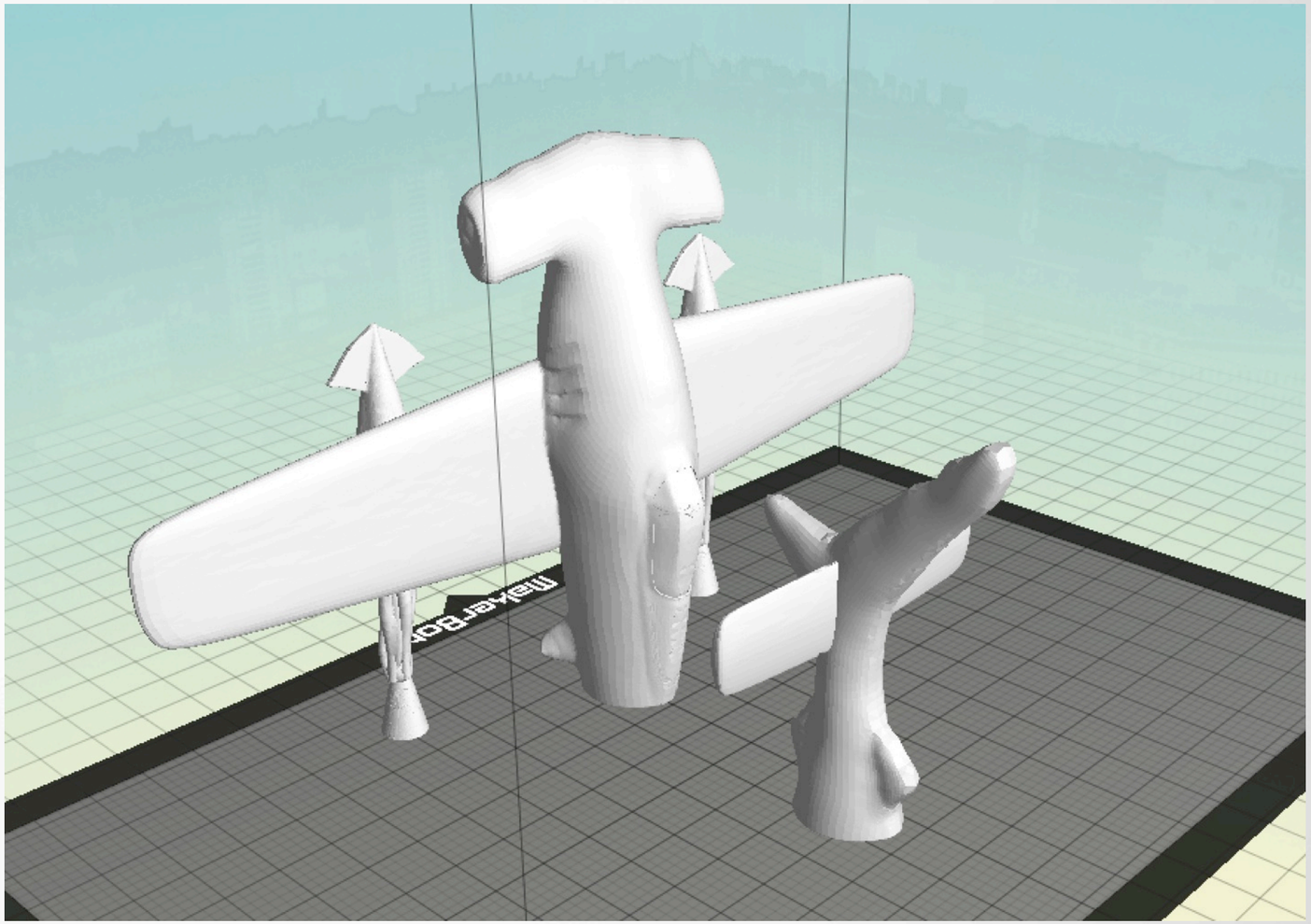
Combining parts to maximize strength



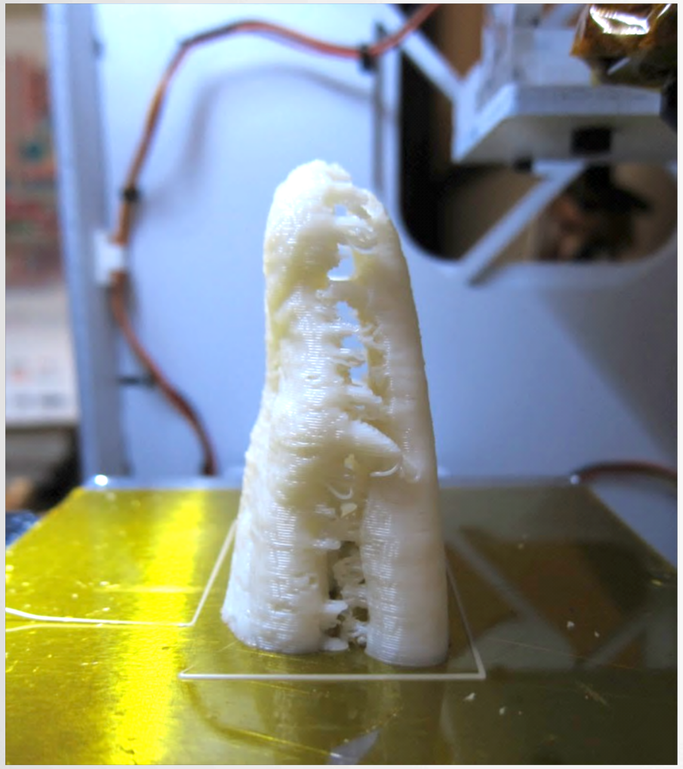


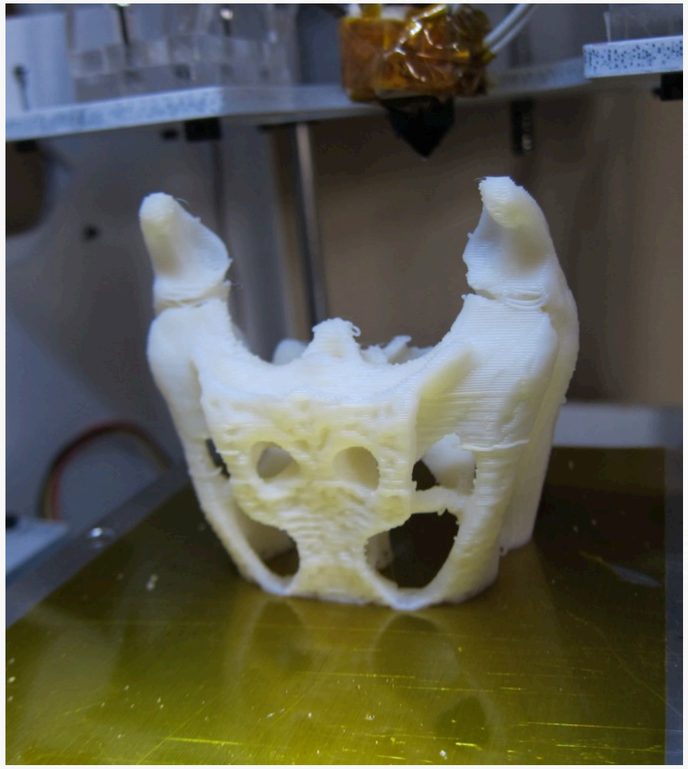
Divide into multiple parts

- Slice models into multiple parts to reduce need for support, reduce print time and improve finish
- Make cuts to reduce visible seams



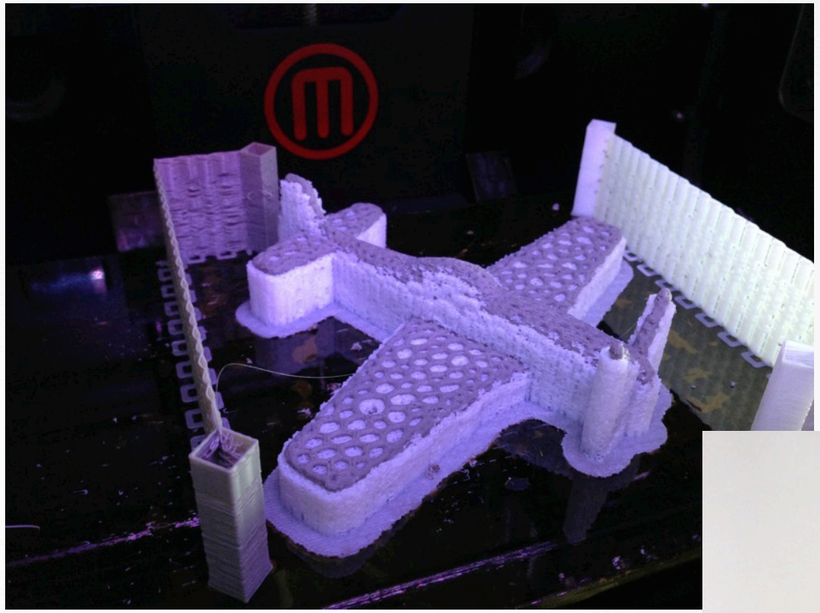
Slice into halves to avoid support





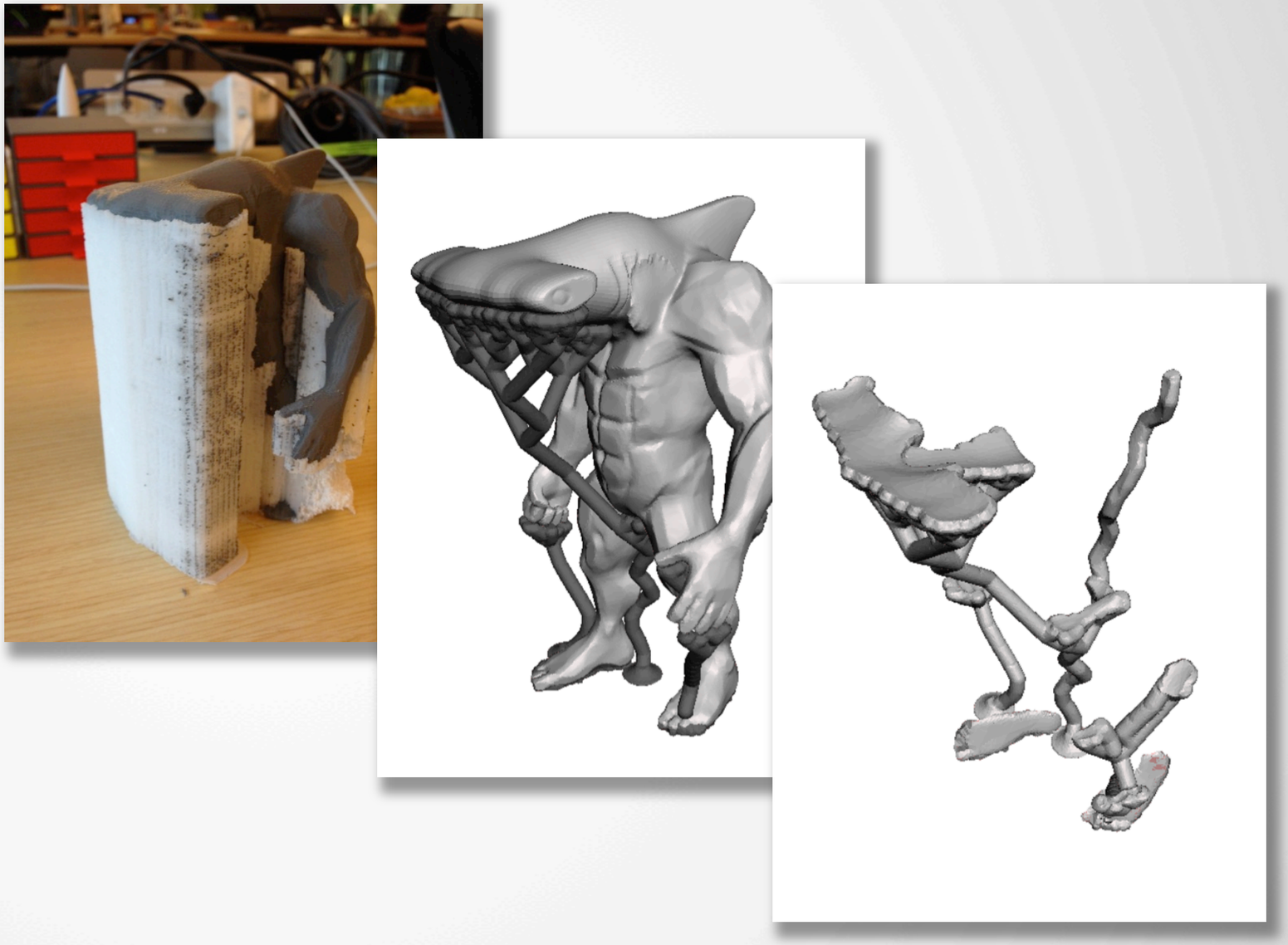
Working with soluble support

- Allows for more complex geometry
- More freedom in part orientation
- Soluble vs single material support requires different optimization



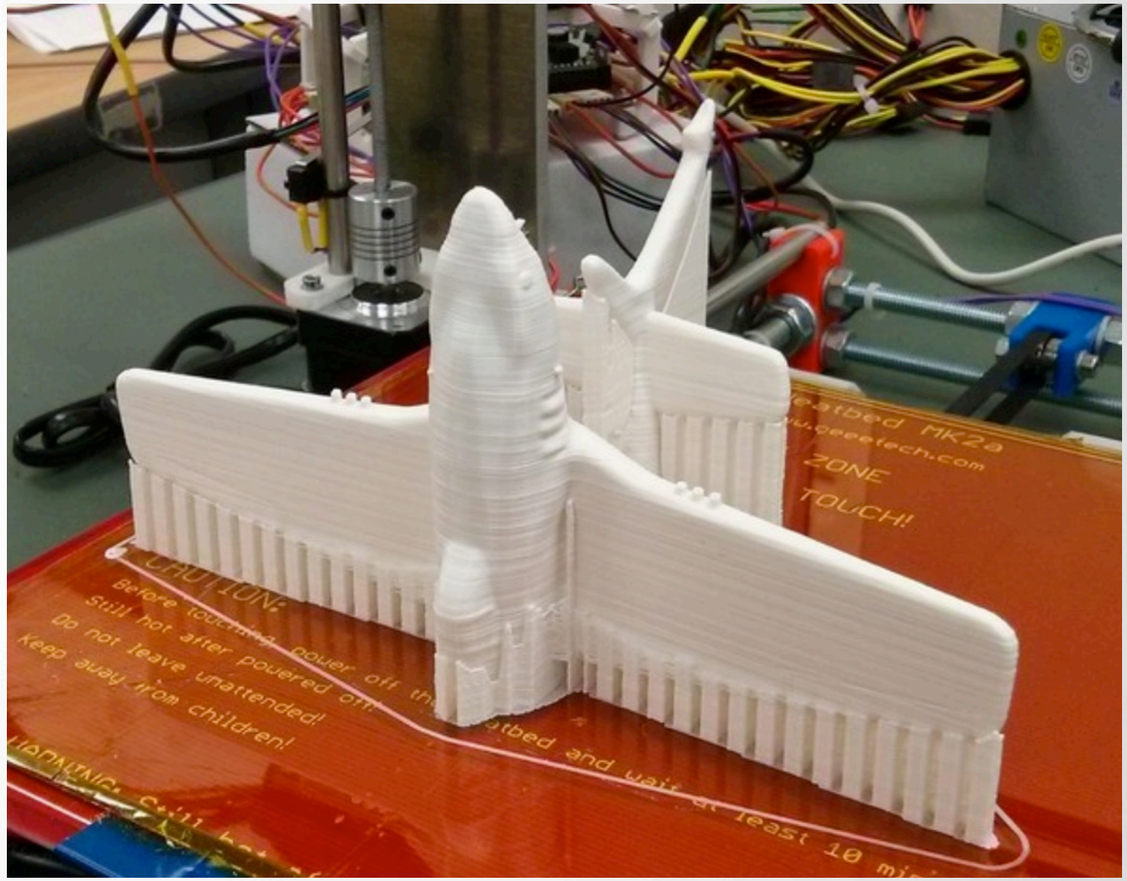
Optimizing soluble support

- Very different from single material support
- Allow for drainage
- Maximize contact area, not minimize
- Defaults are not optimal
- Meshmixer is adding excellent options



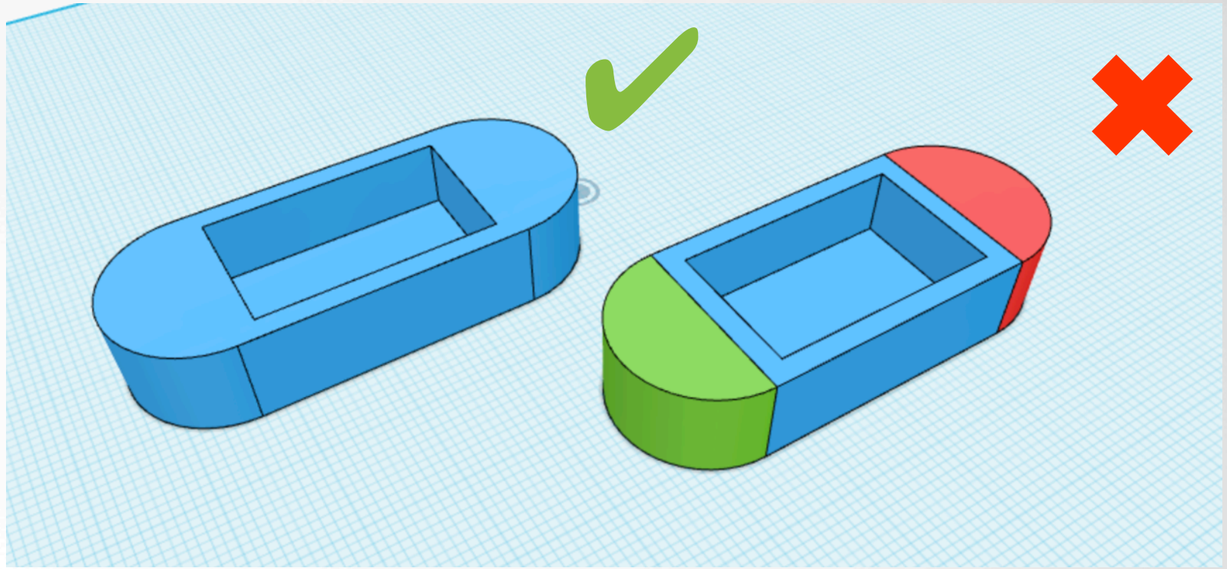
Minimize support

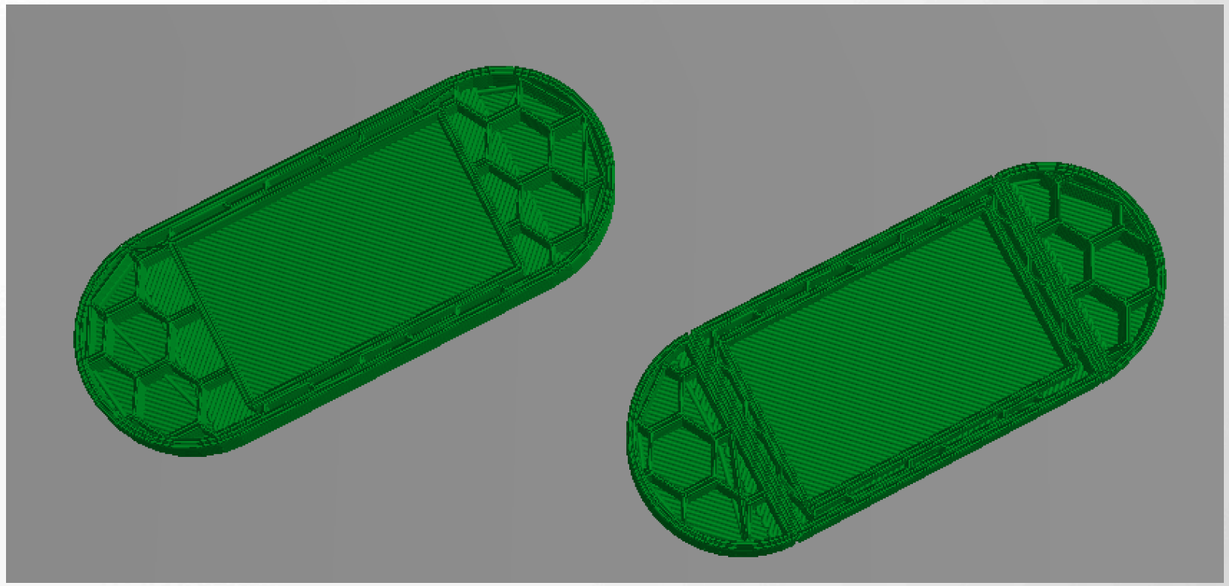
- Orient to minimize support
- Ensure supported areas are not visible



Make good meshes

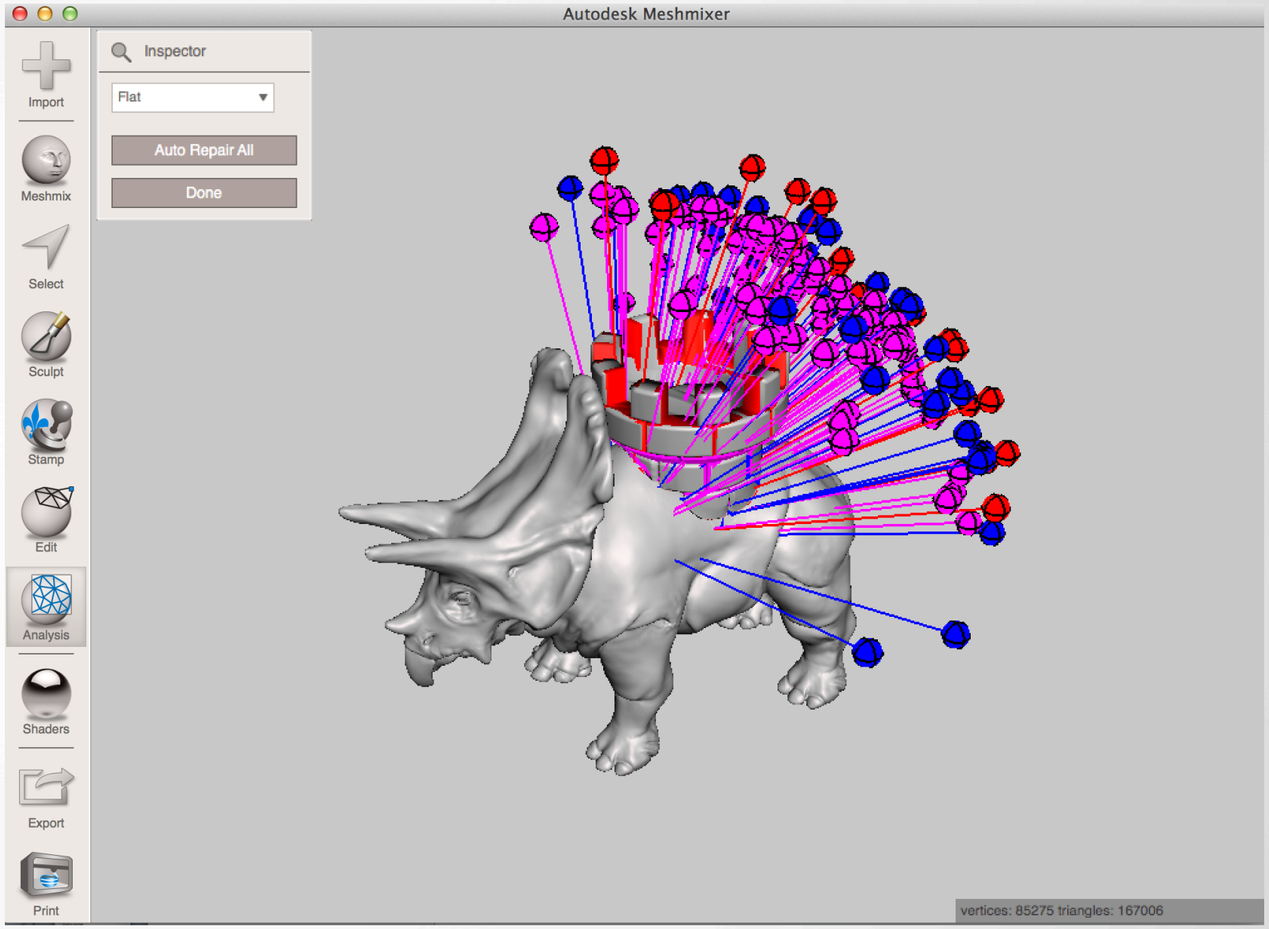
- Solid
- Watertight
- Normals
- Not too many polys
- No self-intersections
- Use boolean unions to ensure a single body





Repair meshes

- Use repair and analysis tools to fix
  - Meshmixer
  - Tinkercad
  - Print Studio

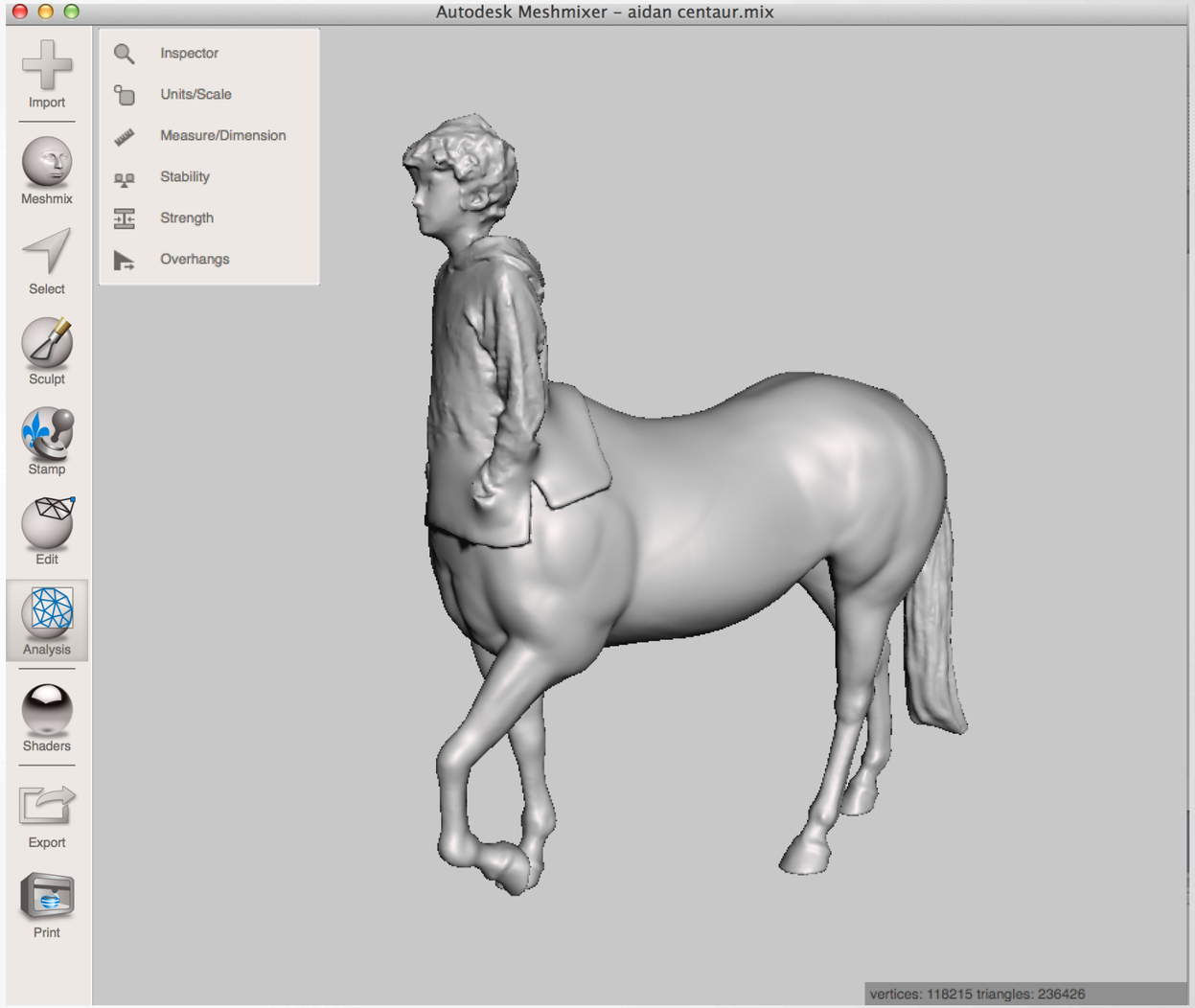


Software Tools

Meshmixer

- Superb tool for working with meshes
- Sculpt, remix, edit and paint
- Great new tools for pre-print (Make Solid, Support, Patterns)
- Identify overhangs and generate support
- Powerful pre-print analysis tools
- Integrates 3D print utility

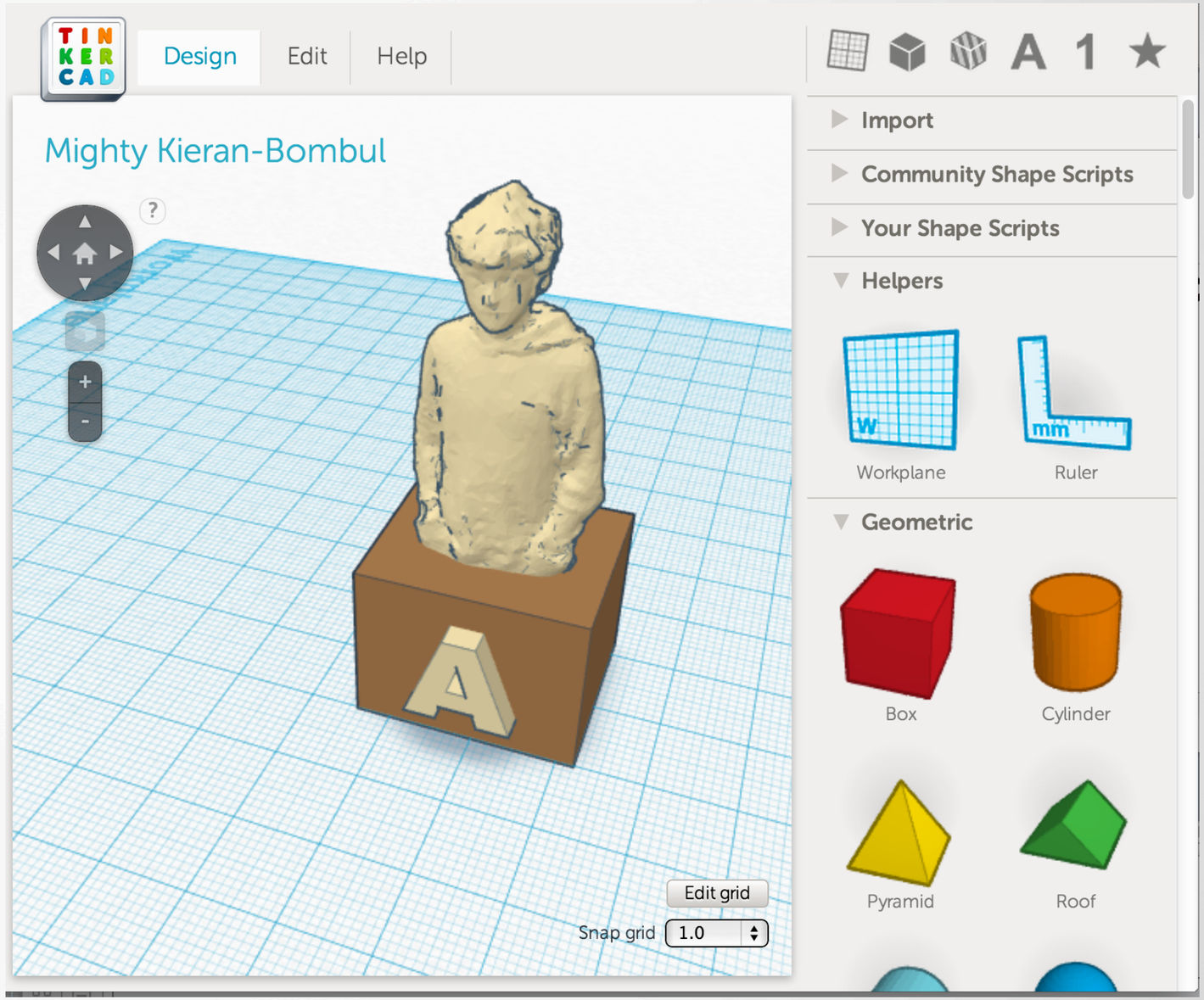
www.123dapp.com/meshmixer



Tinkercad

- Excellent online tool for working with simple geometry
- Can import, modify and export STL files
- Superb automatic mesh repair

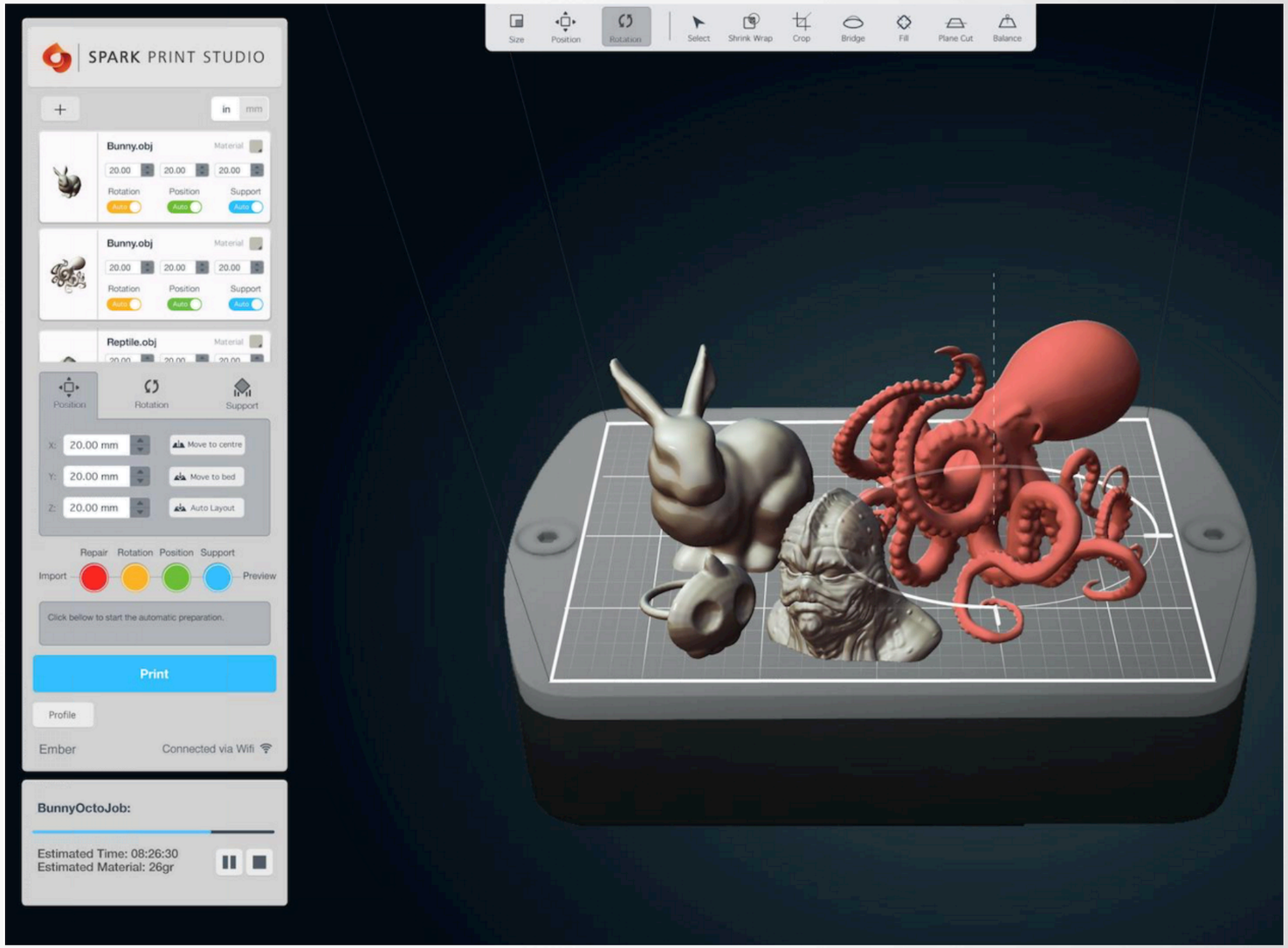
tinkercad.com



Print Studio

- Autodesk's integrated tool for 3D printing
- Advanced support
- Healing and repair
- Layout
- And more…

spark.autodesk.com



Conclusions

- Consumer level 3D printers can make strong, practical parts – in fact this is the main use case
- In order to get the most benefit, it makes sense to design specifically for the characteristics of these printers
- Fortunately, the constraints and design rules are simple
- Tools to get good results are becoming better and more accessible

Session Feedback

- Via the Survey Stations, email or mobile device
- AU 2015 passes given out each day!
- Best to do it right after the session
- Instructors see results in real-time

Students, educators, **and *schools* now have**

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Questions?