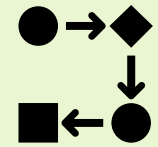
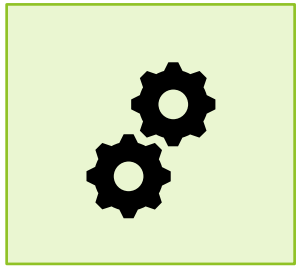


SCUTTLE™ 3D Printing Guide

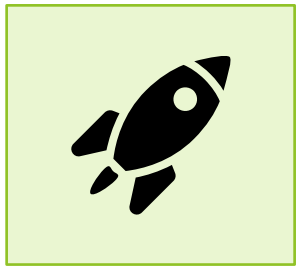
Last revised 2023.02.09

This Guide Contains:



PRINTING SETUP
- Properly orienting parts for printing
- Suggested printing parameters for getting started

MATERIAL SELECTION
- Engineering characteristics of popular plastics
- Resources to learn from experienced printing teams



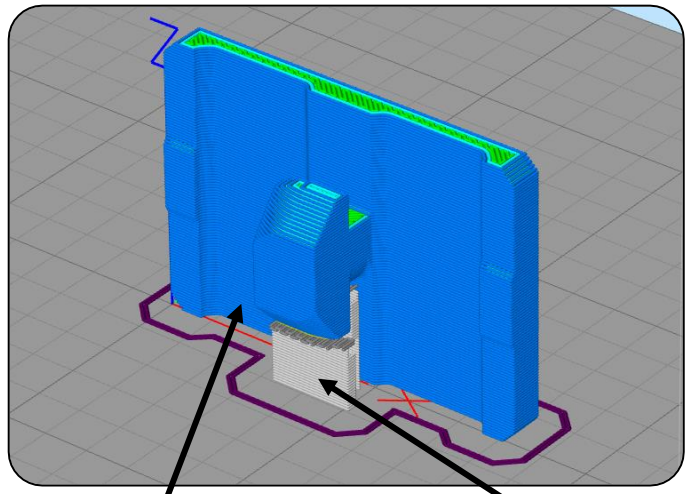
PRINT EXAMPLES
- Test prints with parameters
- Printed parts sets with parameters

Printing Setup

General setup of printed parts & settings

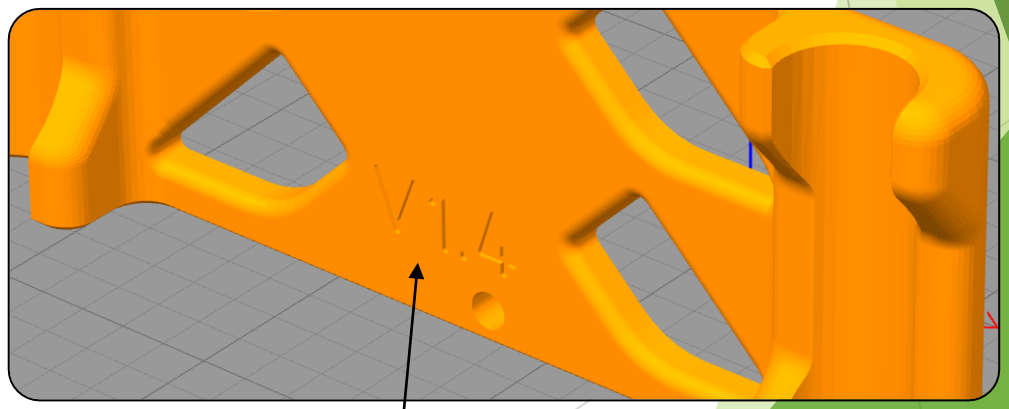
Orientation & Supports

- We design our parts for Fused Deposition Modeling (FDM) without supports
  - The **twist bracket** is an exception
  - **Holes**: small holes don't need supports and large holes have a teardrop shape
  - **Overhangs** are designed at 45 degrees or taller.
  - **Parts thickness** is constrained to avoid bulk material
  - Design-for-manufacturing is implemented
- The Version Number indicates print orientation.
  - Version should be upright
  - Debossed text begins printing 6mm from base of part



SCUTTLE Twist Bracket in slicer software.

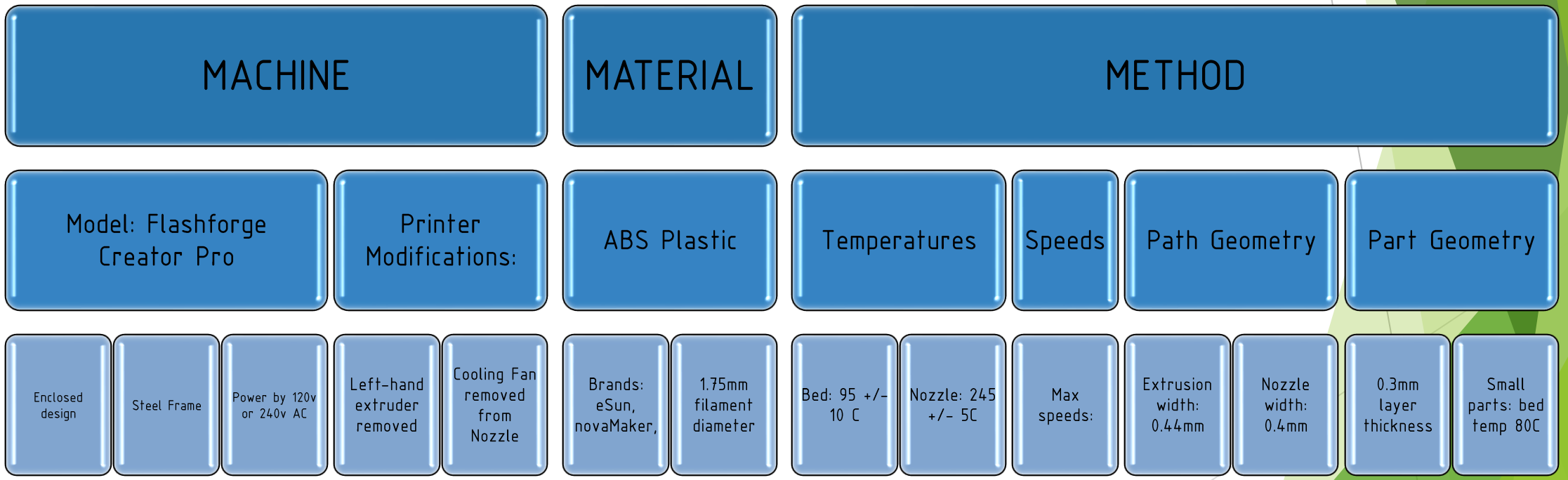
Printed Supports



Model version indicates upright orientation

Standard Settings

- Our typical print settings in the general scope which can be applied across various:
  - slicer softwares
  - slicer versions
  - printer models
  - CAD variations



Settings Snapshot 2022.07.29

- Example of fine-tuning changes from our standard settings
- May occur as printer wears, with changed filament brands, or with environmental change (room temp, etc).

- DM Changes from 07.29 standard:
  - Extrusion Ratio – 103%
  - start point acceleration distance: 10mm
  - minimum speed: 20mm/s
  - Path Width – 0.44mm
  - Bridge: NO
  - Min extrusion speed: 20mm/s
  - slow down first few layers: 0
  - use random start points
  - infill style: 3D infill
  - overlap perimeter: 15%
  - pre extrusion speed: 20mm/s
  - margin: 3mm
  - shell print order: anti overrush decel
  - cooling fan control: always OFF
  - Enable Pre-extrusion: OFF

Material Selection

Interesting data that compares 3D printing materials

What you can learn:

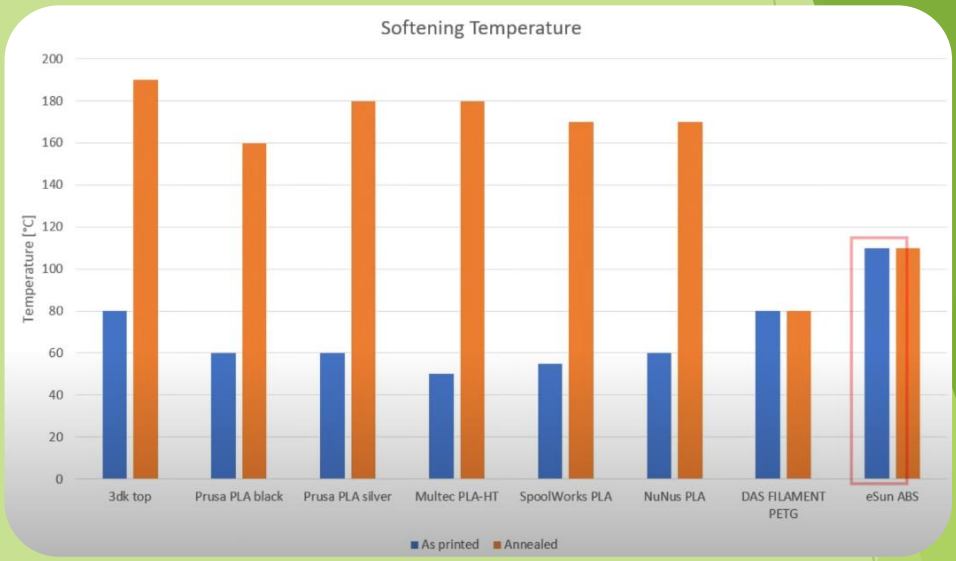
1) How do the popular materials differ?
2) What drives the selection of materials for a design engineer?
3) How does my material impact printing effort?

MATERIALS – Preferred Materials

- We prefer ABS, followed by PETG.
- ASA is a popular derivative of ABS formula used by industrial printing brands
- In engineering, one material is not better than another, but we focus on the key properties for our design application.
- For SCUTTLE mechanical parts **and their failure modes**, ABS properties excel.

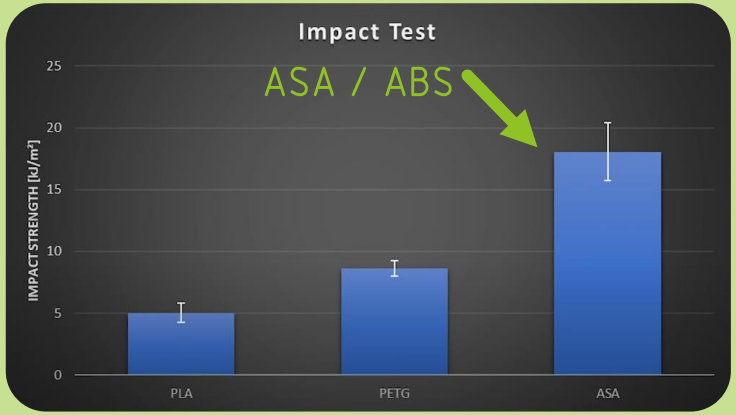
Heat Performance

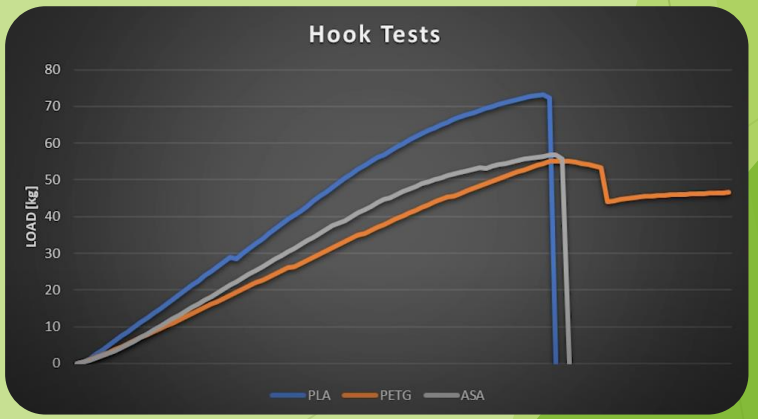
Source: CNC Kitchen tests on youtube



Mechanical Performance

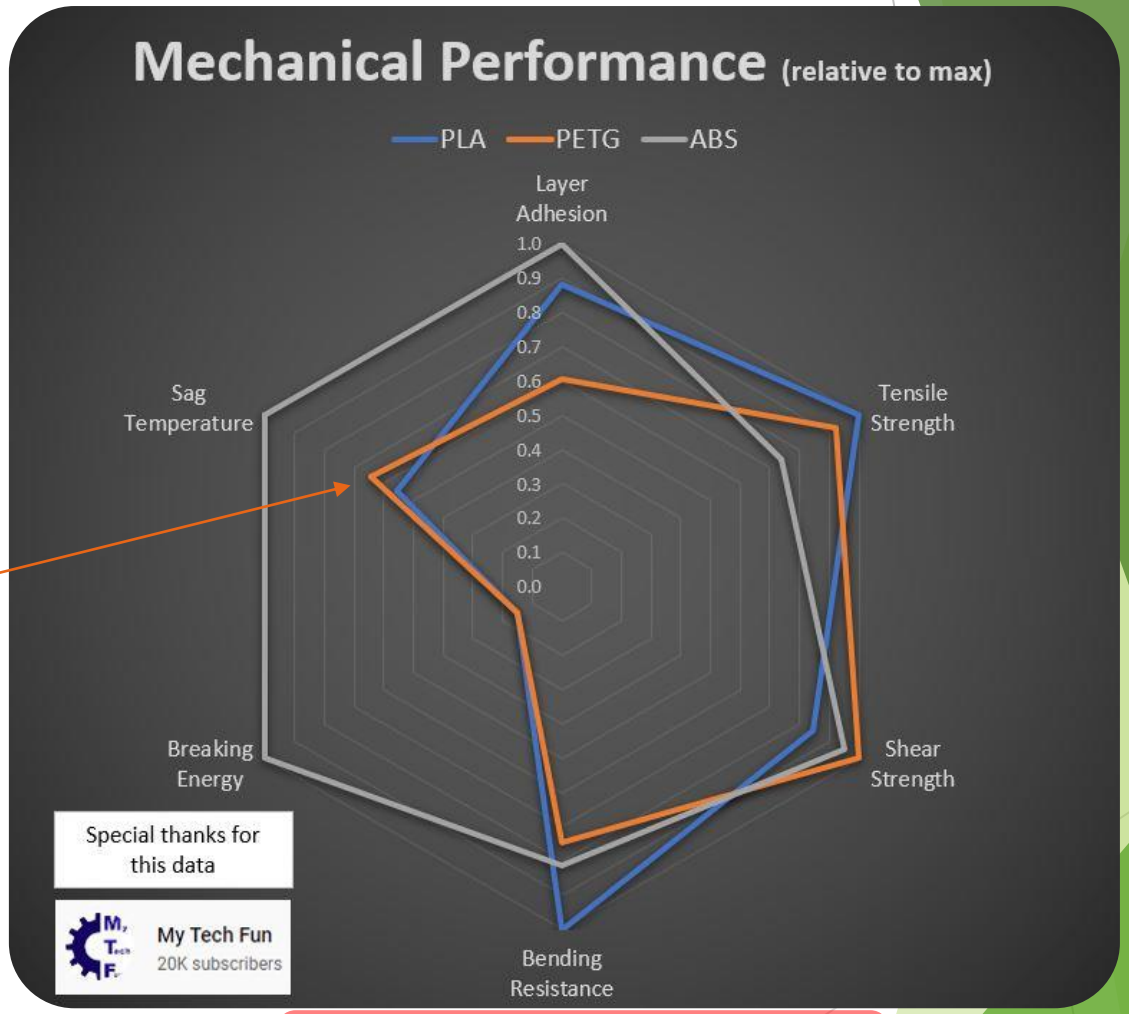
Source: CNC Kitchen tests on youtube





MATERIALS – Impact Performance

- Discussions of materials often highlight tensile strength and omit a common failure mode, which is impact. PETG, while more maker-friendly for printing, underperforms in impact resistance.



Video Explanation for this data

Regardless of drawbacks, PETG maintains popularity among makers. It is easier to achieve successful prints in comparison with ABS.

Hatchbox3D.com Embraces ABS

"Industries as varied as automotive and toy-making use acrylonitrile butadiene styrene (ABS) for its durability and formability. These properties also make ABS filament a solid choice for 3D printing whether for commercial applications or household objects.

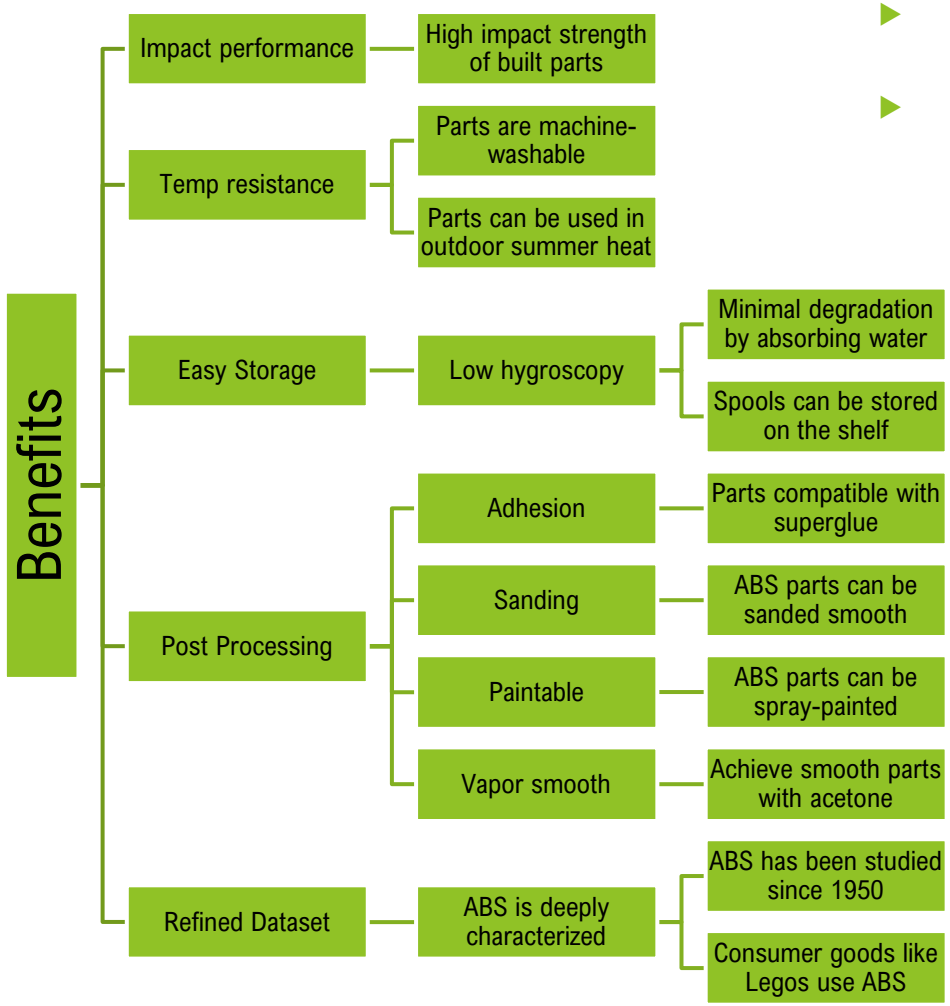
Because **ABS plastic is stronger and better withstands impacts** than PLA materials, ABS filament is a better choice for objects that will bear structural loads or will be handled frequently. The base ABS material is translucent so adding pigments creates ABS filaments in a wide range of colors, like our popular black ABS filament. ABS objects can also be kid-safe.

ABS will work with all but the cheapest FDM 3D printers because, while the ideal ABS print temperature is relatively low, the material requires a heated bed and an enclosed print volume. These temperature management features prevent adhesion and layer separation issues caused by ABS's tendency to contract when cooling. ABS produces fine details and **works with post-processing techniques** such as acetone smoothing.

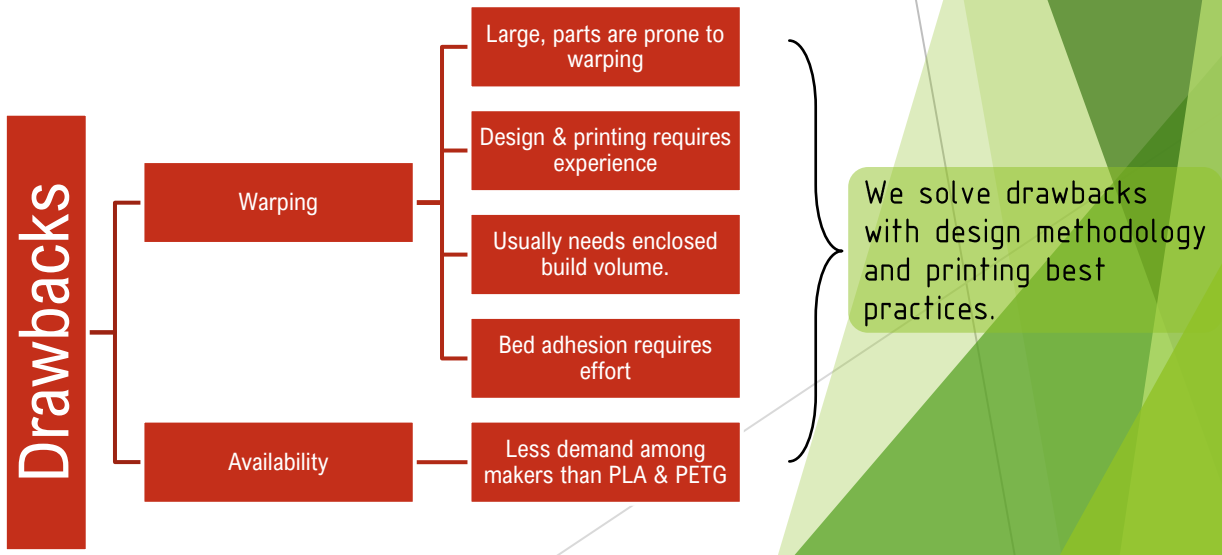
Strength, durability and temperature resistance are why you will see ABS materials used in the automotive and medical device industries. These material properties are also why people choose ABS 3D printer filaments. With fine surface details, a variety of color options and post-processing techniques like solvent welding and acetone smoothing, ABS 3D printing lets you create objects that will withstand day-to-day use."

HATCHBOX
YOUR CREATIVITY. OUR TOOLS.

Materials: ABS Pros & Cons



- Consider these qualities *relative to the most popular 3D filaments on the market*
- How to interpret:
  - "These are subjective comments with a logical translation. Take a case where the designer is choosing a filament based only on ONE quality. Then, if the property is listed under Benefits, ABS is the best choice. If the property is listed under Drawbacks, ABS is not the best choice." –David M



Printing Sets

Benchmarks for printing key parts in pairs or common sets required for building the SCUTTLE Robot Kits.

What you can learn:

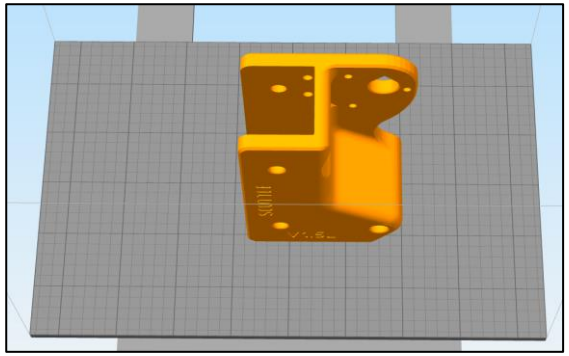
1) How fast can the parts print in good quality?
2) How do settings deviate for outlier parts?
3) How are parts usually oriented on the bed?

3D Prints Parts List

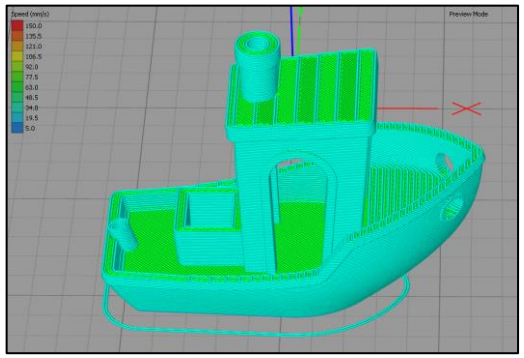
- Version 2.4 Printed Parts Sheet
- Version 2.4 STL Files on Github

Print Tests

whlBrkL66

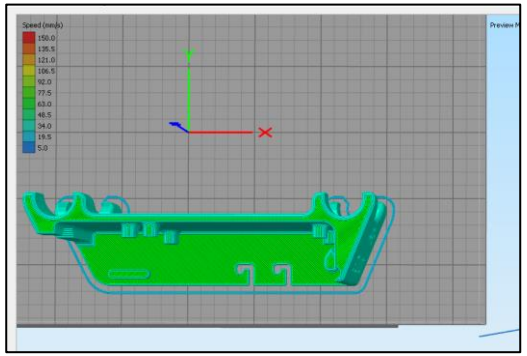


Benchy_45m

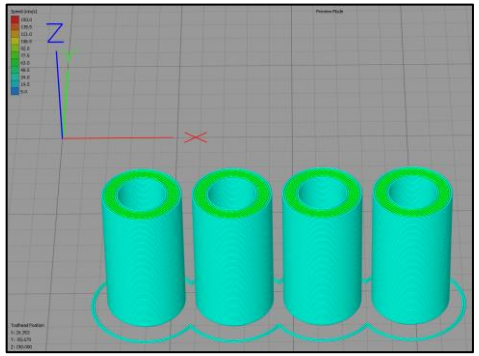


Param	WhlBrkL66	Benchy_45m	cpuBrkt	Spacers	pulyWhl
Speed(mm/s)	65	60	65	60	50
Outline(%)	60	50	50	50	50
Bed Temp	85	85	100	85	100
Extr Temp	245	245	245	245	245
Infill (%) / perimeters	35/2	raised temp improved warp	35/2	35/2	35/2
Plastic	Hbx ABS	HBX ABS	ABS_BMT	HBX ABS	ABS_BMT
Extr Width (mm)	0.40	0.40	0.44	0.40	0.44
Layer thick (mm)	0.3	0.30	0.3	0.30	0.3
Time (h:mm)	3:23	0:45	1:54	0:49	1:50

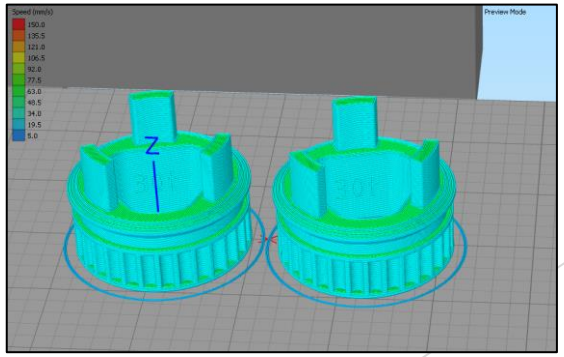
CpuBrkt



Spacers

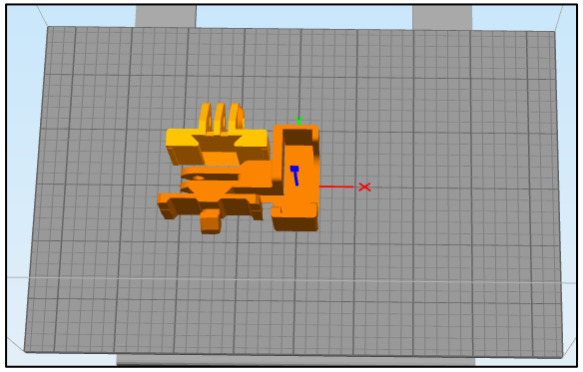


pulyWhl

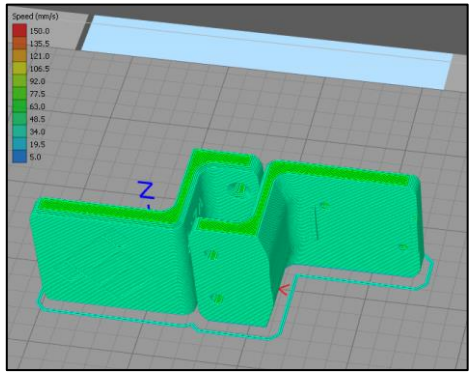


Print Sets

cameraSet

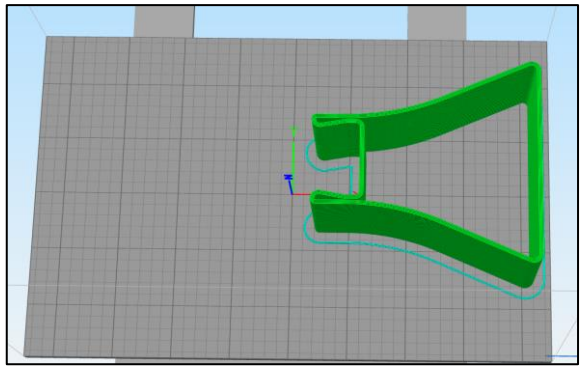


encdrPair

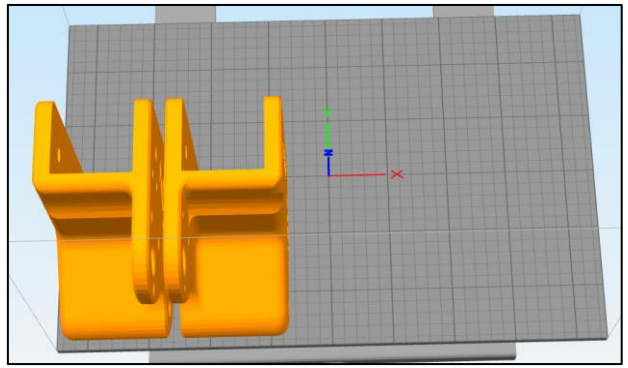


Param	CameraSet	encdrPair	KickStand_t2	rodBrktSet2	WhlBrk Pair_v1.5
Speed(mm/s)	60	60	60	65	60
Outline(%)	50	50	100	60	50
Bed Temp	85	90	85	90	85
Extr Temp	235	250	235	250	235
Infill(%) / perimeters	35 /2	35/2	35 / 3	35/2	35/3
Plastic	Hbx ABS	ABS	Hbx ABS	BUMAT ABS	Hbx ABS
Extr Width (mm)	0.40	0.40	0.48	0.40	0.40
Retraction (mm)	2.0	2.0	2.0	0.3	
Time	1:26	0:47	1:08	1:18	7:22

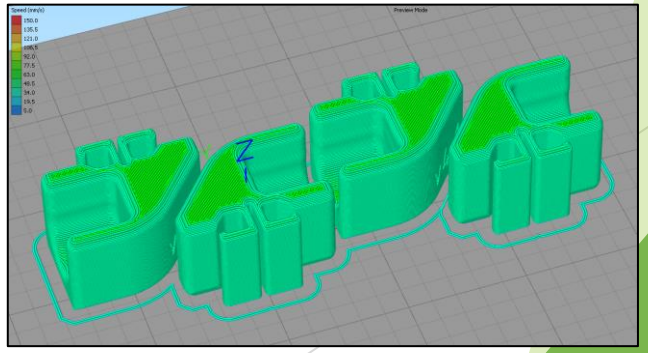
Kickstand_t2



WhlBrkPair_v1.5

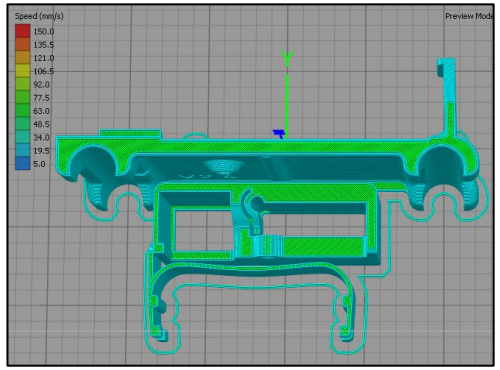


rodBrkSet2

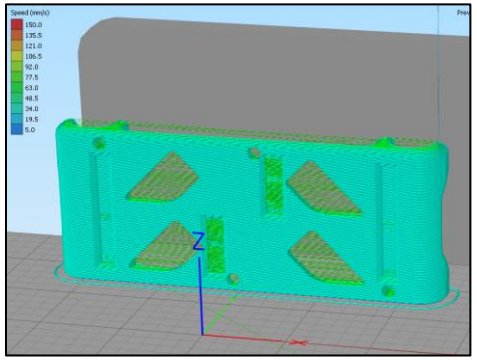


Print Sets

batBrkt

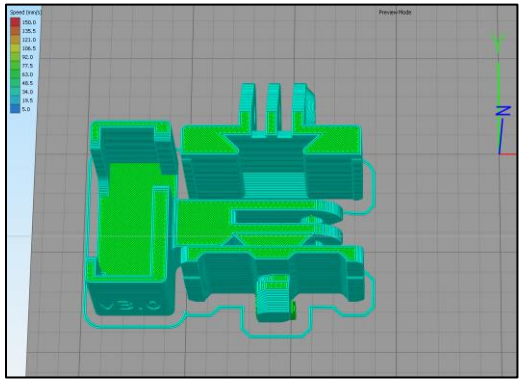


mDriverBrk

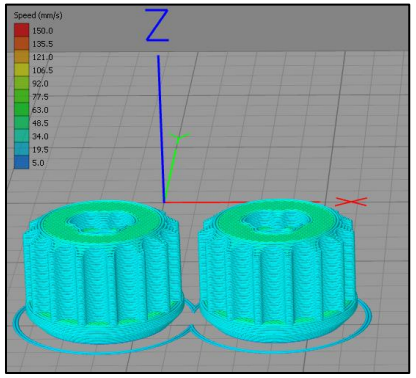


Param	batBrkt	mDriverBrk	camSet2	mPulley_v3	pulleySet3
Speed(mm/s)	60	60	60	40	40
Outline speed (%)	40	50	50	60	50
Bed Temp	85	85	85	85	85
Extr Temp	245	245	245	245	245
Infill (%) / perimeters	35/2	35/2	35/2	35 / 2	35 / 2
Plastic	HBX abs	HBX ABS	HBX ABS	HBX ABS	HBX ABS
Extr Width (mm)	0.44	0.40	0.40	0.44	0.44
Layer thick (mm)	0.3	0.30	0.30	0.25	0.25
Time (h:mm)	3:23	1:17	1:24	0:29	2:55
Outline overlap (%)	20	20	Retr vert lft: 0mm	30	20
Extr ratio	100			103 %	

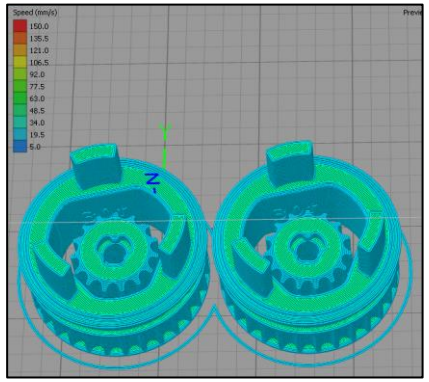
camSet2



mPulley_v3

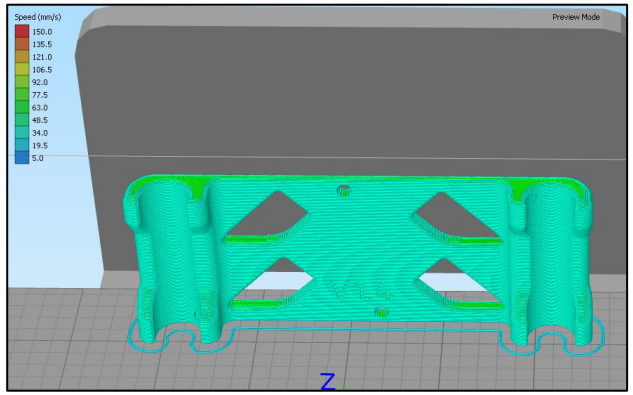


pulleySet3

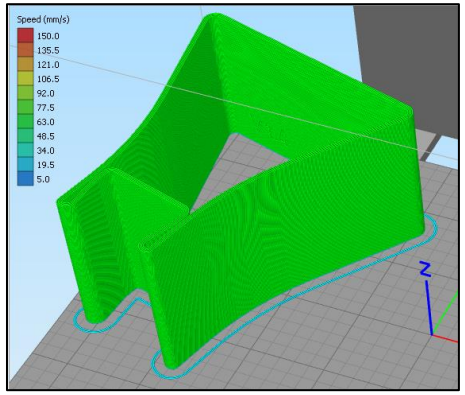


Print Sets

mtrDrvBrkt1

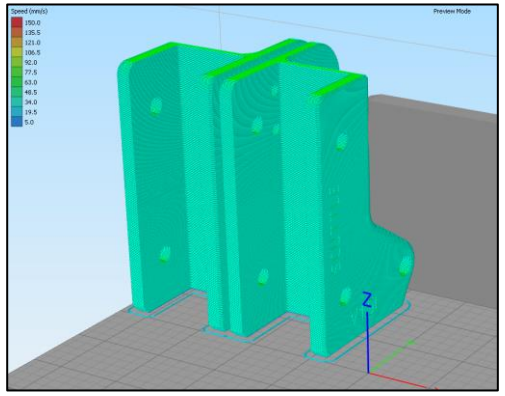


kickstand_t3

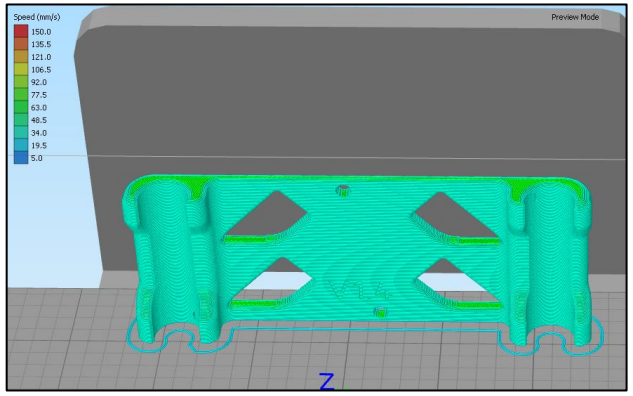


Param	mtrDrvBrkt1	Kckstand_t3	whlBrktSet_t2	mtrDrvBrkt_t2	camSet3
Speed(mm/s)	65	65	65	65	65
Outline(%)	50	100	50	50	50
Bed Temp	90	105	100	100	100
Extr Temp	245	245	245	245	245
Infill (%) / perimeters	35/2	35/2	35/2	35/2	35/2
Plastic	BMT ABS	GZMO GRN	BMT_ABS	BMT ABS	GZMO GRN
Extr Width (mm)	0.40	0.48	0.44	0.44	0.44
Layer thick (mm)	0.30	0.30	0.3	0.30	0.30
Time (h:mm)	1:09	1:03	6:38	1:09	1:18
Outline overlap (%)	20		20	20	20
Extr ratio		1.00	1.00		1.0
OTHER Layer1 Spd Layer 1 Ht	35%	35%	35%	35% 100%	

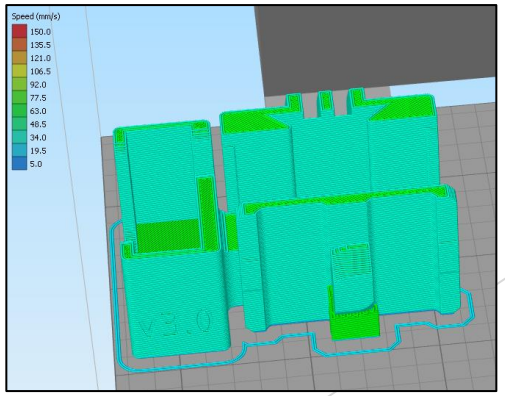
mtrDrvBrkt1



mtrDrvBrkt_t2

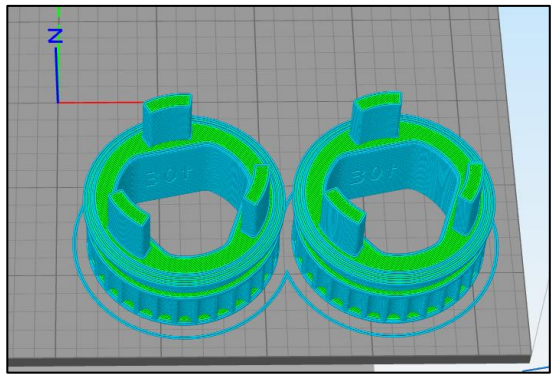


camSet3

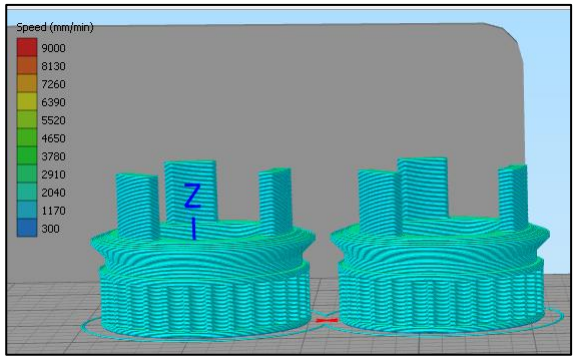


Print Sets

whlPuly2



whlPuly_v3.3



Param	whlPuly2	whlPuly_v3.3			
Speed(mm/s)	65	50			
Outline(%)	30	50			
Bed Temp	90	100			
Extr Temp	245	245			
Infill (%) / perimeters	35/2	35/2			
Plastic	GRN_GZM				
Extr Width (mm)	0.44	0.44			
Layer thick (mm)	0.30	0.3			
Time (h:mm)	1:55	1:47			
Outline overlap (%)	20	20			
Extr ratio		100%			
OTHER Layer1 spd	35%				

placeHolder

placeHolder

placeHolder