

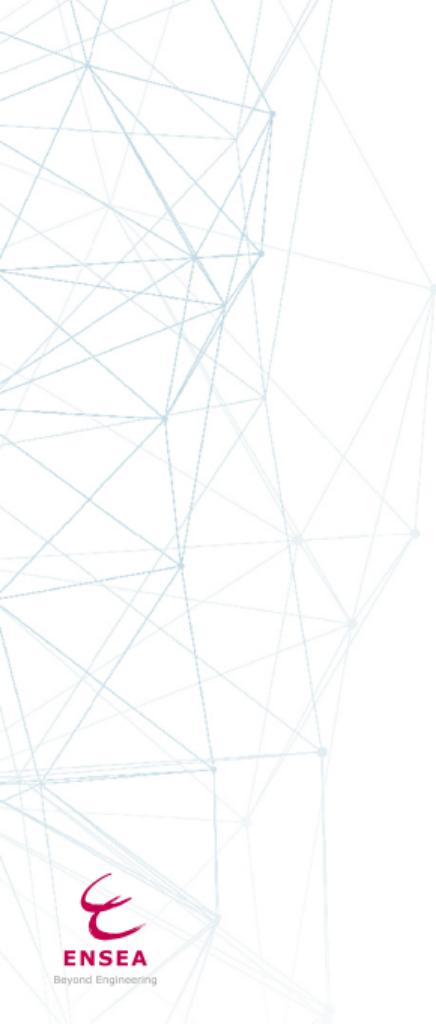


OPTION MAKER

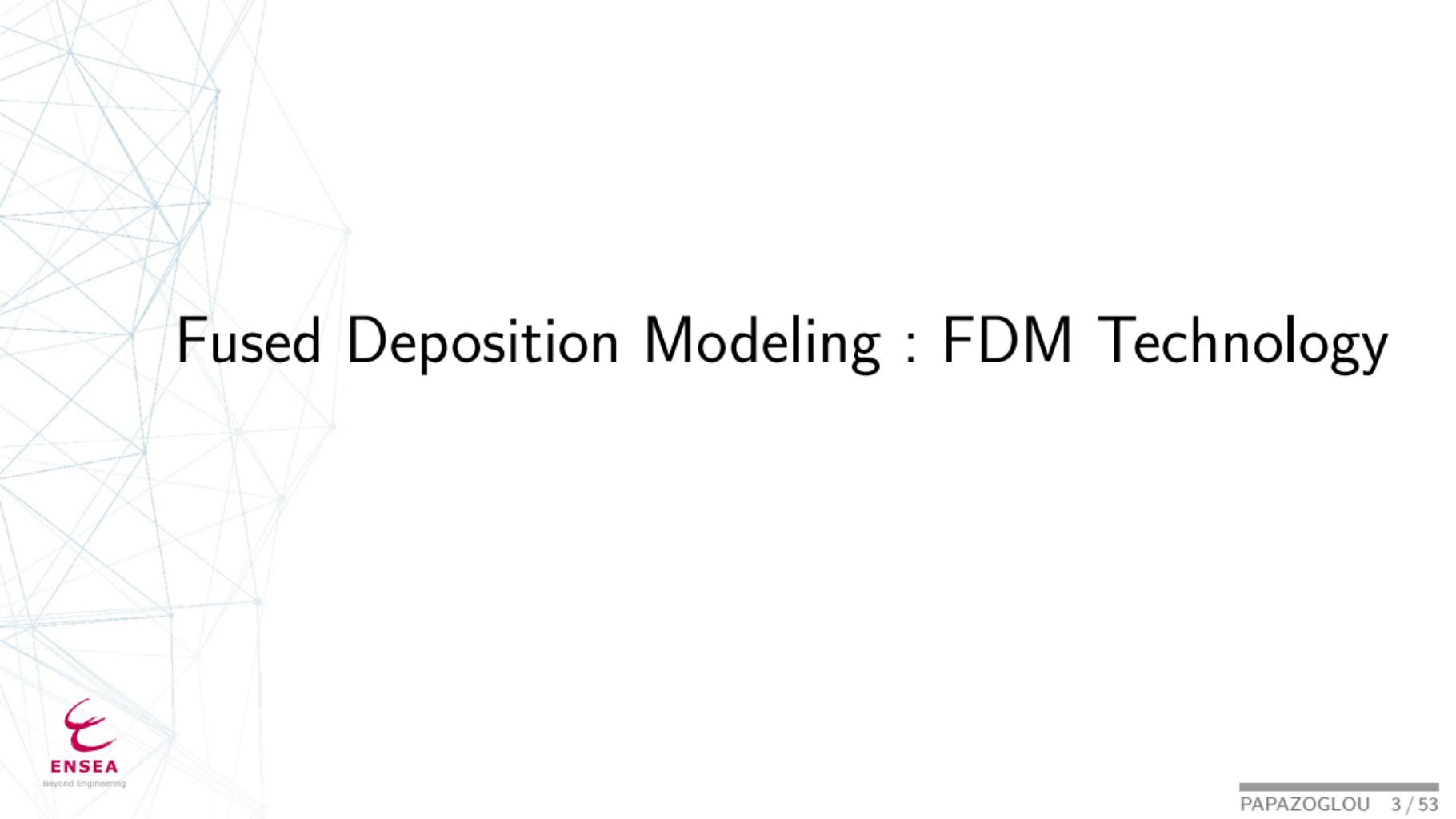
ENSEA

Nicolas Papazoglou nicolas.papazoglou@ensea.fr

22 janvier 2025



Impression 3D



Fused Deposition Modeling : FDM Technology

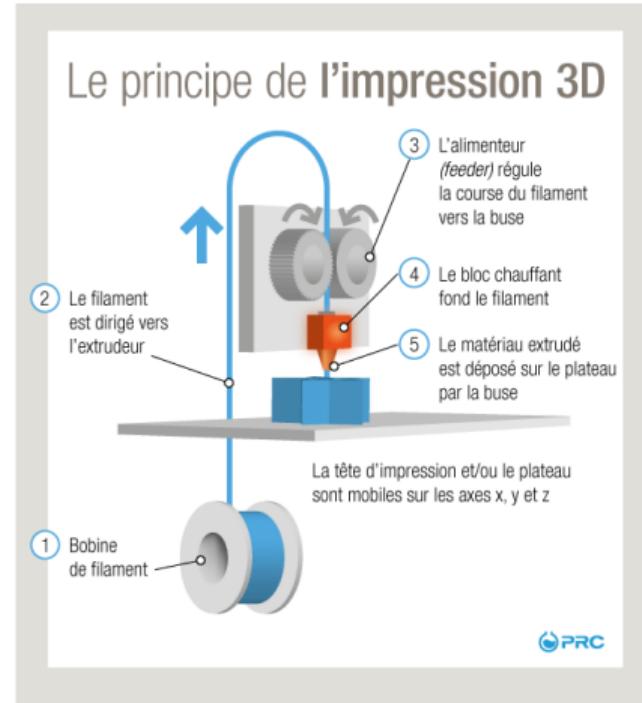


Figure – Example impression 3D



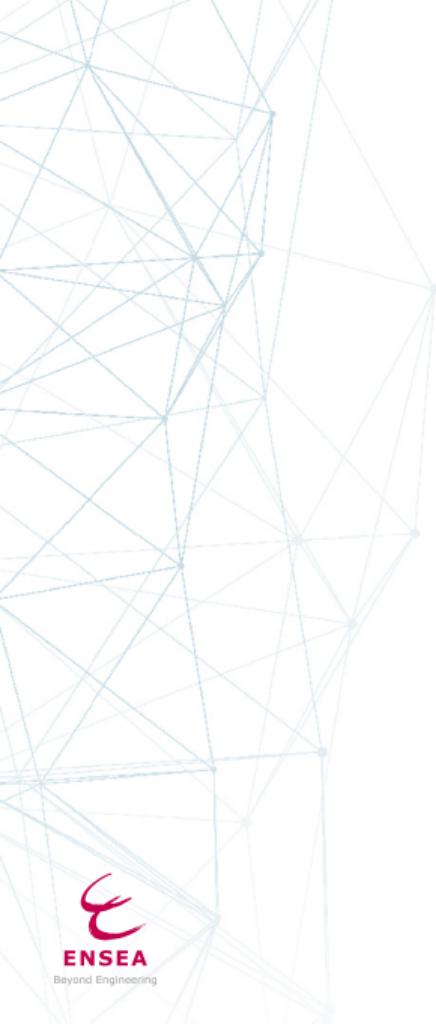
Ce qui est possible d'imprimer

Ce qui est possible d'imprimer

- Pièces décoratives
- Pièces mécaniques
- Pièces techniques



Figure – Example impression 3D



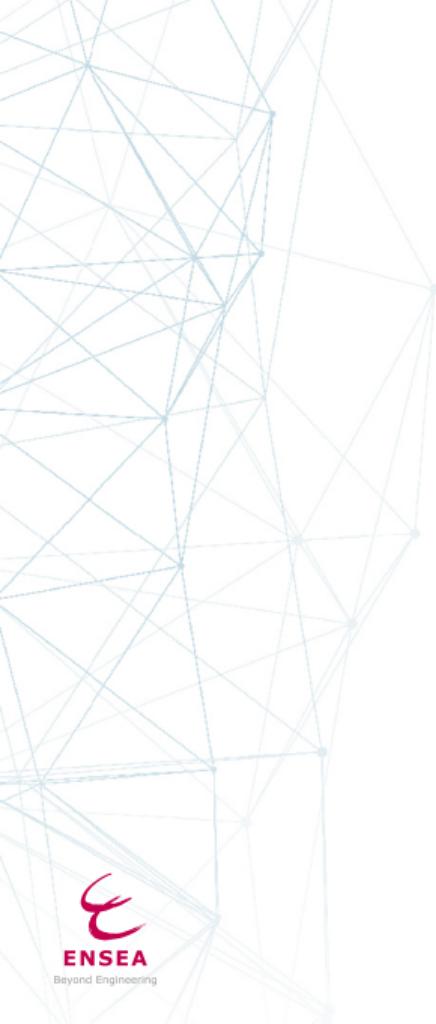
L'imprimante 3D

Termes techniques :

- Nozzle : buse d'impression,
- Hotend : tête d'impression,
- Extruder,
- Bowden : tube PTFE qui guide le filament,
- Bed : plateau d'impression.

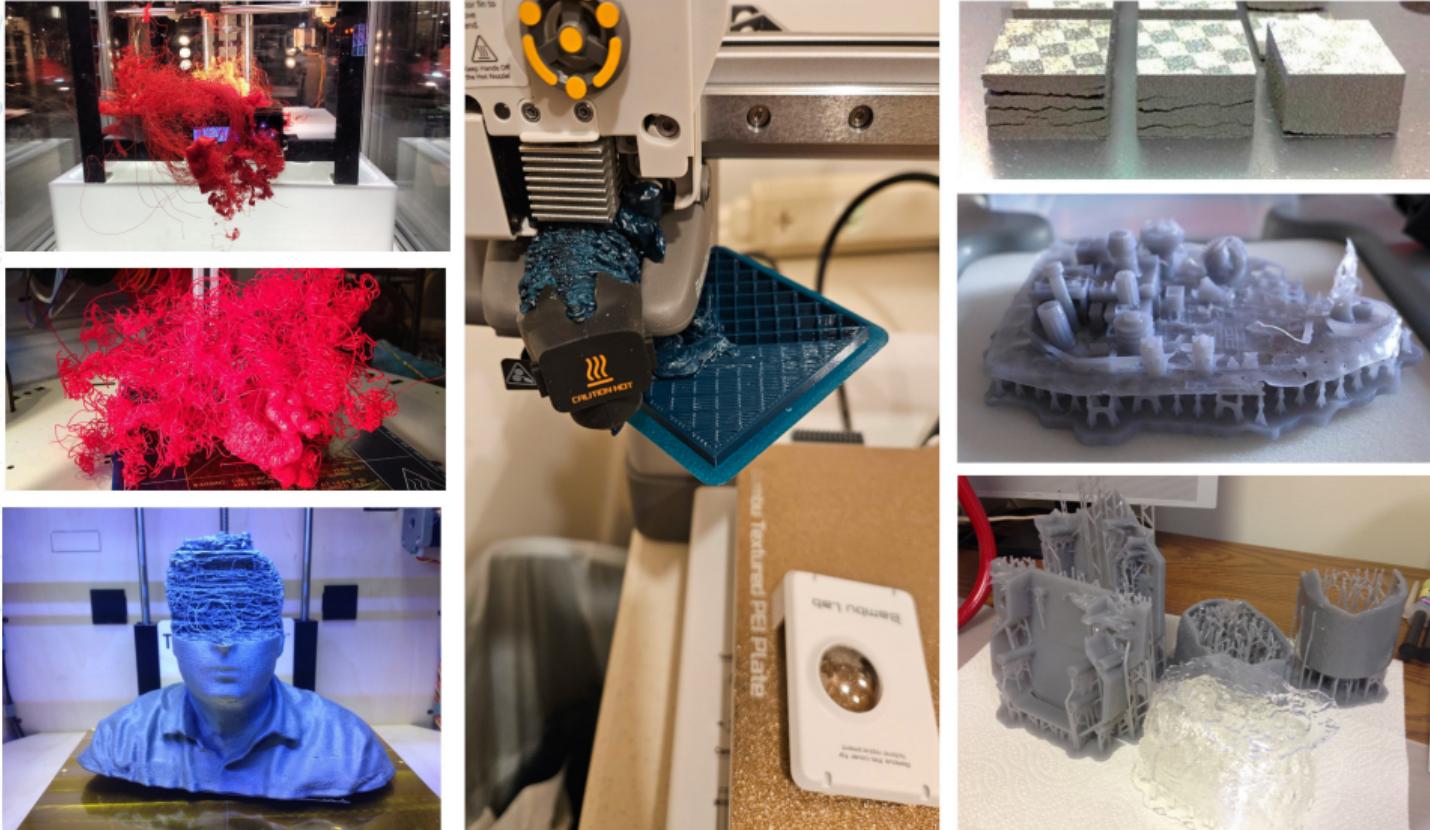


Figure – Imprimante 3D : les différentes pièces

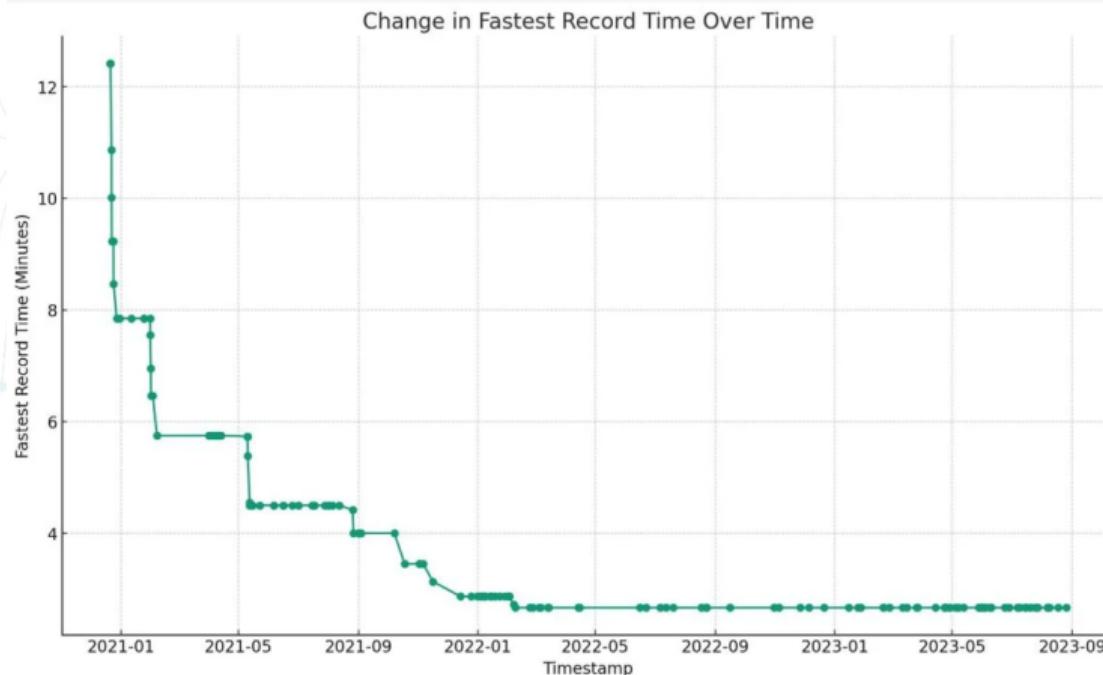


Contraintes

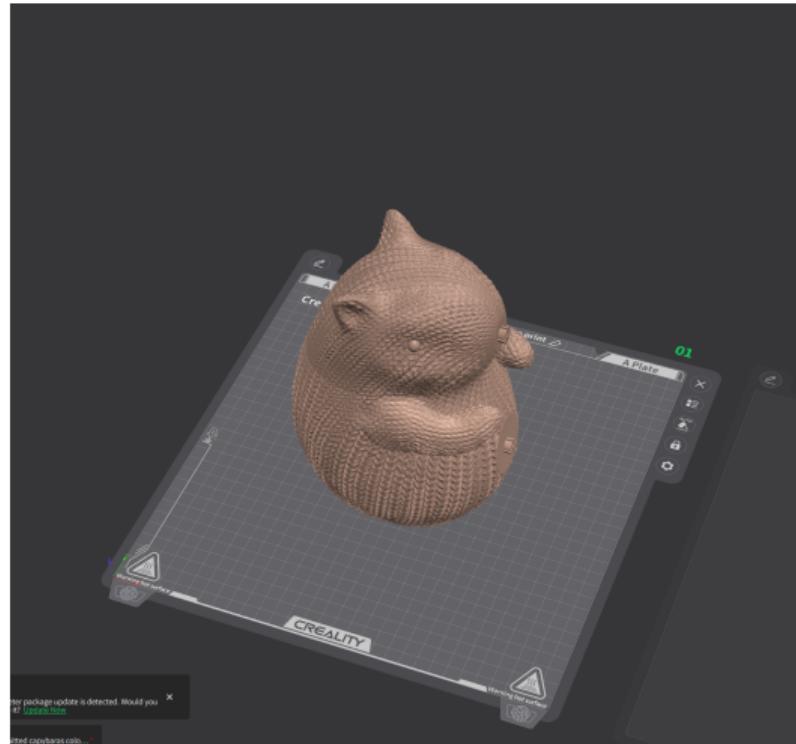
Echecs



$$V=d/t$$



$$V=d/t$$



Filament pour impression 3D

Filament	Propriétés principales	Usages	Inconvénients
PLA	Facile à imprimer, biodégradable, esthétique	Prototypes, objets décoratifs	Fragile, faible résistance à la chaleur
PETG	Résistant, peu de warping	Pièces fonctionnelles, résistantes à l'humidité	Adhérence au bed parfois difficile
ABS	Résistant aux chocs, thermique, ponçable	Prototypes, pièces mécaniques	Dégage des fumées, nécessite une enceinte
TPU	Flexible, résistant à l'abrasion	Joints, gadgets souples	Lent à imprimer, difficile avec Bowden
PVA	Soluble dans l'eau, support PLA	Support pour impressions complexes	Absorbe l'humidité, difficile à imprimer

Matériels composites : métal, bois

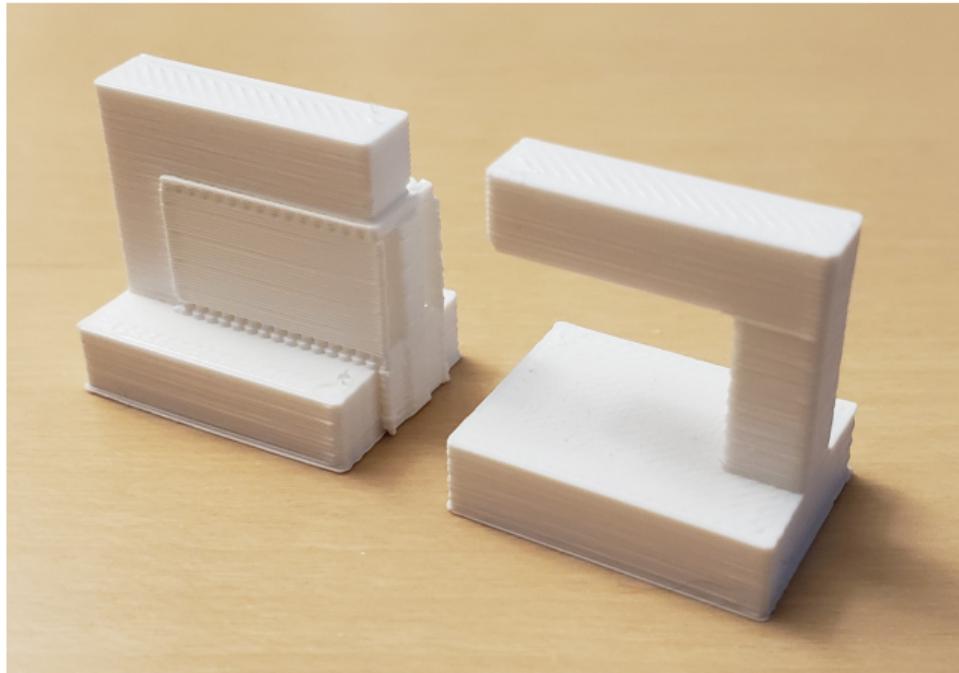
Ventilation

- Emission
- Green gard certified

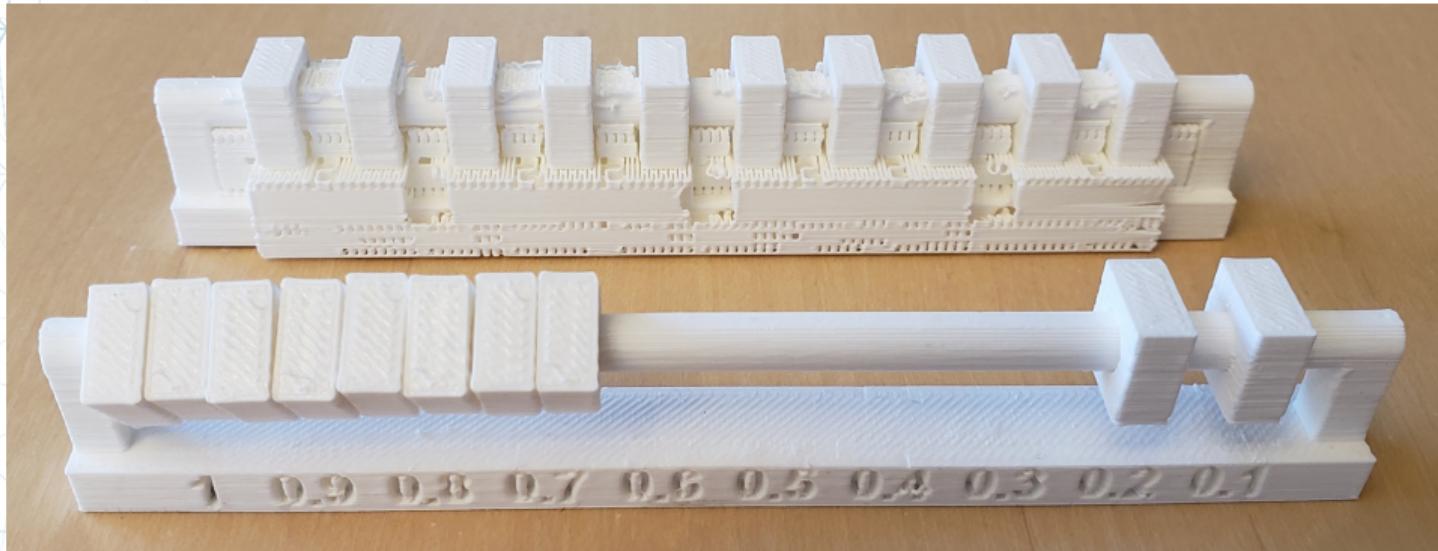


Règles de design

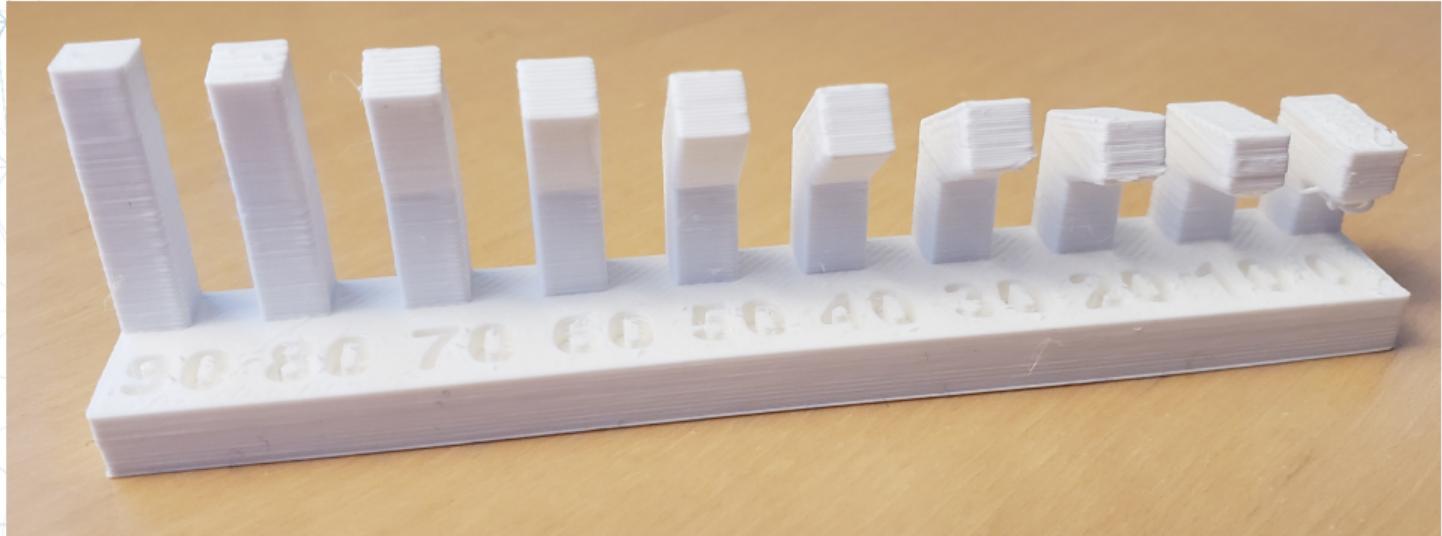
Avec support : Overhang



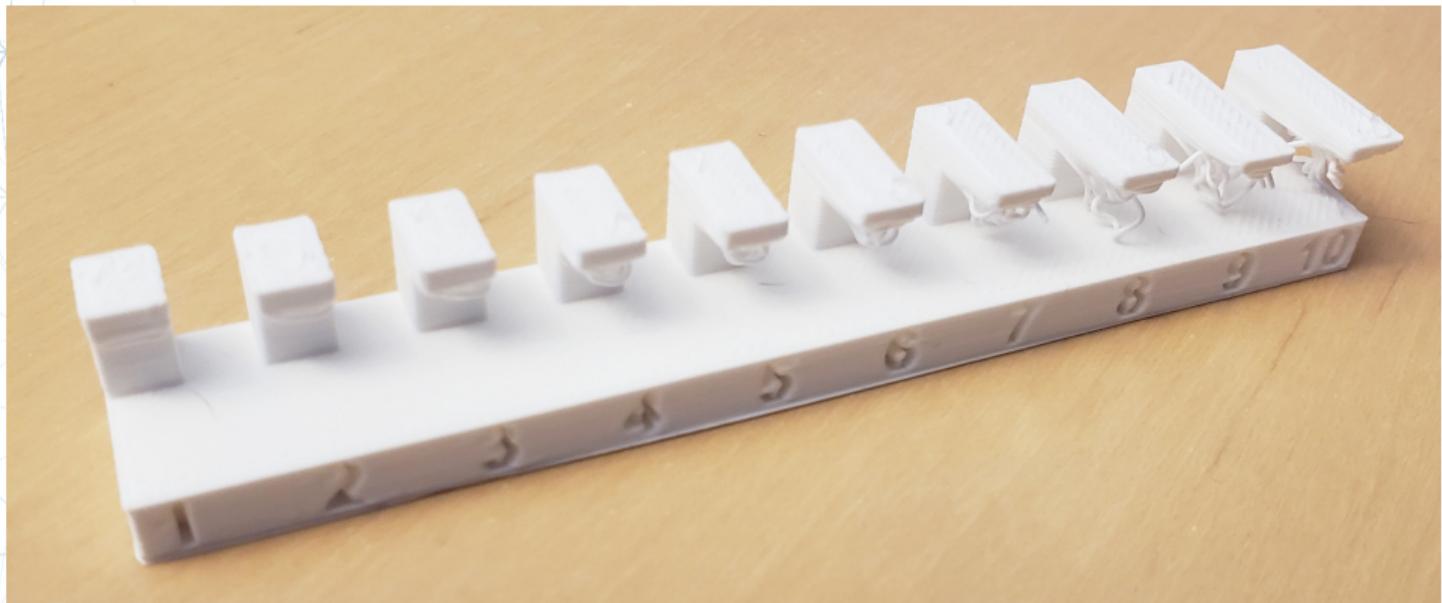
Avec support : Clearance



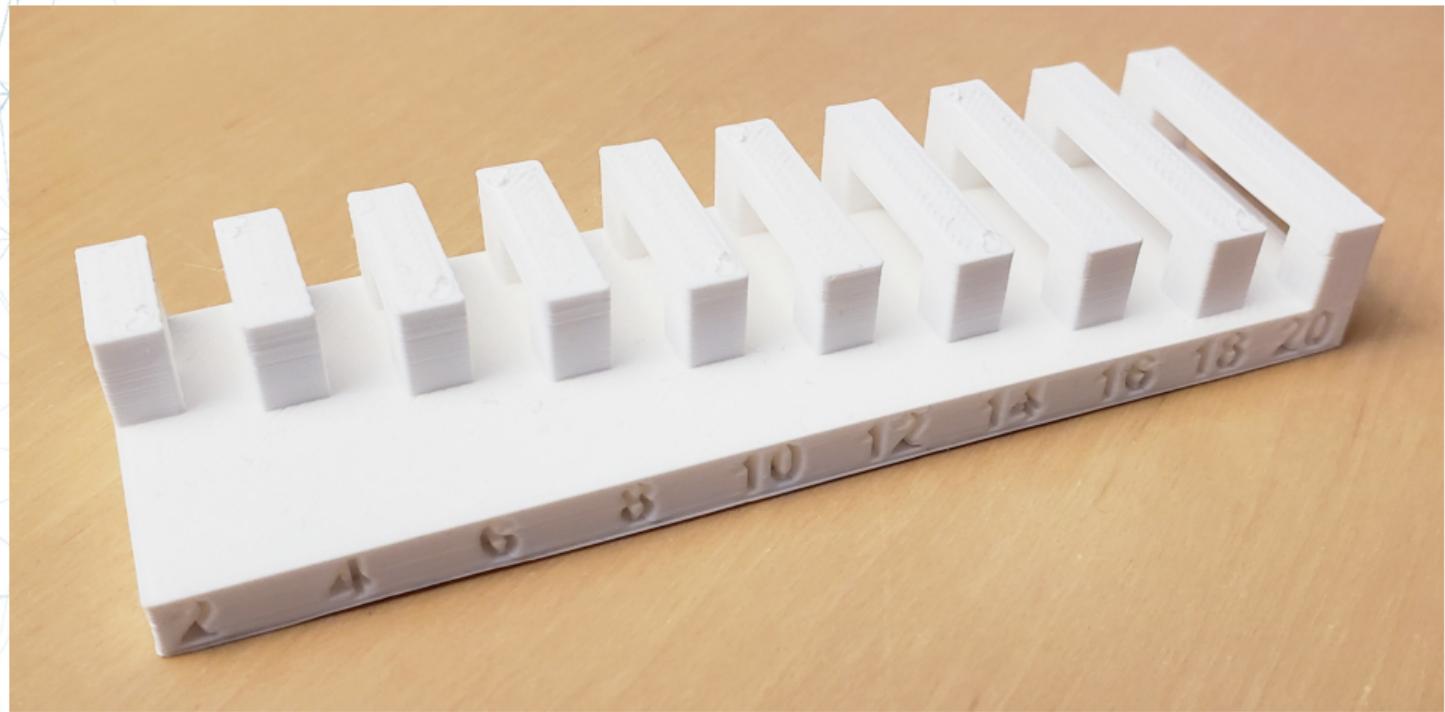
Sans support : Clearance



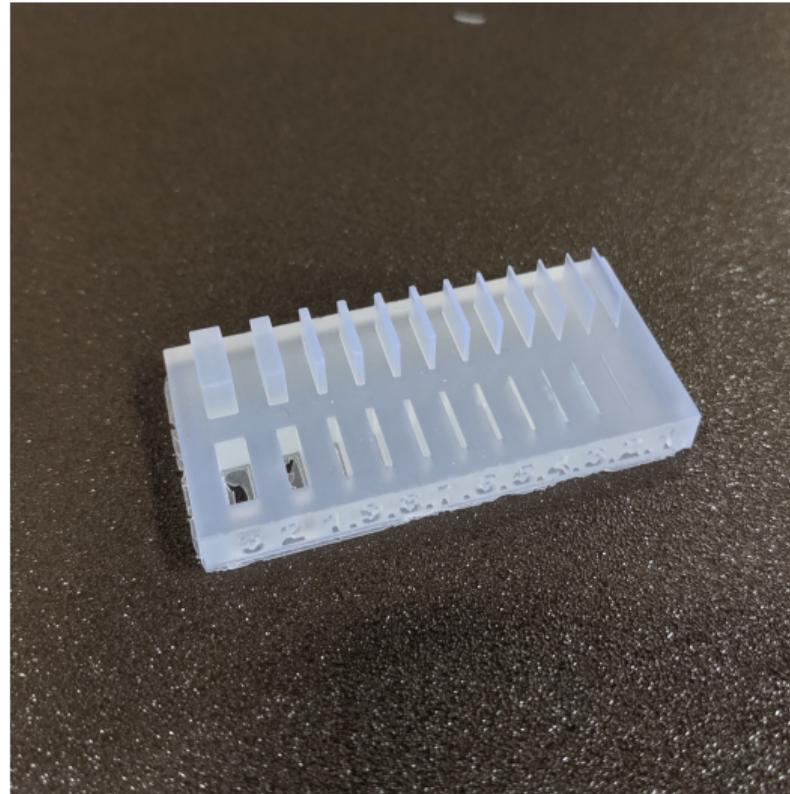
Sans support : Free



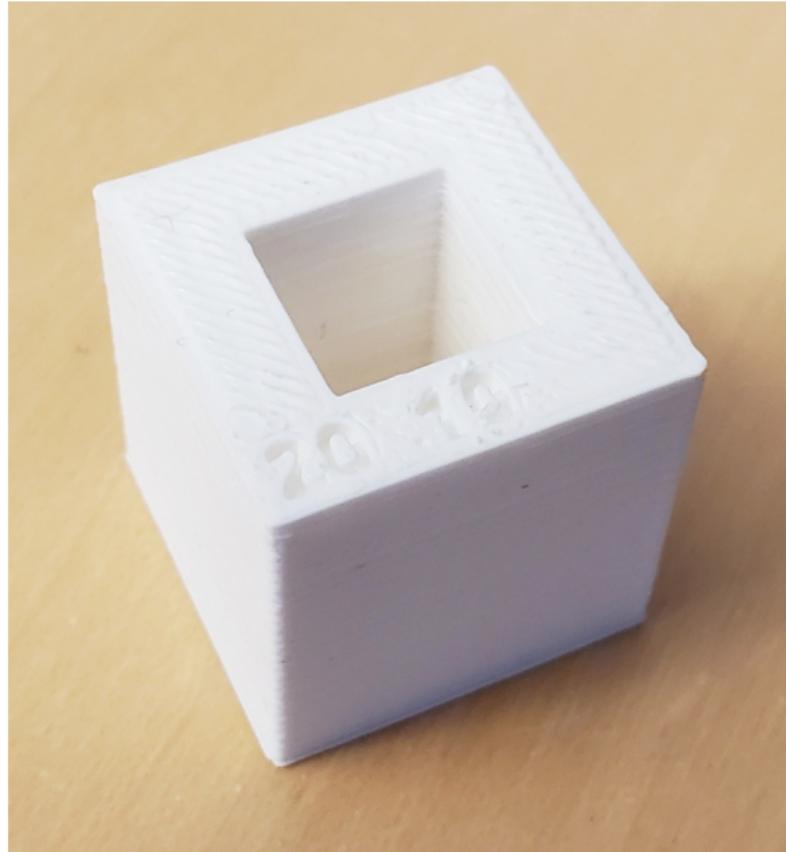
Sans support : Bridging



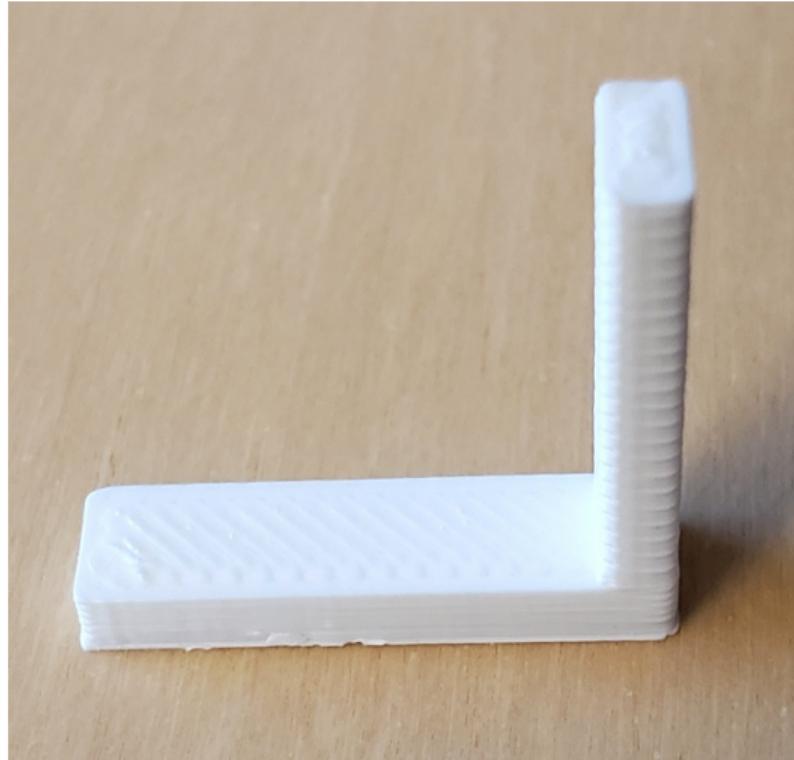
Wall thickness



Dimensions



Anisotropy



Surface finish



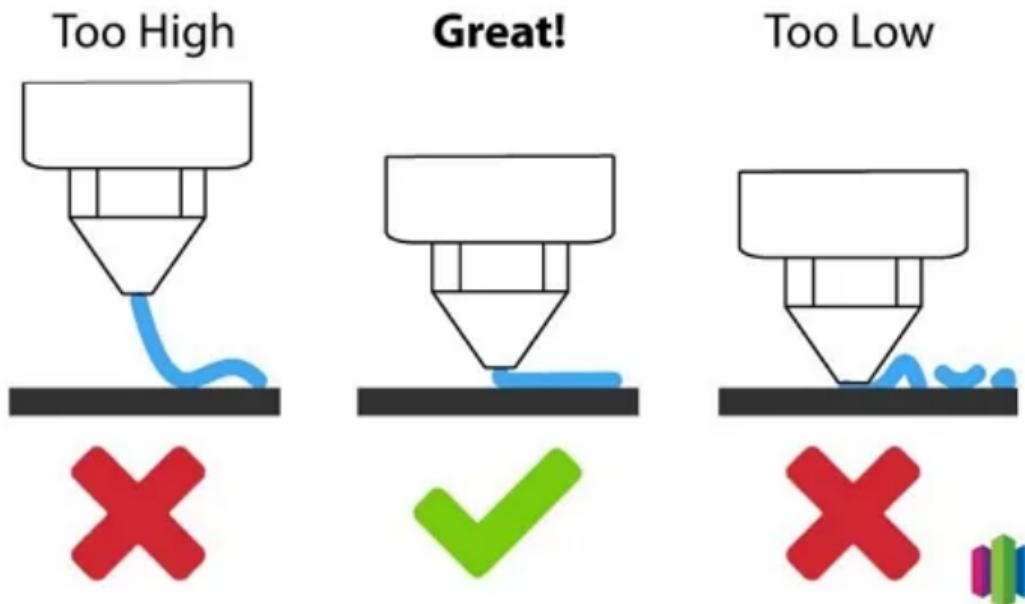
Infill





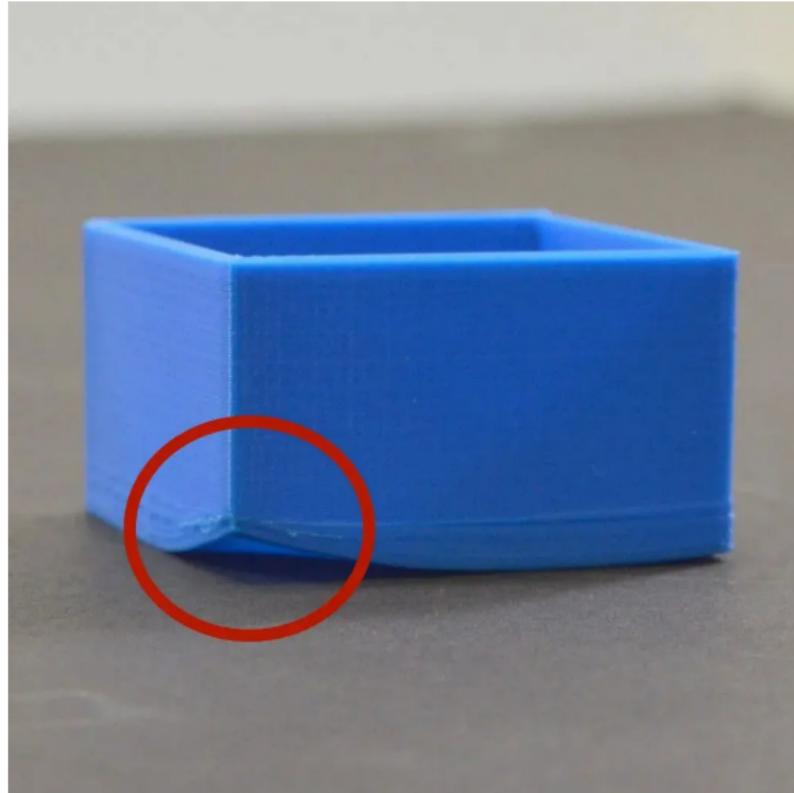
Problèmes

Adhésion : first layer



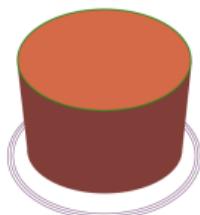
adhesion, warping, rafts, brims

Adhésion : warping



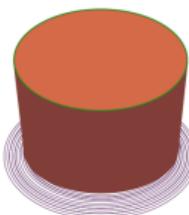
Adhésion : solutions

Skirt



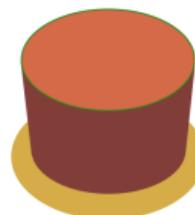
Good for purging the nozzle
before printing model.

Brim



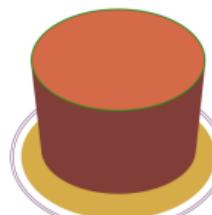
Good for increasing bed
adhesion.

Raft



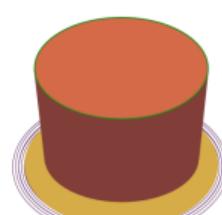
Good for clean first layer
of model.

Raft with Skirt



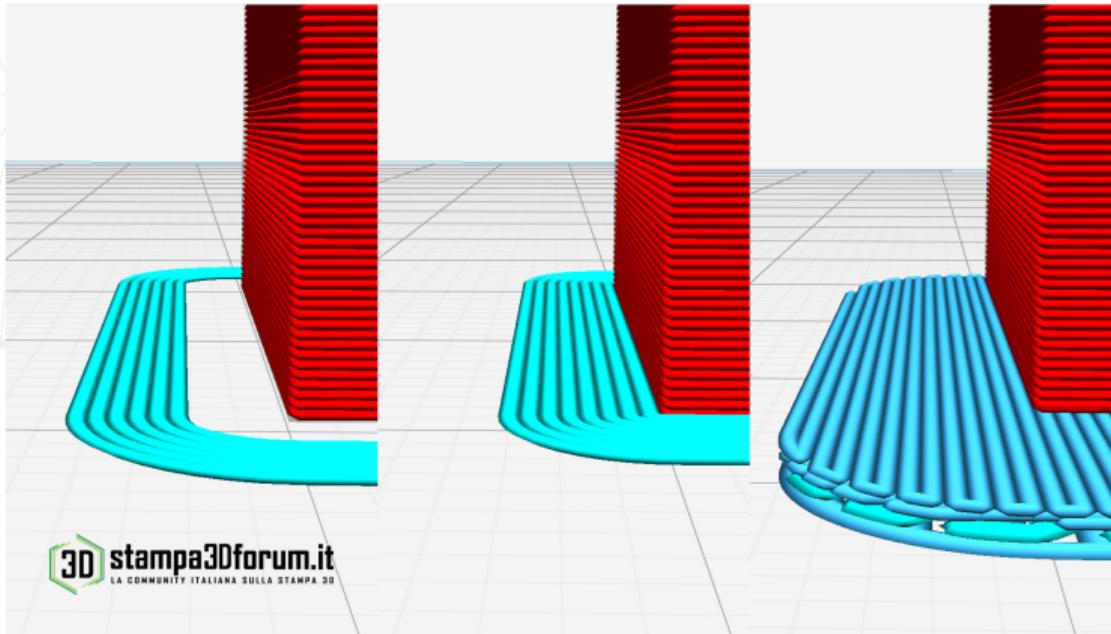
Good for purging and clean
first layer of model.

Raft with Brim



Good for bed adhesion and
clean first layer of model.

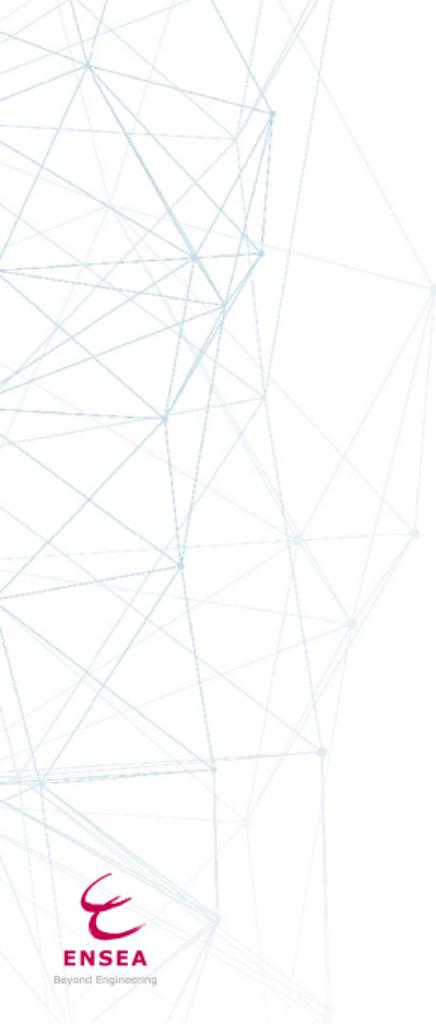
Adhésion : solutions



stampa3Dforum.it
LA COMMUNITY ITALIANA SULLA STAMPA 3D

Pour aller plus loin...

- Post-processing
- Plating



Hardware

Marché de l'impression 3D

Domaine	Marque	Nationalité	Modèle	Exemples d'usages	Échelle de prix
Home	Creality	Chine	Ender 3, CR-10	Projets DIY, miniatures, hobbyists	150€ - 500€
	Anycubic	Chine	Kobra, Photon	Projets DIY, miniatures, hobbyists	150€ - 500€
	Prusa	République Tchèque	Prusa MK4, Prusa Mini+	Projets DIY avancés, hobbyists	500€ - 1000€
Fablab	Ultimaker	Pays-Bas	Ultimaker S5, S3	Prototypage, projets éducatifs	2500€ - 6000€
	Raise3D	Chine	Raise3D Pro3, E2	Prototypage dans les makerspaces	2000€ - 5000€
	FlashForge	Chine	Adventurer 4, Creator 3	Prototypage, projets éducatifs	300€ - 1500€
Farm	Bambu Lab	Chine	X1 Carbon, P1P	Production en série, objets personnalisés	1000€ - 4000€
	Prusa	République Tchèque	Prusa MK4	Production en série, objets personnalisés	500€ - 1500€
	LulzBot	USA	TAZ Workhorse, Mini 2	Production en série, objets personnalisés	1500€ - 3500€
Factory	Stratasys	USA	F370, J55	Aéronautique, automobile, médical, industriel	5000€ - 20000€
	3D Systems	USA	Figure 4, ProX series	Aéronautique, automobile, médical, industriel	10000€ - 50000€
	HP	USA	HP MJF 5200, 580	Production rapide, grands volumes	10000€ - 50000€
	EOS	Allemagne	EOS M 290, P 396	Production métallique, aéronautique	30000€ - 100000€
	Markforged	USA	Mark Two, X7	Pièces fonctionnelles, secteur industriel	3000€ - 10000€

Creality K1 Max

- Company : Creality
- Print size : 300 x 300 x 300 mm
- Enclosure : closed
- Max speed : 600 mm/s
- Materials : PLA, ABS, PETG, TPU, Nylon, ASA, PC
- Filament diameter : 1.75mm
- Layer thickness : 0.1 - 0.4mm
- Nozzle Diameter : 0.4mm (standard)
- Feeder system : direct drive system
- Extruder : single
- Connectivity : USB, Wifi, LAN, Cloud
- Slicing : Creality Print (compatible with others)
- Others : auto bed leveling, AI-assisted monitoring
- Price : 800€



Figure – Creality K1

Bambulab X1C

- Company : Bambulab
- Print size : 256 x 256 x 256 mm
- Enclosure : closed
- Max speed : 500 mm/s
- Materials : PLA, ABS, PETG, PET, TPU, PA, ASA, PC, Nylon, Carbon Fiber
- Filament diameter : 1.75mm
- Layer thickness : 0.1 - 0.3mm
- Nozzle Diameter : 0.2mm - 0.6mm
- Feeder system : direct drive system
- Extruder : single (with AMS for multi-material)
- Connectivity : SD Card, Wifi, Cloud
- Slicing : Bambu Studio (compatible with others)
- Others : auto bed leveling, lidar-assisted calibration
- Price : 1200€



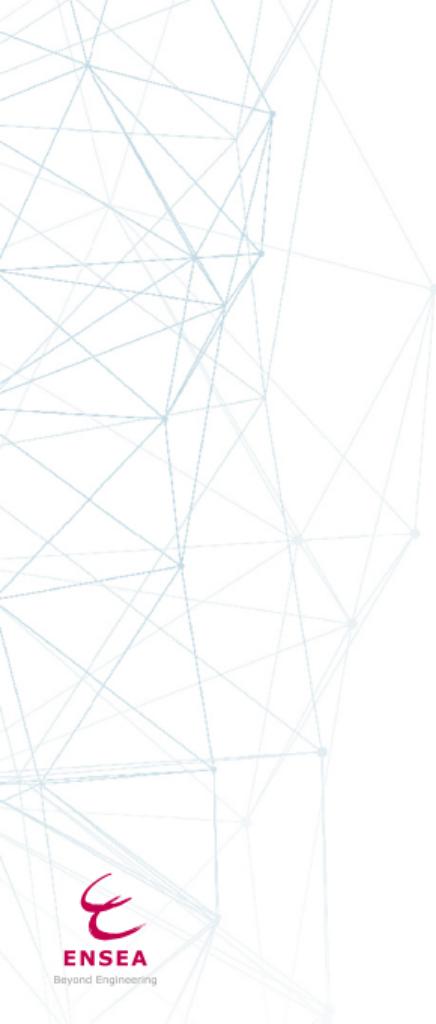
Figure – Bambulab X1C

Prusa XL4

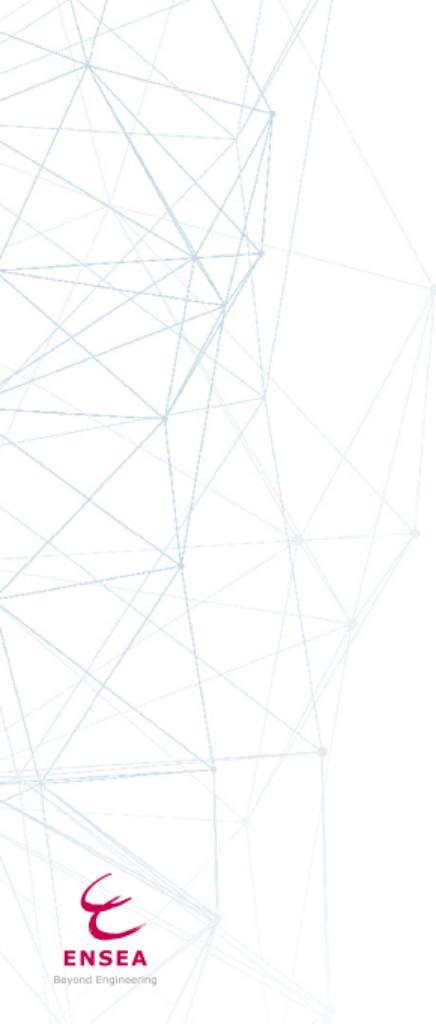
- Company : Prusa
- Print size : 360 x 360 x 360 mm
- Enclosure : closed
- Max speed : 500 mm/s
- Materials : PLA, ABS, PETG, PET, TPU, PA, ASA, PC, Nylon, Carbon Fiber
- Filament diameter : 1.75mm
- Layer thickness : 0.1 - 0.3mm
- Nozzle Diameter : 0.2mm, 0.4mm, 0.6mm, 0.8mm, 1.0mm
- Feeder system : direct drive system
- Extruder : 5 with multi-material capability
- Connectivity : SD Card, Wifi, Cloud
- Slicing : PrusaSlicer (compatible with others)
- Others : auto bed leveling, lidar-assisted calibration
- Price : 4500€



Figure – Prusa XL4



Software



Format de fichiers

Format de fichiers

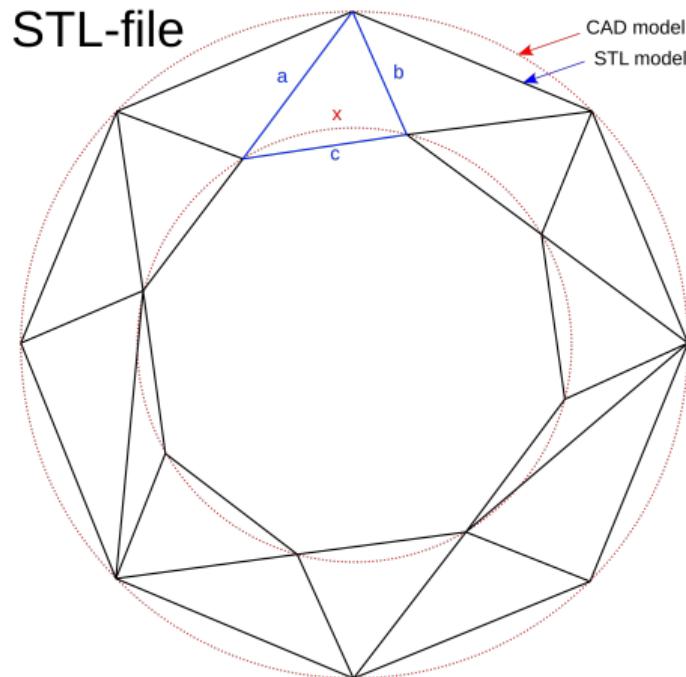


Figure – CAD vs STL

ASCII STL File

```
solid name
...
facet normal ni nj nk
    outer loop
        vertex v1x v1y v1z
        vertex v2x v2y v2z
        vertex v3x v3y v3z
    endloop
endfacet
...
endsolid name
```

- facet normal ni nj nk :
Ce vecteur normal permet de déterminer l'orientation de la face dans l'espace 3D.
- outer loop :
Indique le début de la définition des sommets (ou vertices) de la facette. Chaque facette est un triangle et se compose de 3 sommets.
- vertex vx vy vz :
Chaque ligne vertex définit un sommet du triangle en utilisant les coordonnées x, y, z.
- endloop :
Marque la fin de la boucle externe où sont définis les sommets du triangle.
- endfacet :
Marque la fin de la facette. Cela clôture la description de cette face du modèle 3D.

Binary STL File

```
UINT8[80]      - Header           - 80 bytes
UINT32         - Number of triangles - 04 bytes
foreach triangle
    REAL32[3]   - Normal vector     - 12 bytes
    REAL32[3]   - Vertex 1          - 12 bytes
    REAL32[3]   - Vertex 2          - 12 bytes
    REAL32[3]   - Vertex 3          - 12 bytes
    UINT16       - Attribute byte count - 02 bytes
end
```

gCode File

```
; Start of the G-code file
; Setup
G21          ; Set units to millimeters
G90          ; Use absolute positioning
M107         ; Fan off

; Heat up the bed and extruder
M104 S200    ; Set extruder temperature to 200°C
M140 S60     ; Set bed temperature to 60°C
M190 S60     ; Wait for the bed to reach 60°C
M109 S200    ; Wait for the extruder to reach 200°C
```

gCode File

```
; Start the print
G28          ; Home all axes
G1 Z0.3 F1200 ; Move the nozzle to 0.3mm height
G1 X0 Y0 F1500 ; Move the print head to the origin (0,0)
G1 X50 Y50 E10 ; Move to X50, Y50 and extrude 10mm of filament

; Example of printing a simple square (a few layers)
G1 X100 Y50 E20 ; Move to X100 Y50 and extrude 20mm of filament
G1 X100 Y100 E30 ; Move to X100 Y100 and extrude 30mm of filament
G1 X50 Y100 E40 ; Move to X50 Y100 and extrude 40mm of filament
G1 X50 Y50 E50 ; Move back to the origin (50,50) and extrude 50mm of :
```

gCode File

```
; End of the print
G1 X0 Y0          ; Move the print head back to the origin
M104 S0          ; Turn off the extruder
M140 S0          ; Turn off the heated bed
M107              ; Turn off the fan
G28                ; Home all axes
M84                ; Disable motors
; End of G-code
```

Meshting

Meshing

- MeshLab
- Netfabb
- Meshmixer
- Geomagic

Slicing

Slicing

Slicer : Découper en tranche.

Logiciel pour transformer vos pièces en fichier compréhensible par l'imprimante :

- **PrusaSlicer**
- **Creality Print**
- **Bambu Studio**
- **Orcaslicer**
- Cura
- ReplicatorG
- Skeinforge
- Slic3r
- IceSL
- Kiri :Moto
- t43

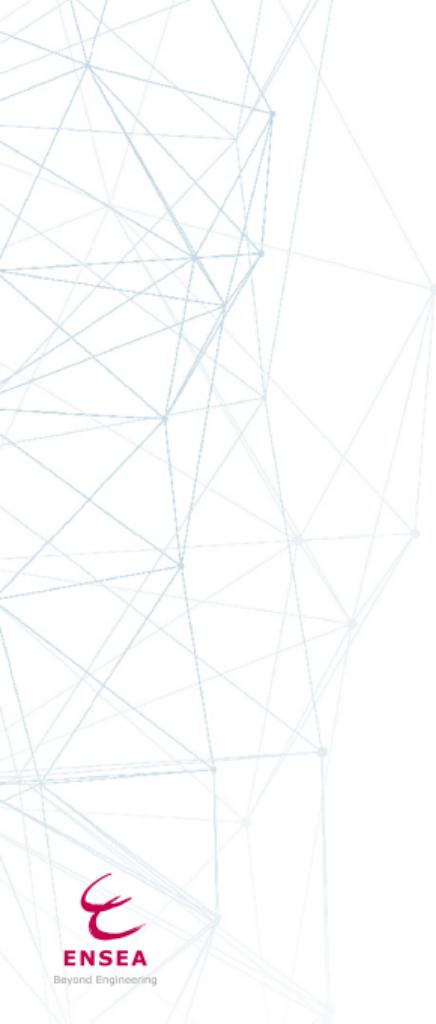
Printing

One user multiple 3D Print

- **Bambu Studio**
- **Creality Print**

3D Print Farm

- Printrun
- Repetier
- **OctoPrint**



Sharing

Partage / Vente de fichiers

- Sketchfab : <https://sketchfab.com/>
- Cults3d : <https://cults3d.com/>
- Thingiverse : <https://www.thingiverse.com/>
- **Printables** : <https://www.printables.com/>
- Modelviewer : <https://modelviewer.dev/>