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UNIVERSITÉ DE REIMS CHAMPAGNE-ARDENNE

EiSINe École d'ingénieurs en Sciences Industrielles et Numérique

ITheMM Institut de Thermique, Mécanique, Matériaux

CAD voor de productie van additieven
CAO pour la fabrication additive
CAD for additive manufacturing

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08/12/2020

Cofinanciering

met de steun van west-vlaanderen de gedreven provincie

Wallonie

AGENTSCHAP INNOVEREN & ONDERNEMEN

Projectleider

Chef de projet

CENTEXBEL

Partners

Partenaires

Université de Lille, Université de Reims Champagne-Ardenne, IMT Lille Douai (École Mines-Télécom, IMT-Université de Lille), ARMINES, Materia Nova (Materials R&D Center), KU Leuven

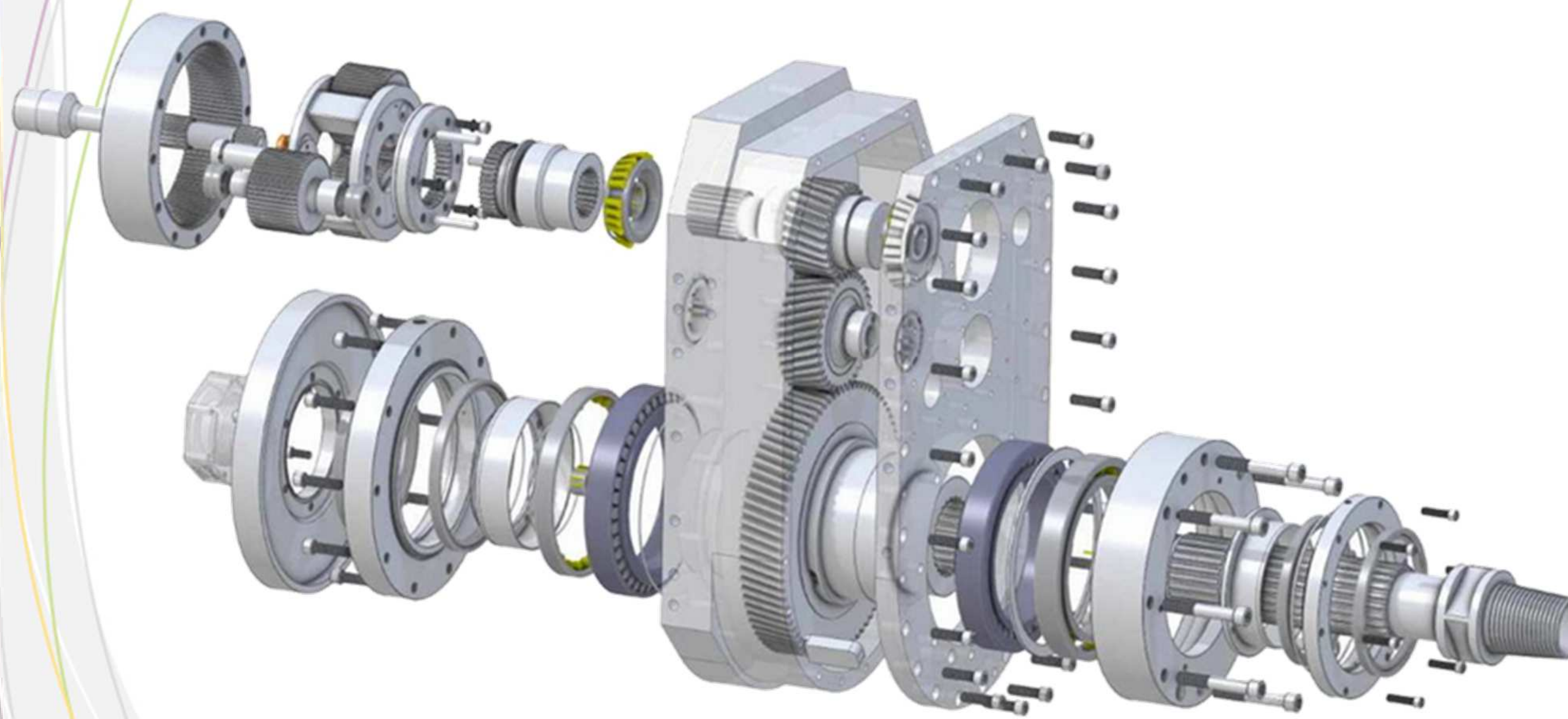
Geassocieerde partners

Partenaires associés

Plastiwin (Plastics Innovators), EuraMaterials, Materalia

CAD/CAM :

Computer Aided Design / Computer Aided Manufacturing



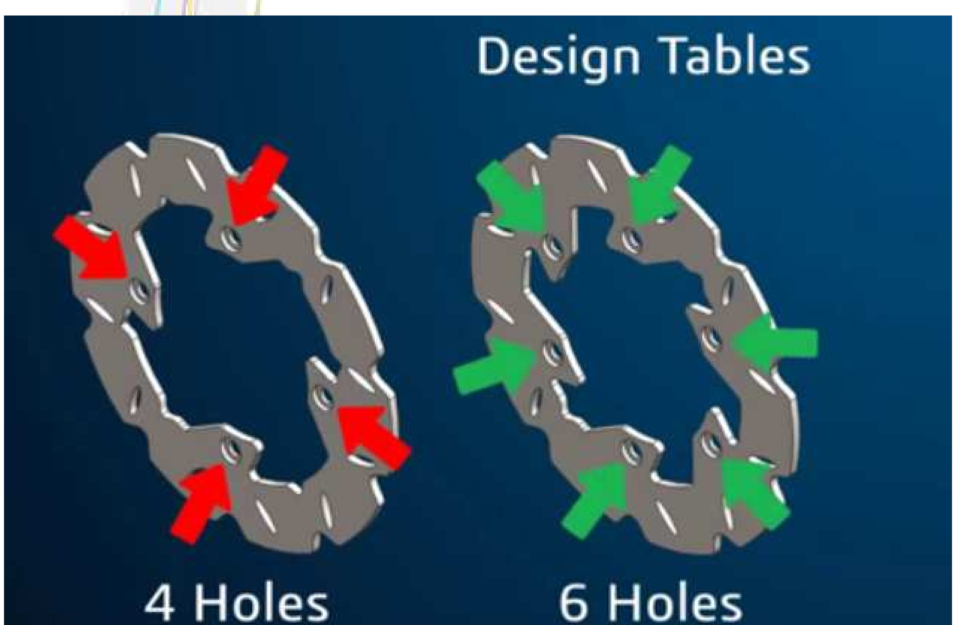
CAD/CAM : Definition :

- Computer Aided Design / Computer Aided Manufacturing
  - Use of softwares to help design and manufacture products
  - This corresponds to the birth of the part or product.

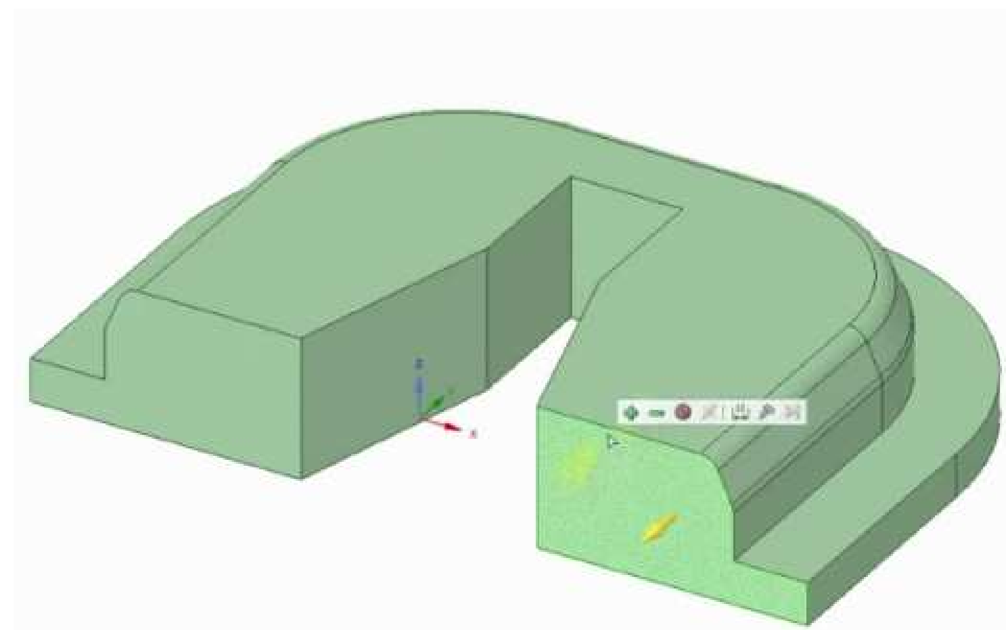
Parametric vs. Direct Modeling

- Parametric modeling
  - You capture design intent using features and constraints
  - Automate repetitive changes
  - Propagate changes to the drawing, the manufacturing process, the assembly …
  - Excellent integration with manufacturing processes
  - Volumes and surfaces

- Direct modeling
  - Quick
  - Without features and constraints
  - Geometry is king
  - Volumes and surfaces

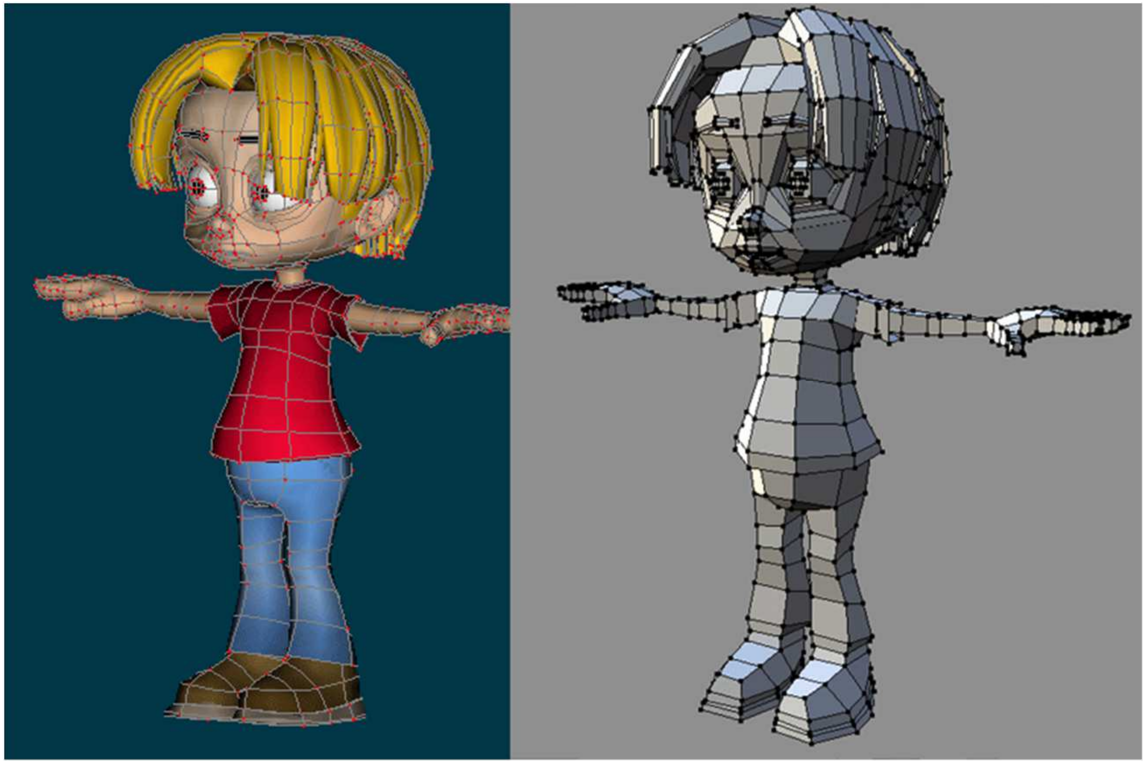


Source : https://learnsolidworks.com/solidworks_tutorials/solidworks-design-tables



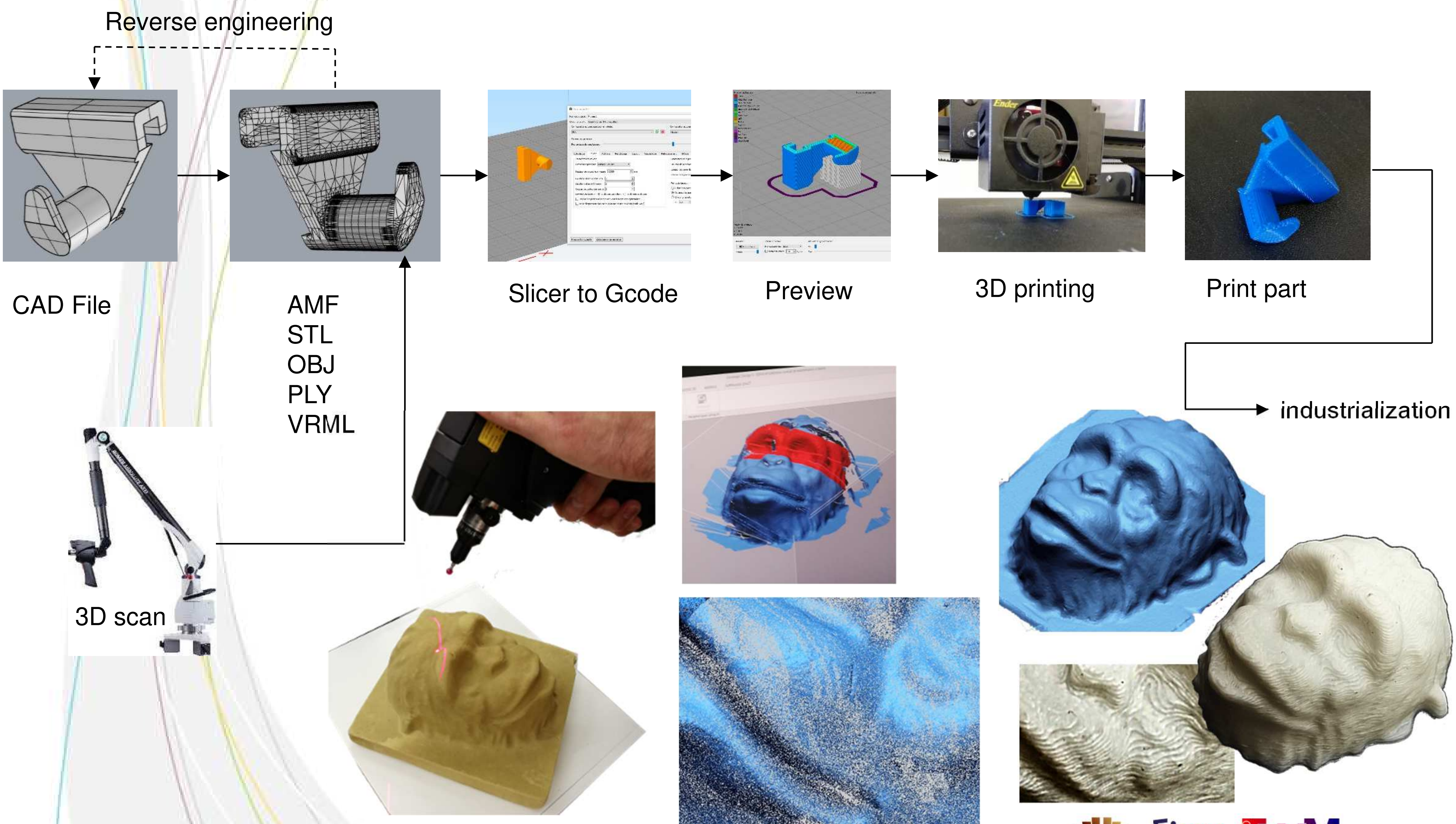
Source : https://www.youtube.com/watch?v=ctI-tMc8U7M

Polygonal modeling



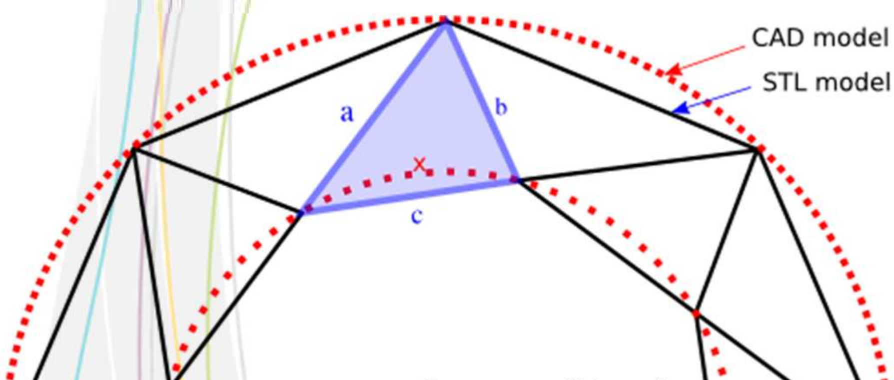
- Mesh modeling + smooth
- Sculpt meshes
- Textured meshes
- Render and animation

Usual Numerical chain for Additive Manufacturing

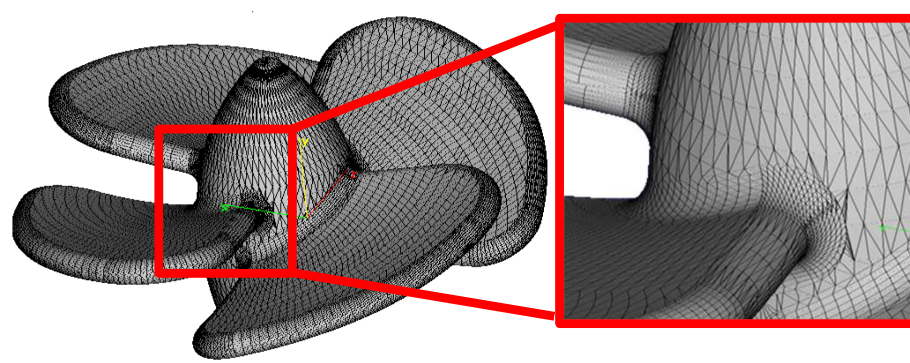


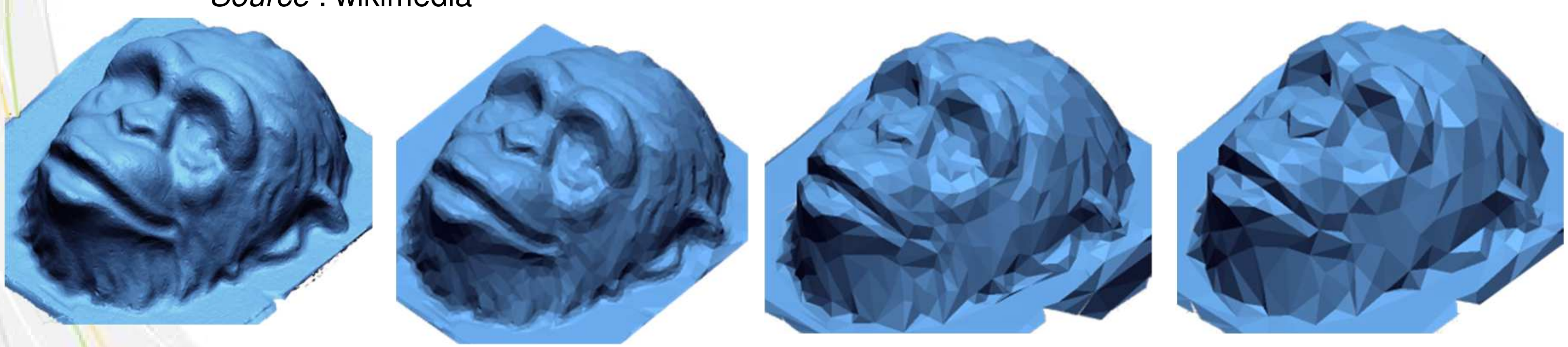
STL : A standard for additive manufacturing

- STL : Stereolithography Tessalation Language
- Meshing of the surfaces (interior & exterior) with triangles
- → Facetization characterized by the chord error
- The more triangles, the smaller the error



Source : wikimedia





Design for Additive Manufacturing (DfAM)

7 golden rules of Design for AM

#1 DfAM rule: It depends.

#2: Should you be using AM in the first place?

#3: It doesn't cost any more to make your product beautiful. Add useful details, logos, part numbers, etc.

#4: Always design with print orientation in mind.

#5: Design to avoid support material.

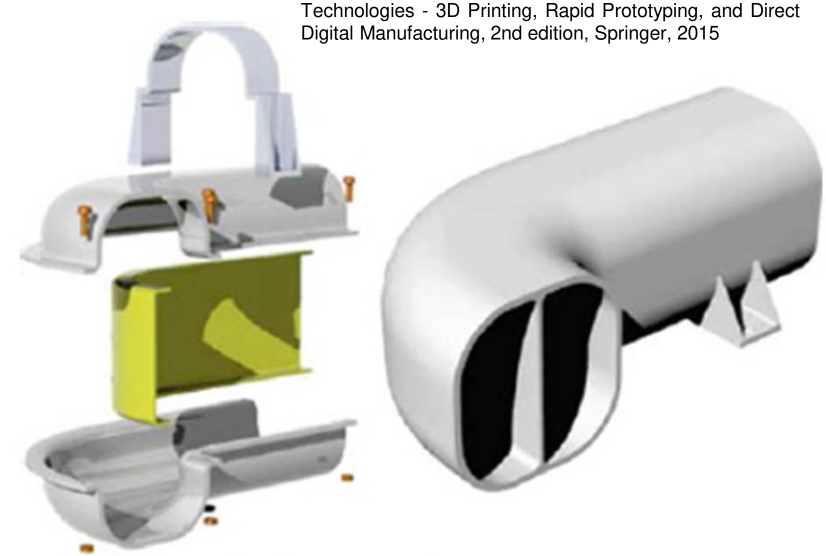
#6: Avoid large masses of material. They cost a lot, cause residual stress and add little engineering value.

#7: Fillet everything. Sharp corners cause stress concentrations, which increases the need for support.

Source : O. Diegel et al., "Teaching Design for Additive Manufacturing Through Problem-Based Learning", in E. Pei, M. Monzón et A. Bernard (Eds.), *Additive Manufacturing – Developments in Training and Education*, Springer, 2018, pp. 139-148, ISBN 978-3-319-76084-1.

- DfAM allows for instance to reduce the number of parts (replace an assembly by a single "printed" part)

Sources : I. Gibson, D. Rosen et B. Stucker, Additive Manufacturing Technologies - 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, 2nd edition, Springer, 2015



a original design with 16 parts **b** consolidated design

Aircraft duct example

DfAM : An opportunity to lighten structures

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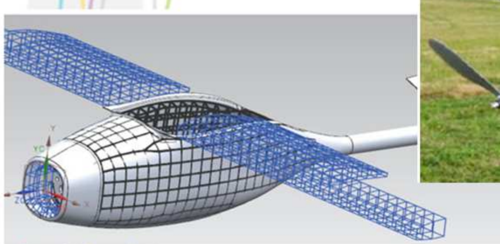
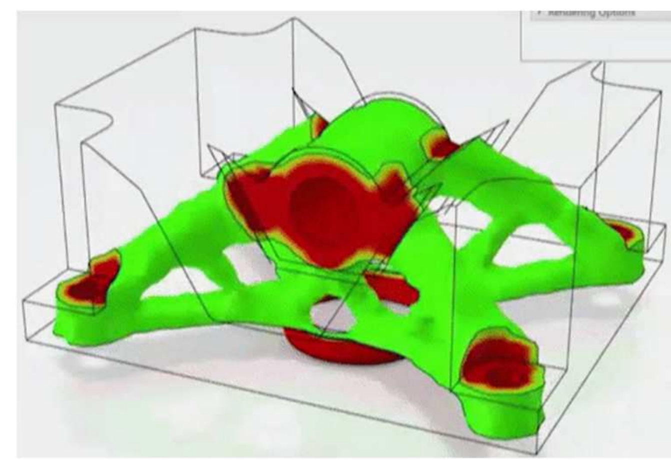
- Use of lattices structures:
  - Inspired by biological structures (such as bones)
  - Lightening + specific functions (osteointegration)



Sources : http://medcell.med.yale.edu/systems_cell_biology/bone_lab.php
I. Gibson, D. Rosen et B. Stucker, Additive Manufacturing Technologies - 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, 2nd edition, Springer, 2015
L.E. Murr *et al.*, *Journal of Biotechnology and Biomaterial*, vol. 2, 2012

- Topology optimization:
  - Put the material only where it is needed for functional (mechanical) reasons
  - Combines CAD + FEM + optimization algorithms

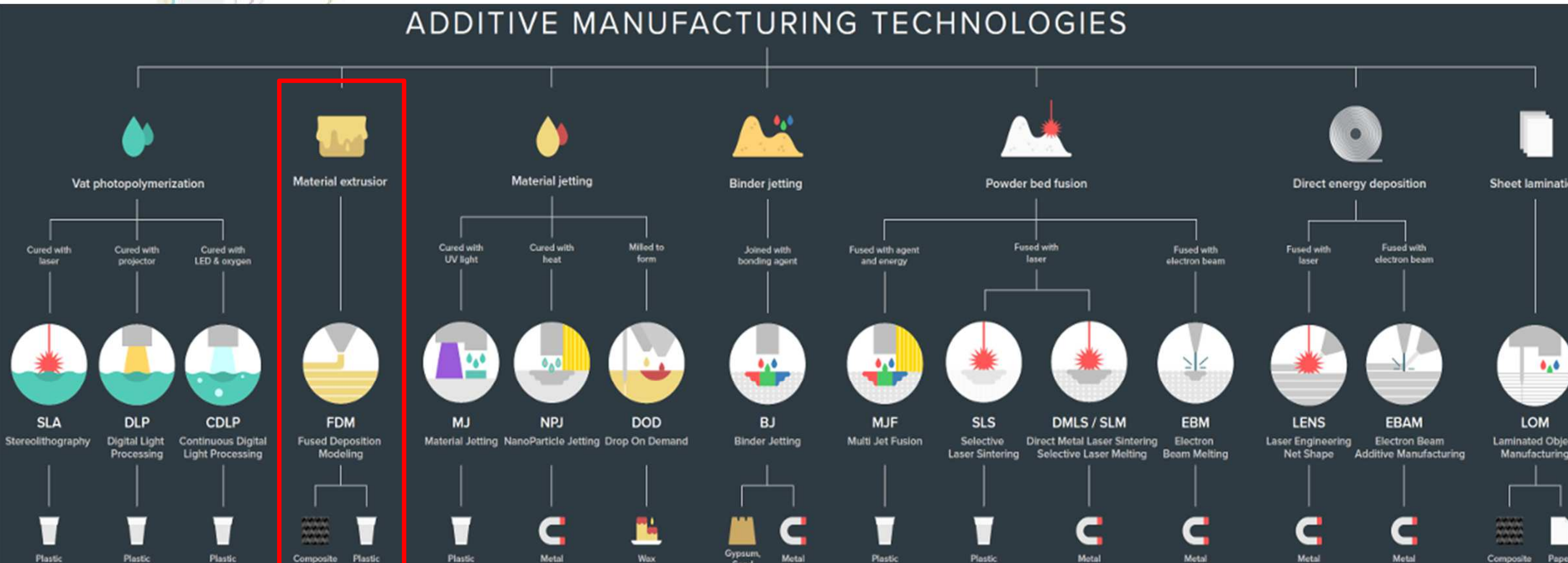


Source : 3D Experience, Dassault systems

- The two can be combined :

Source : Materialise

Classification of Additive Manufacturing Technologies



Source : 3DHubs

GoToS3 Catalyseur d'innovation Katalysator van innovatie

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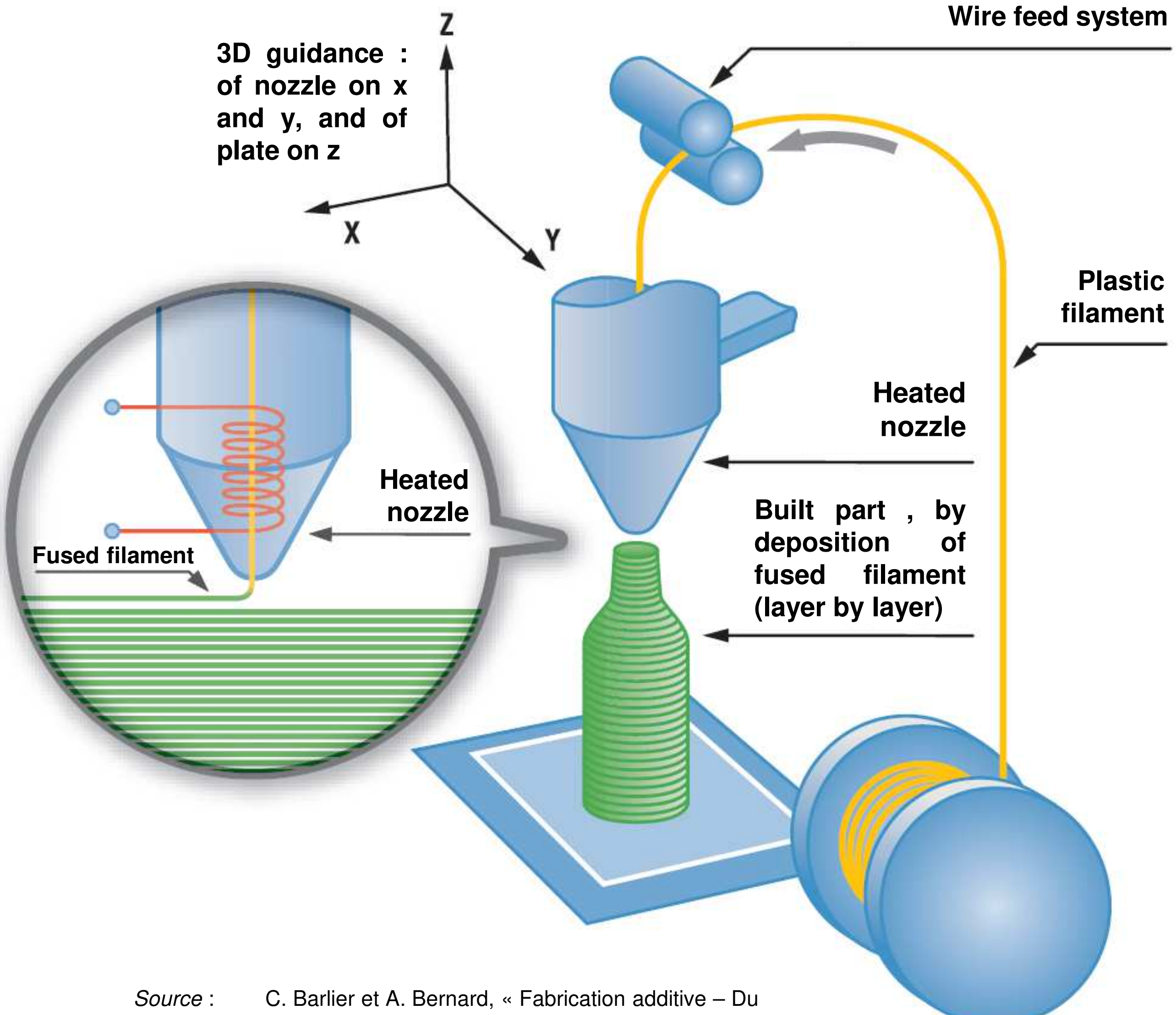
F.D.M.® : Fused Deposited Modeling® or F.F.F. : Fused Filament Fabrication

- Principle :

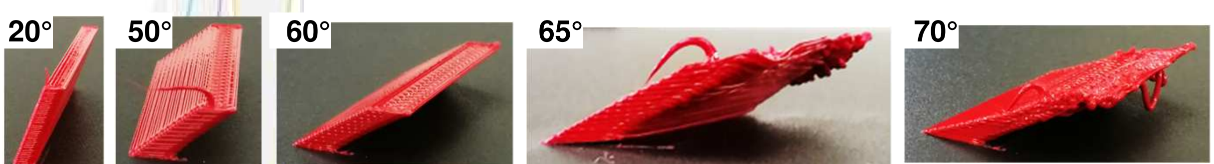


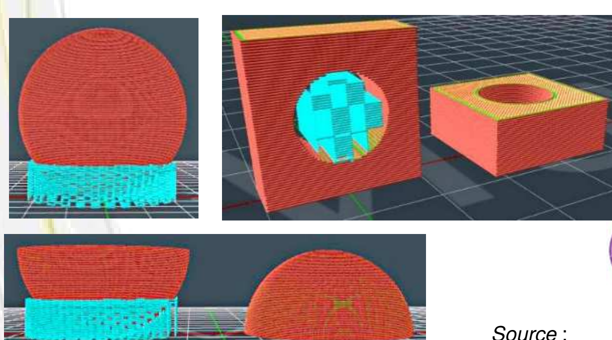
Source : C. Barlier et A. Bernard, « Fabrication additive – Du prototypage rapide à l'impression 3D », Dunod, 2016

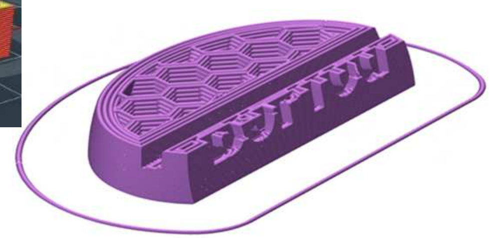
Université de Reims Champagne-Ardenne EiSINe ITheMM

F.D.M.® : Fused Deposited Modeling® or F.F.F. : Fused Filament Fabrication

- IMPORTANT PARAMETERS ON MECHANICAL PROPERTIES
  1. Orientation (anistropic)
  2. Layer thickness + nozzle size
  3. Temperature
  4. Perimeter count (shell)
  5. Infill parameters







Source : https://www.formation-3d-france.com/les-logiciels-tranchage-3d/

- DESIGN RULES
  - Nozzle size : 0,4mm
  - Material : Flexifil (formfutura)
  - T°C : 250°C, Bed : 110°C + buildtak
  - 3D Printer : Raise N2+

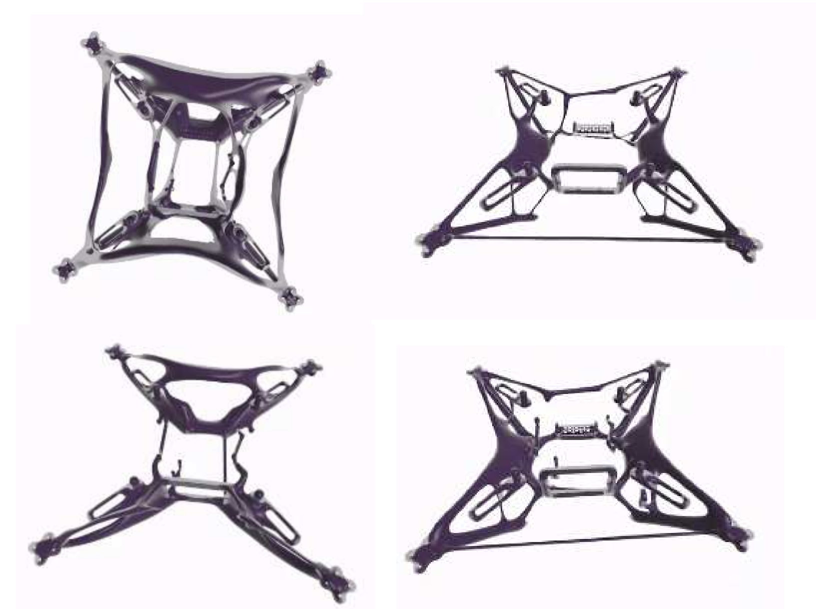
  - Print test :

    1. Bridging (find distance)
    2. Overhangs
    3. Vertical pins
    4. Wall Thickness

  - Dimensional Accuracy
  - splitting up the model (no support)
  - Hole orientation
  - filling (cost)

More tips and tricks :
https://www.materialise.com/en/manufacturing/materials/abs/design-guidelines
https://www.3dhubs.com/knowledge-base/how-design-parts-fdm-3d-printing/

Tomorrow… GENERATIVE DESIGN



Source : Autodesk

- It's a design exploration process
- Inputs data :
  - goal,
  - performance,
  - materials,
  - manufacturing methods,
  - cost constraints…
- Output :
  - software explores all possible permutations of a solution
  - Design alternatives
  - Software learns from each iteration (what works / what doesn't)

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