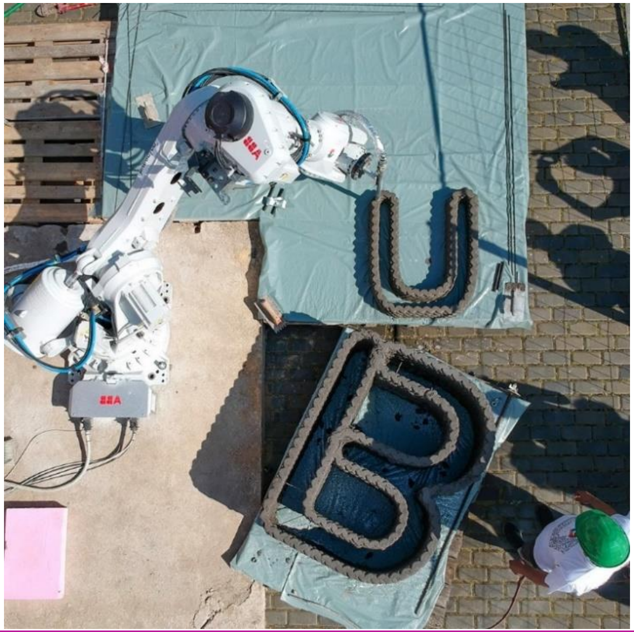
ADDBasiscs course 2022

Technical and Business Opportunities with 3D Printing

Prof. Jouni Partanen
Aalto University



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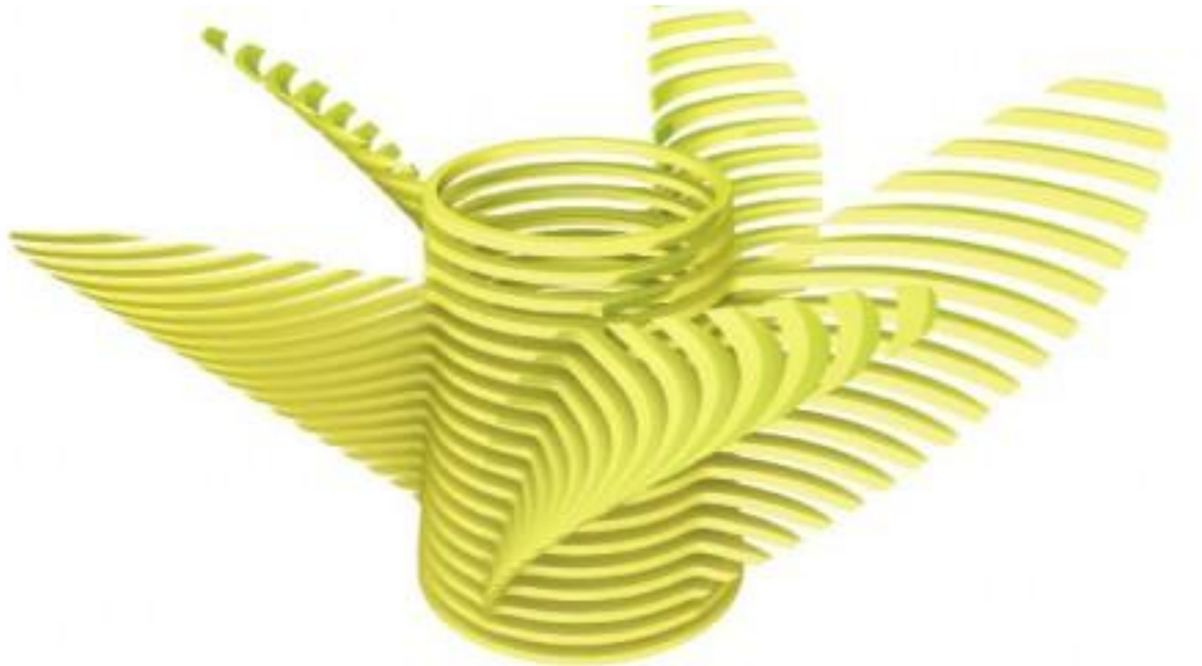
3D-Printing – objects are made out of slices

- Stacking up 2D images you can make 3D objects
- Conceptually simple process – great for automation



https://www.3dsystems.com/

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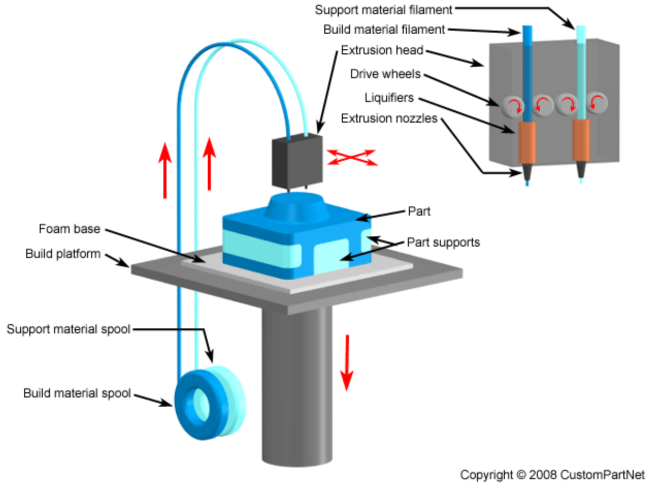
Process Classes in Addive Manufacturing

ASTM-approved AM process terms

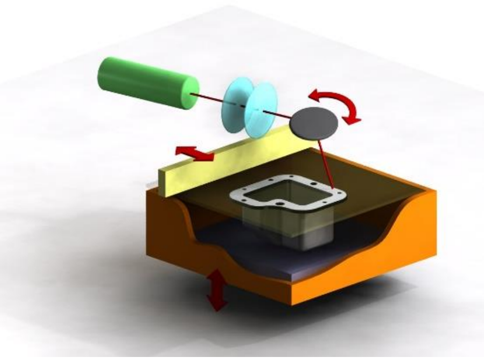
- Vat Photopolymerization
- Powder Bed Fusion
- Material Extrusion

- Material Jetting
- Binder Jetting
- Sheet Lamination
- Directed Energy Deposition

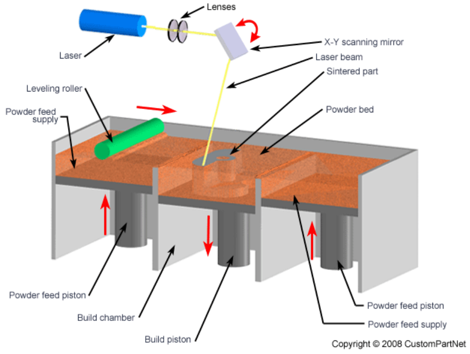
Material Extrusion



Vat Photopolymerization



Powder Bed Fusion



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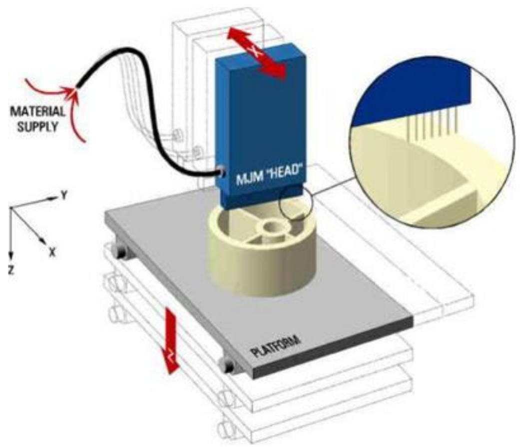
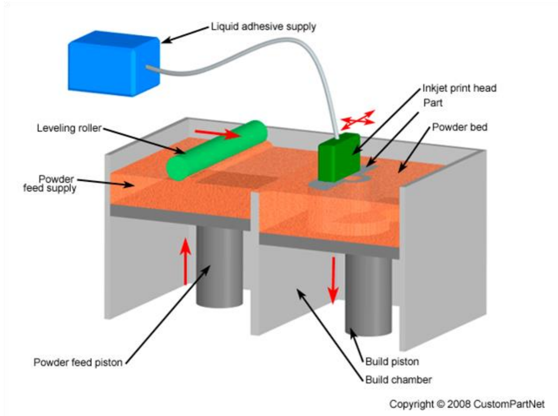
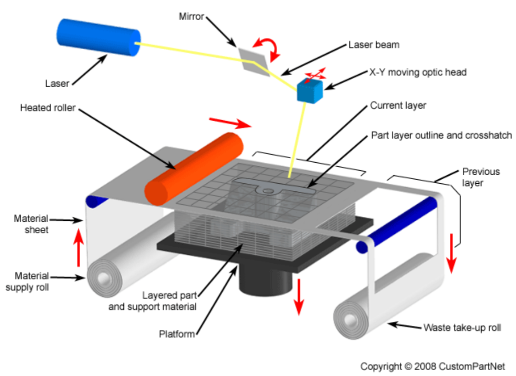
Material Jetting



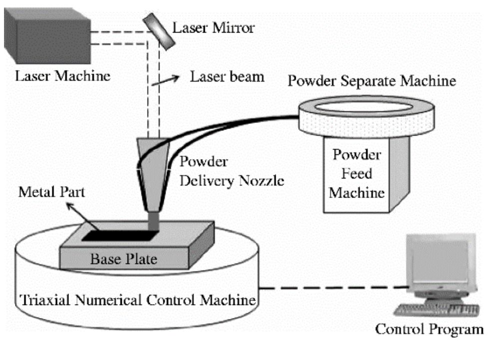
Binder Jetting



Sheet Lamination



Directed Energy Depositon



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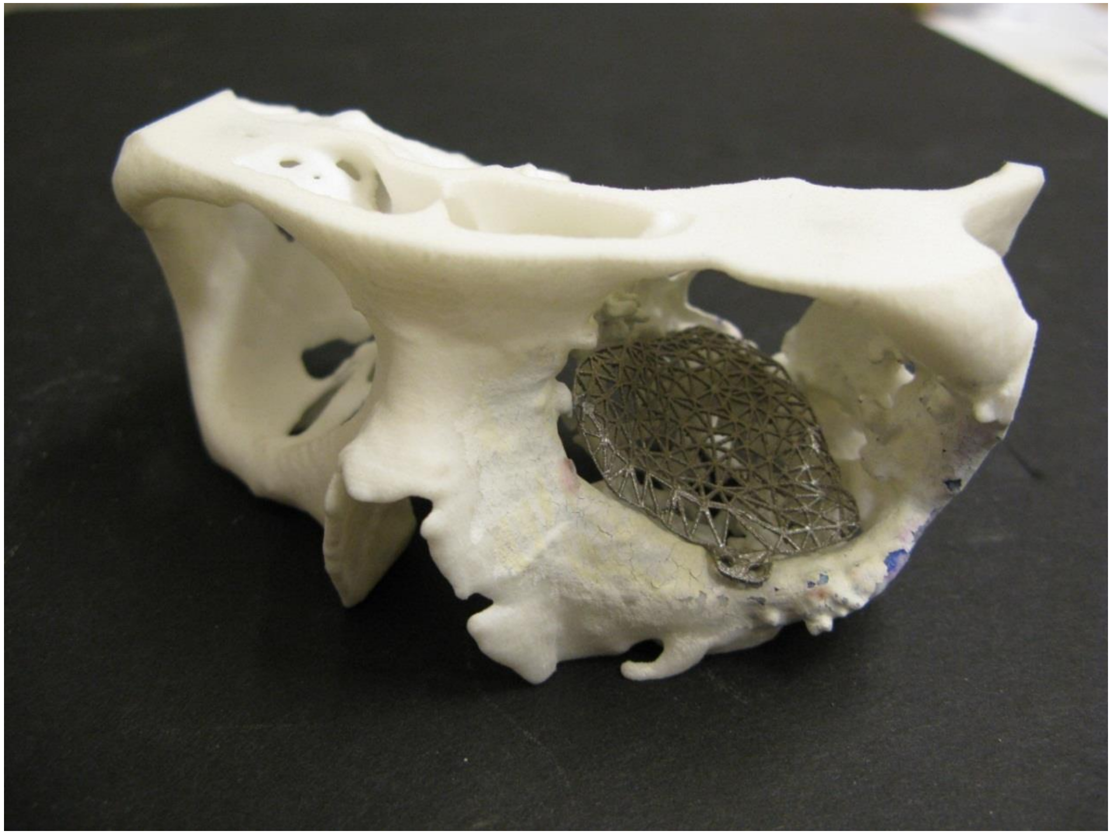
Medical Applications

- Pre-surgical planning
- Inert Implants



Salmi M et al., ”Patient specific reconstruction with 3D modeling and DMLS additive manufacturing.” *Rapid Prototyping Journal,* 18:209-214, 2012.

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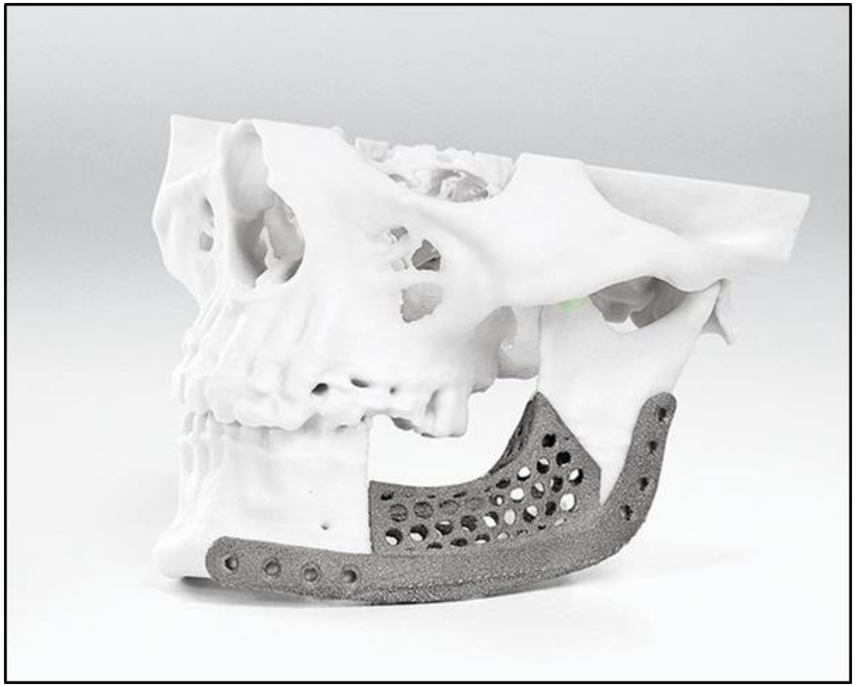
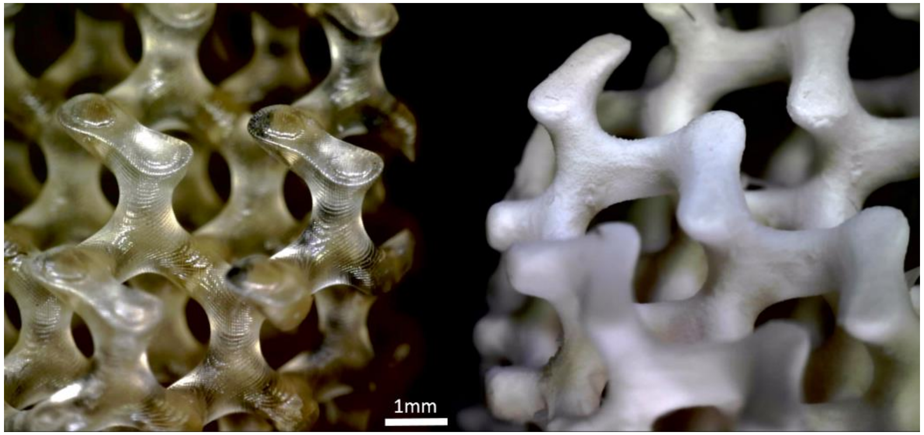
Biocomptible 3D Printed materials for implants





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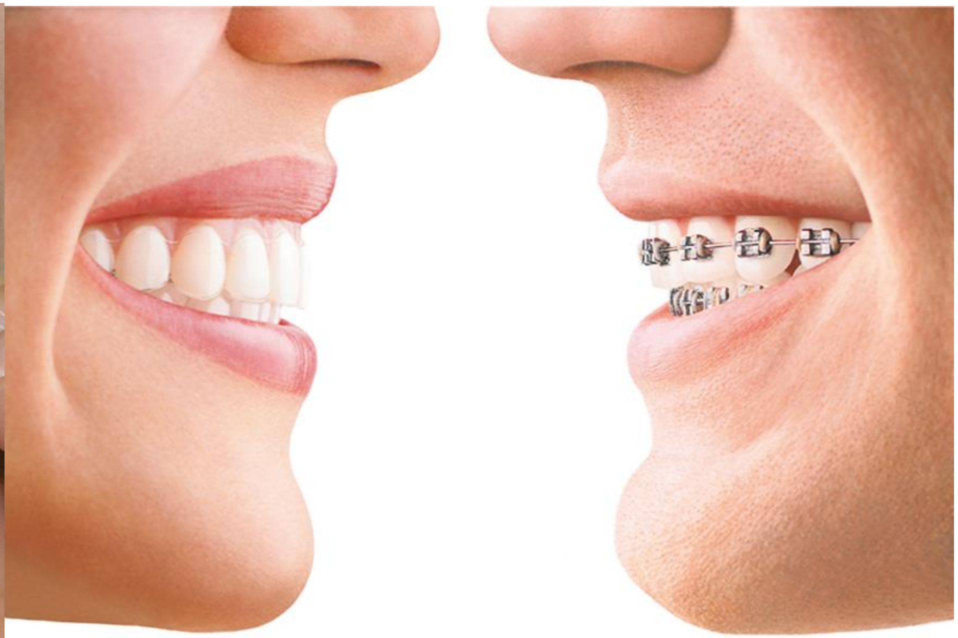
Dentistry Applications

- Invisible teeth aligners



https://www.invisalign.fi/

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3DKera project

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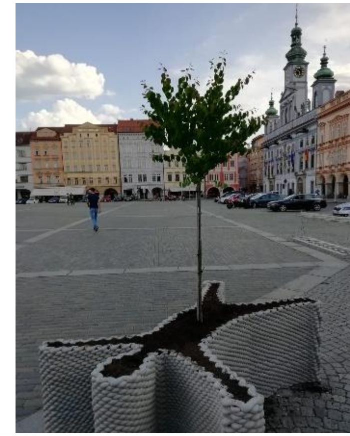
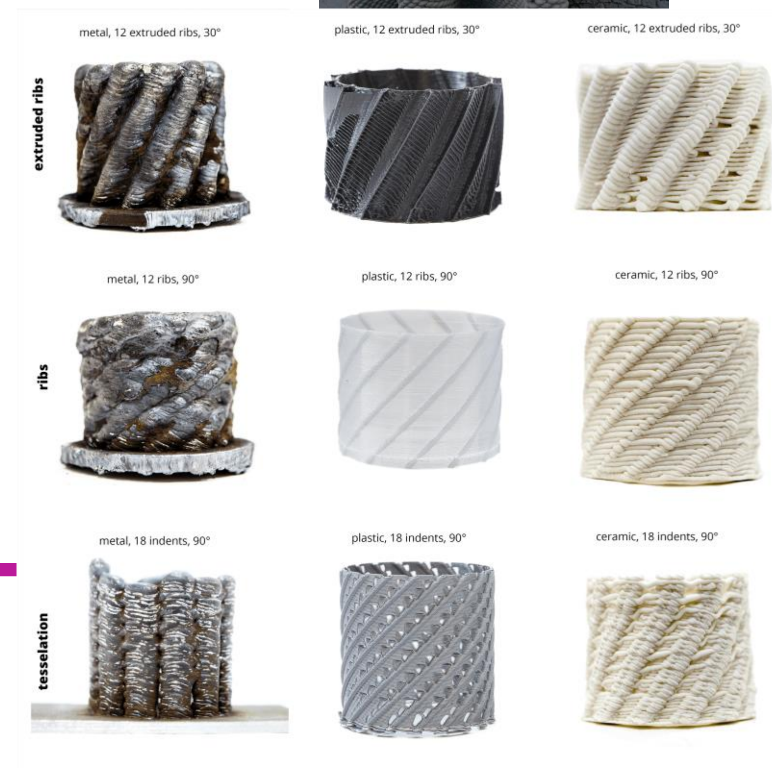
Concrete 3D Printing at Aalto University





Courtesy by Ashish Mohite: Design research and post doc in ADD Lab

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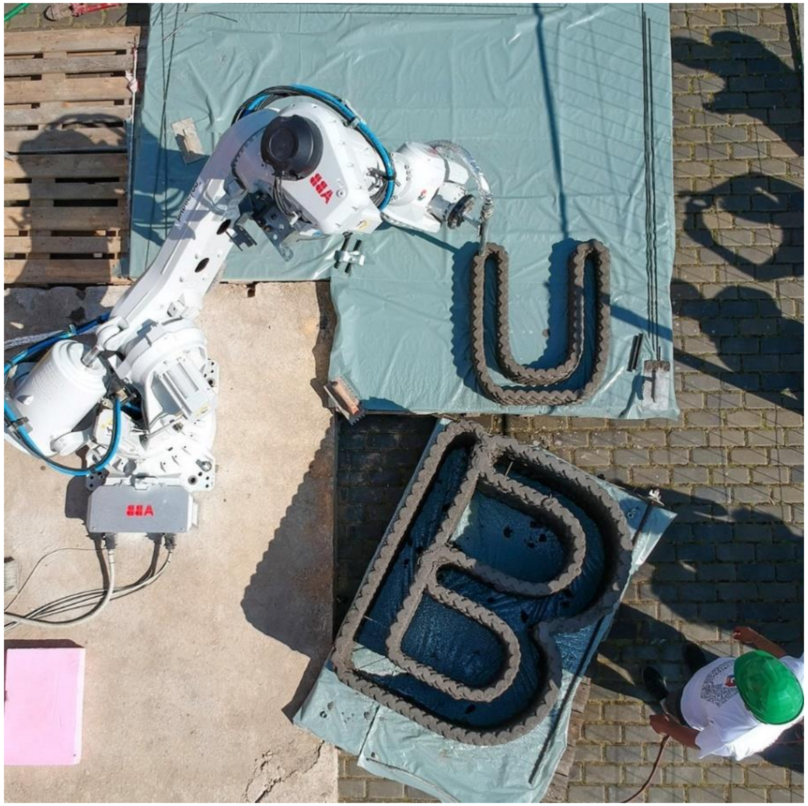
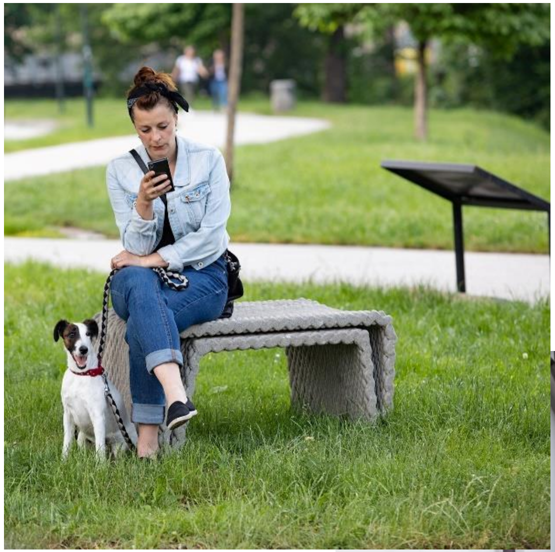
Concrete 3D Printing at Aalto University

- Post Doc Ashish Mohite
- Hyperion Robotics – hyperionrobotics.com





https://www.hyperionrobotics.com/

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Topology optimization

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What are Digital Spare Parts?

- 3D model and production information are stored Digitally
- “Digital Warehouse”
- Manufacturing only when needed – for example by 3D Printing
- Manufacturing close to customer

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Why Digital Spare Parts?

- Reduced Inventory and Cost
- Faster Service and Less Down Time

Potential:

- Smart Digital Spare Parts
  - Product Identification – Digital Twin
  - Wear Monitoring
- Product Upgrades

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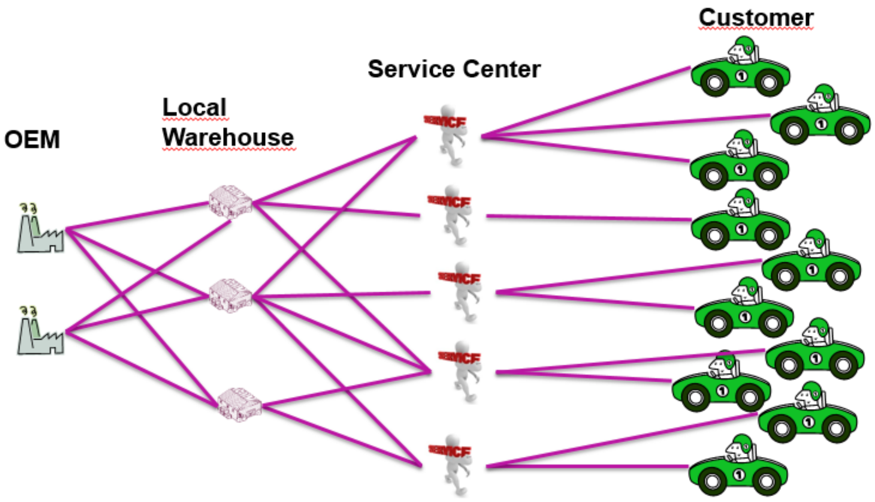
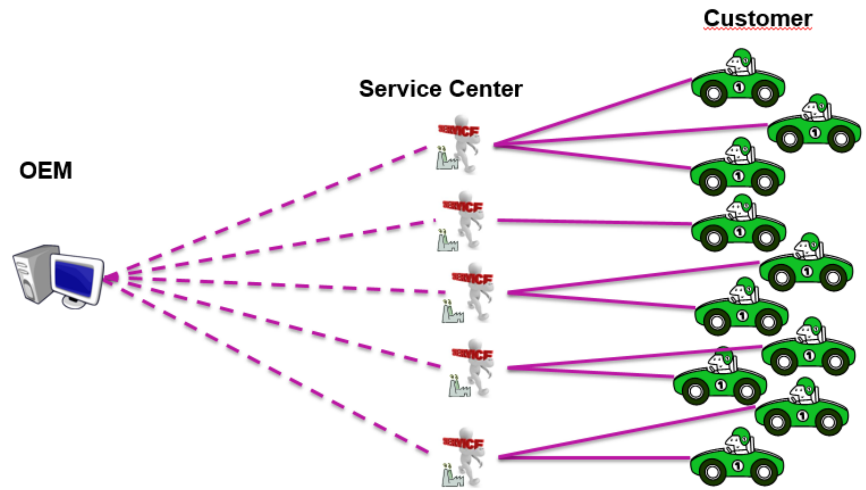
Digital Spare Parts Logistics

Conventional Parts Logistics



Digital Spare Parts



Jan Holmström, Jouni Partanen, Jukka Tuomi, Manfred Walter, "Rapid manufacturing in the spare parts supply chain," Journal of Manufacturing Technology Management, vol. 21, pp. 687 – 697 (2010).

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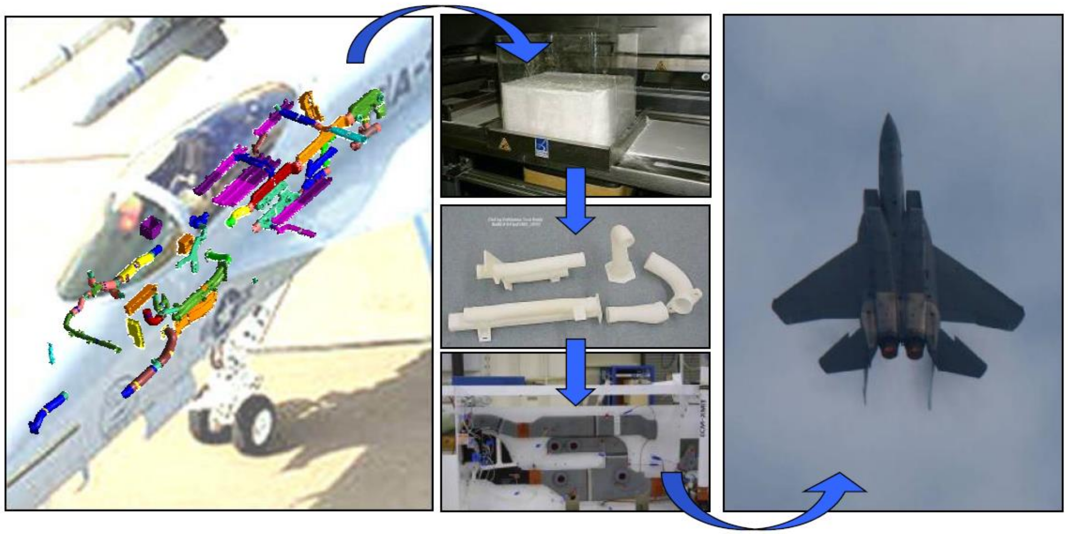
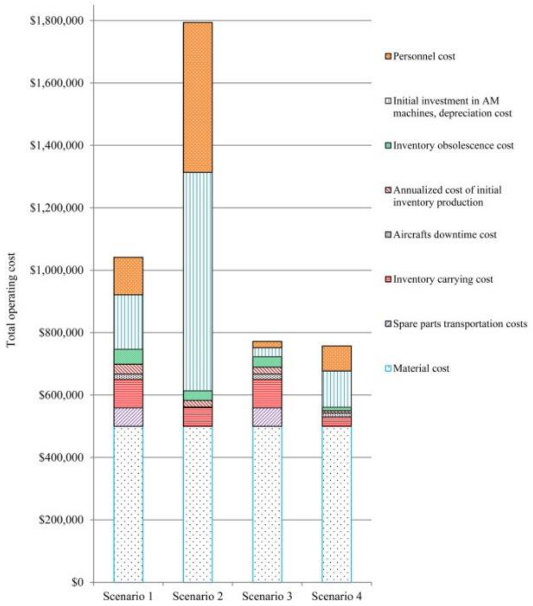
Digital Spare Parts Logistics Modelling

The Boeing company has been utilizing SLS for flight hardware in regular production since 2002, for both military[2] and commercial[3] programs





Siavash Khajavi, Jouni Partanen, Jan Holmström, “Additive Manufacturing in the Spare Parts Supply Chain”, Computers in Industry, vol. 65, pp. 50-63 (2014).

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Digital Spare Parts Project (DIVA) 2016 =>

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ABB
Power and productivity for a better world™

AM FINLAND

GRANO multi+print

HETITEC 3D-Printing

KONE

LASERLE

Patria

materflow

RAUTE

ROLLS ROYCE Rolls-Royce

SACOTEC COMPONENTS

The Federation of Finnish Technology Industries

VTT

WÄRTSILÄ

3DTECH

Tekes

BUSINESS FINLAND

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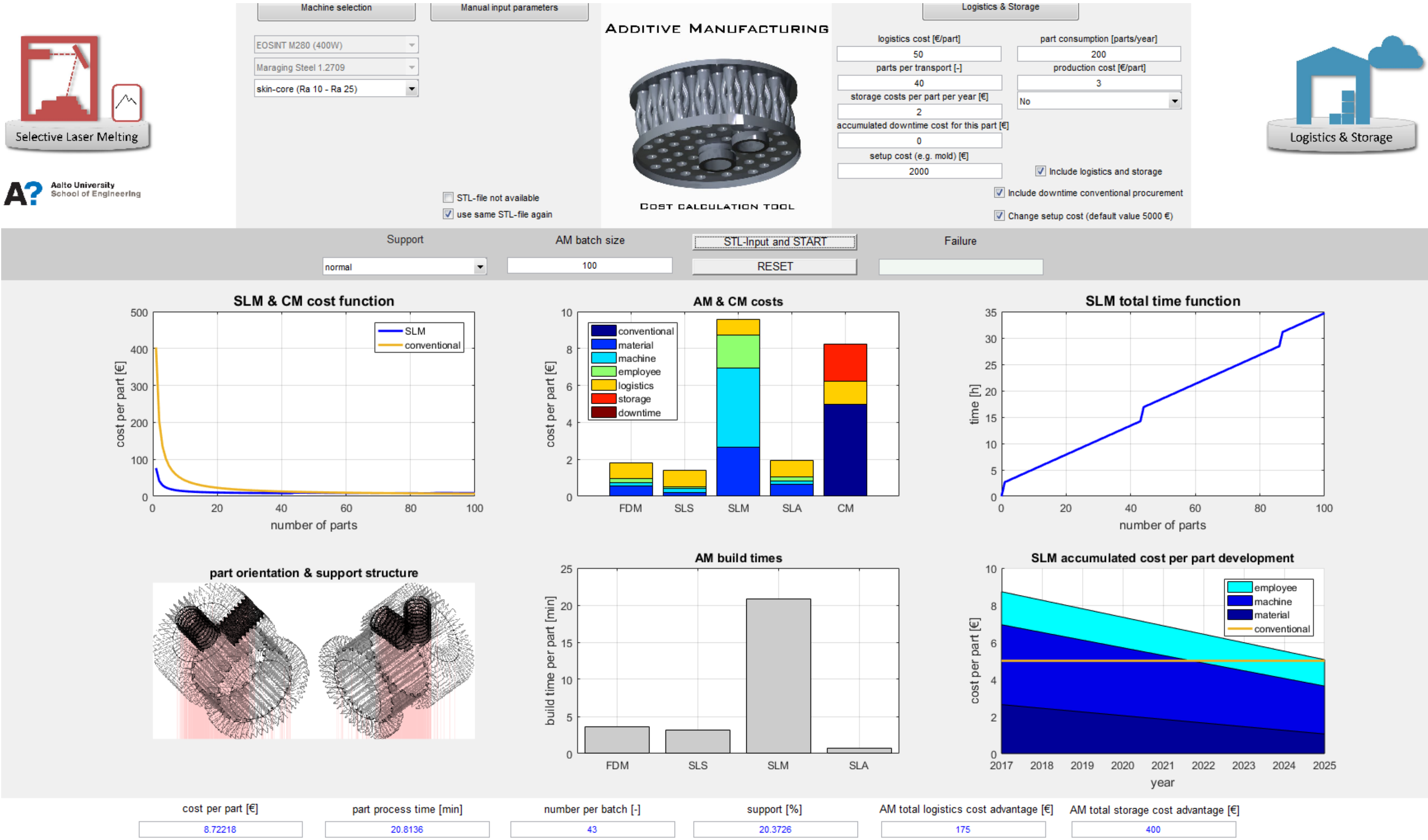
Cost Analysis for 3D Printed Parts



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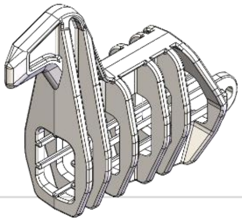
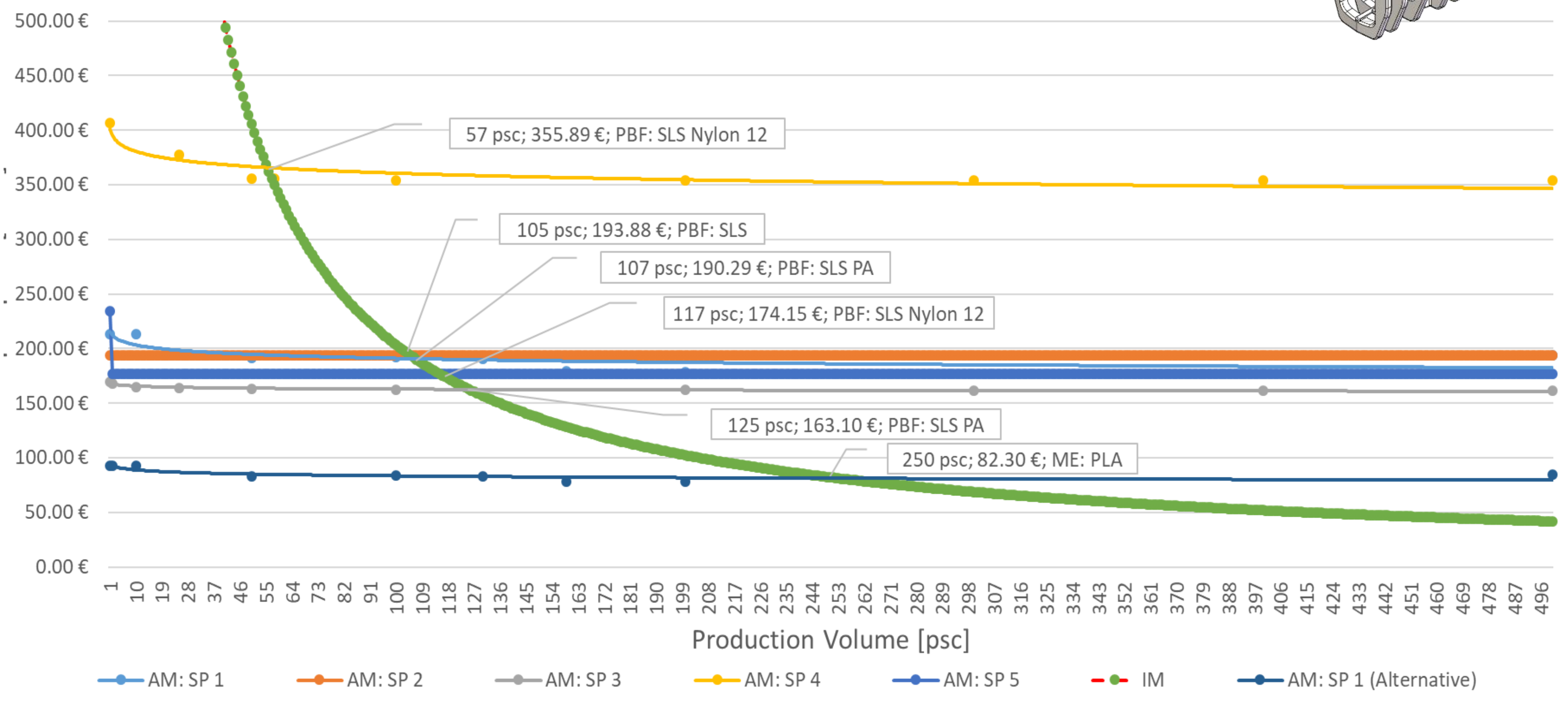
Break Even for 3D Printing vs. Conventional Production





- Post Doc Niklas Kretzschmar
- SelectAM – selectam.io

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https://selectam.io/

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Digital Spare Parts - Issues

- Manufacturing Cost
- Quality
  - Warranty, Liability
  - Intellectual Property Protection
- Availability of 3D model and manuf. data
  - Reverse engineering
  - 3D scanning
  - 3D modelling
- Business Models

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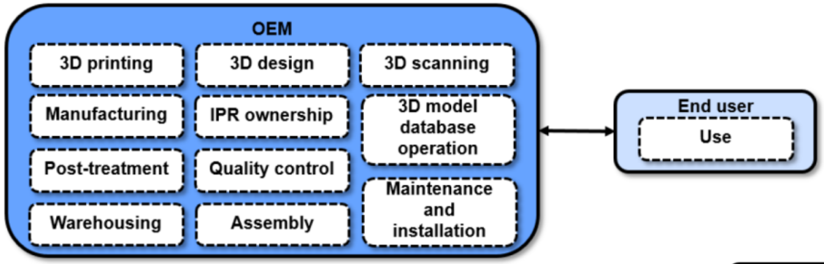
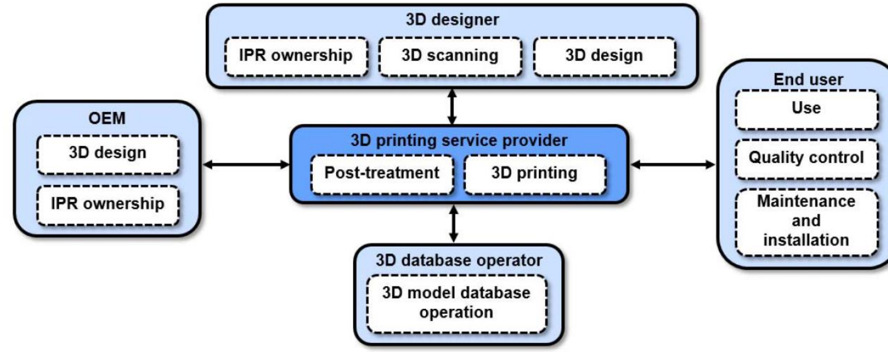
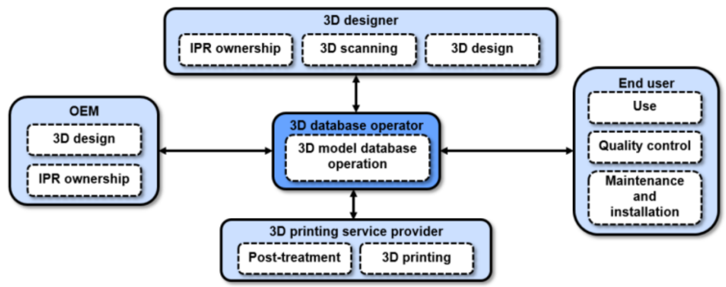
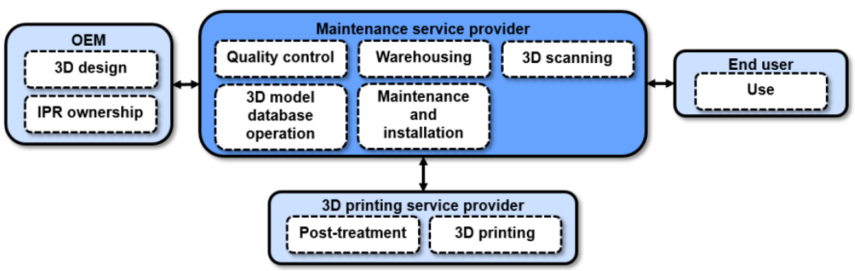
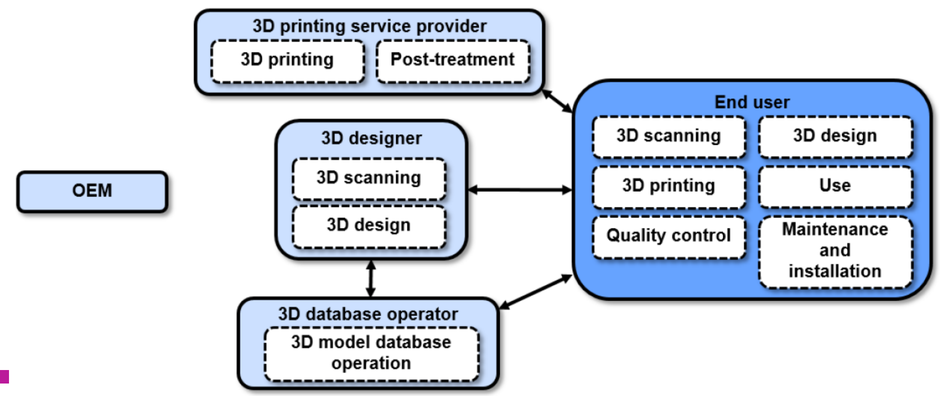
Business Networks











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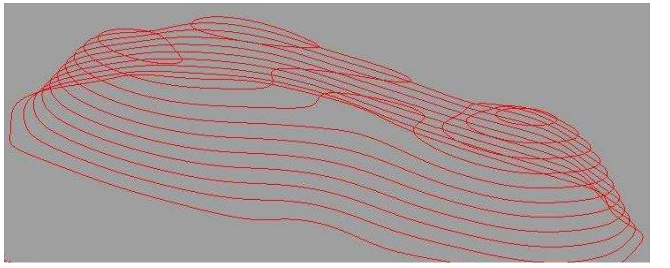
DDShape

1. **DESIGN:**

   Contour Curves



2. **PRODUCTION TECHNOLOGY:**

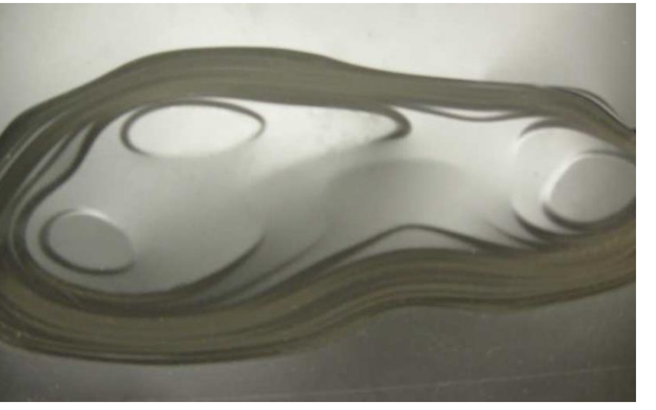
   Thermoplastic material

   Fast => Final Parts in couple of minutes

   Heating by laser beam

   Forming by air pressure

   No mold needed



(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 317 079 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
01.05.2019 Bulletin 2019/18

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(22) Date of filing: **28.06.2016**

(51) Int Cl.:
B29C 51/10 *(2006.01)*

(86) International application
PCT/FI2016/050469

(87) International publication
WO 2017/001726 (05.0

(72) Inventors:
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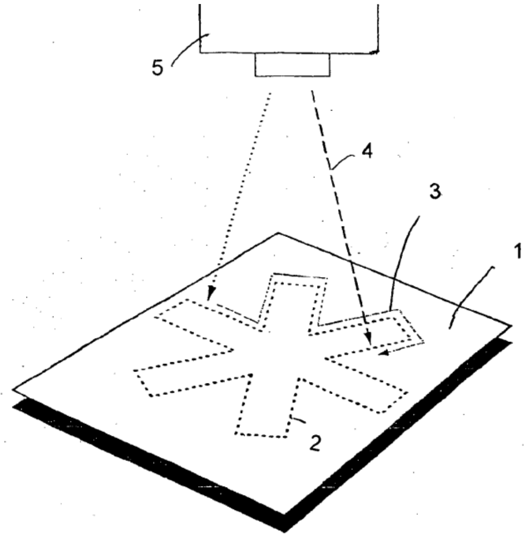
- **SEPÄNMAA, Arto**
  51740 Huuhanaho (FI)
- **PARTANEN, Jouni**
  02100 Espoo (FI)

(54) **METHOD FOR SHAPING A FILM-LIKE/SHEET-LIKE MATERIAL**

VERFAHREN ZUR FORMUNG EINES FILMARTIGEN/FOLIENARTIGEN MATERIALS



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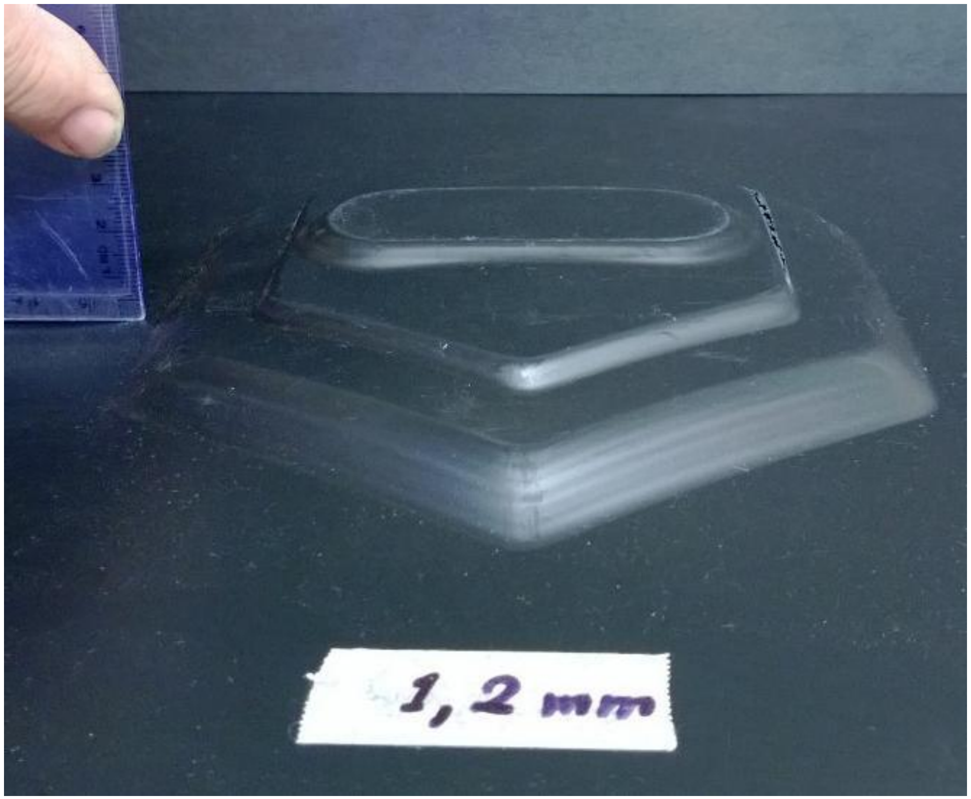
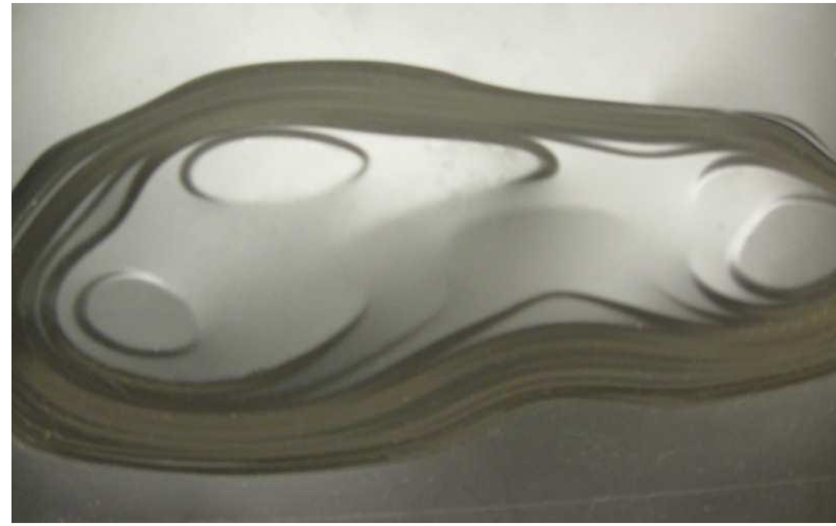
DDShape: State-of-art in 2015





https://www.finder.fi/Tukkuliike/3S-Products+Oy/Huuhanaho/yhteystiedot/2823075

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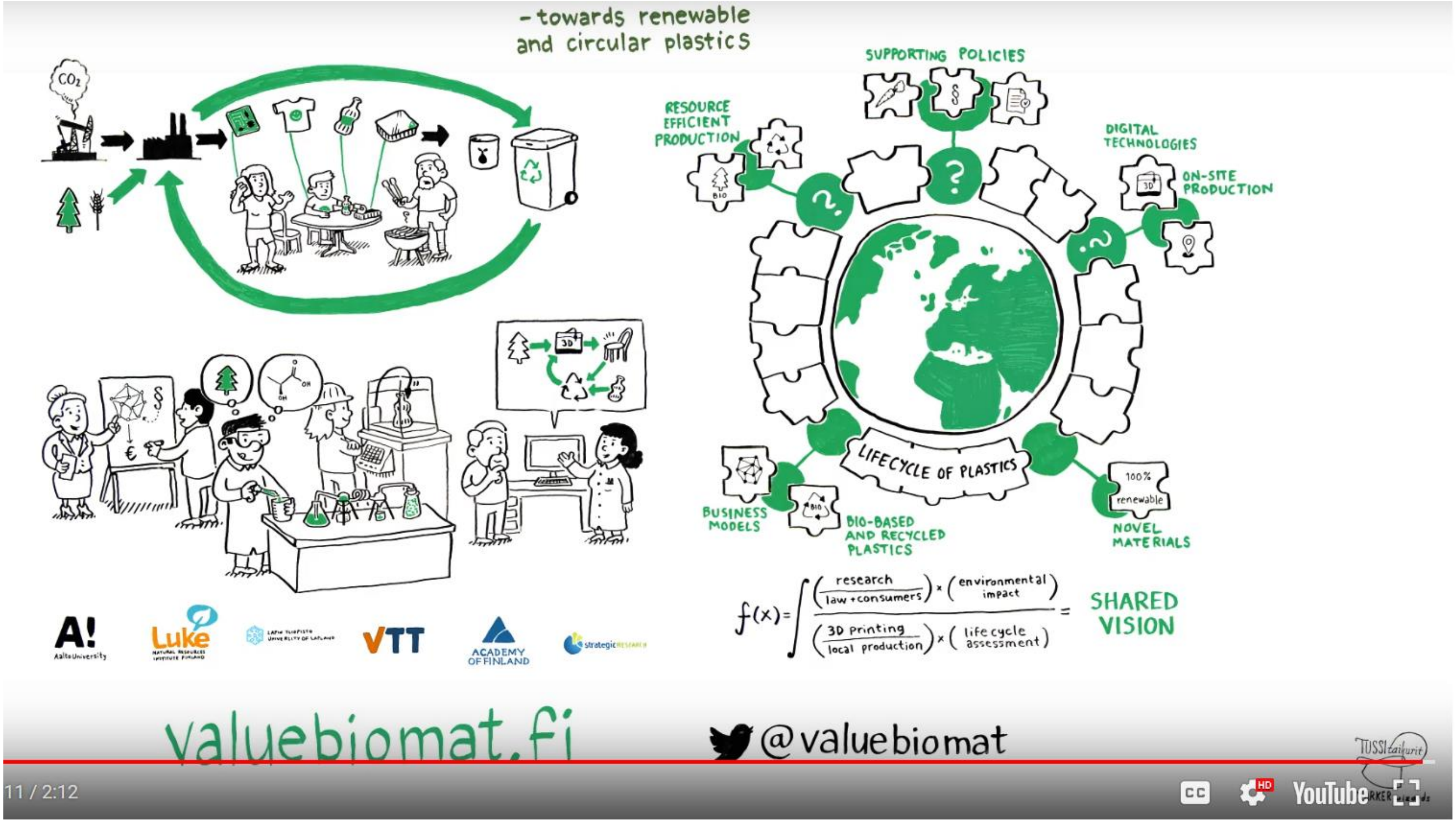

https://valuebiomat.fi/

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Selective Laser Sintering of Lignin-Based Composites

Rubina Ajdary, Niklas Kretzschmar, Hossein Baniasadi, Jon Trifol, Jukka V. Seppälä, Jouni Partanen, and Orlando J. Rojas*

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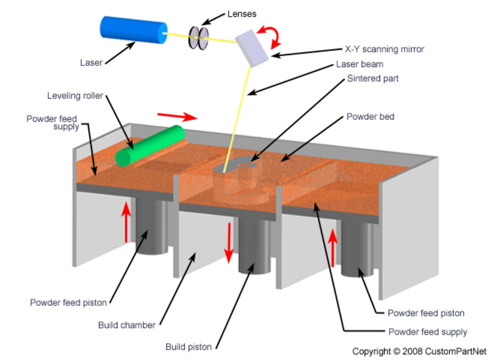

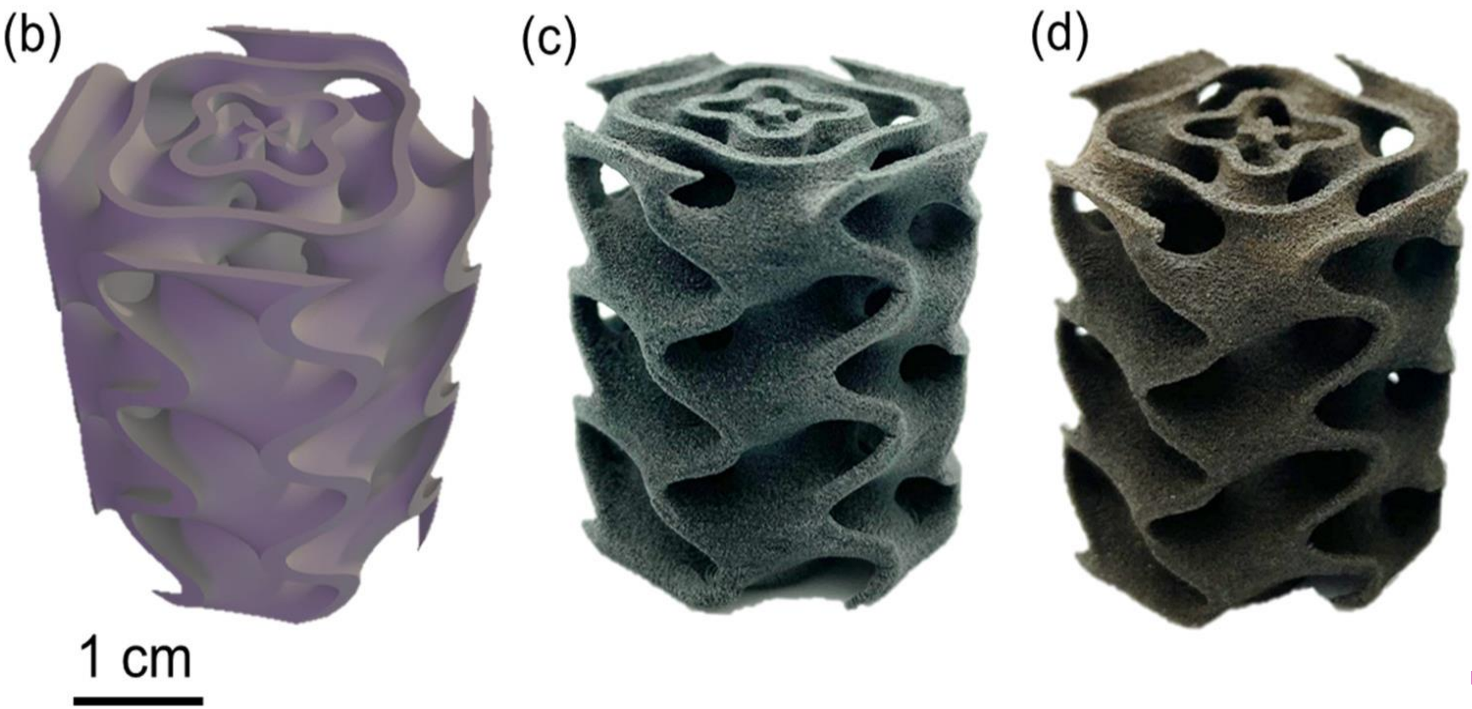

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3D-Printed Thermoset Biocomposites Based on Forest Residues by Delayed Extrusion of Cold Masterbatch (DECMA)

Jon Trifol,[⊥] Siddharth Jayaprakash,[⊥] Hossein Baniasadi, Rubina Ajdary, Niklas Kretzschmar, Orlando J. Rojas, Jouni Partanen, and Jukka V. Seppälä*

Cite This: *ACS Sustainable Chem. Eng.* 2021, 9, 13979–13987

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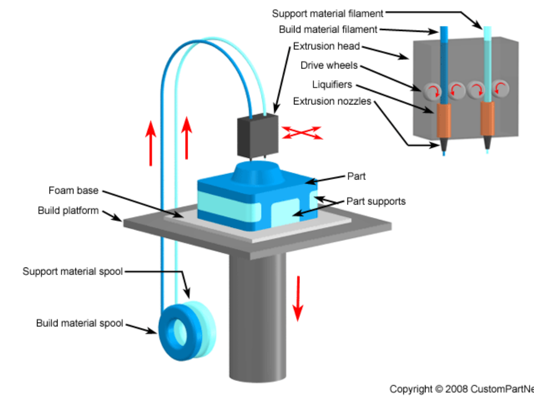

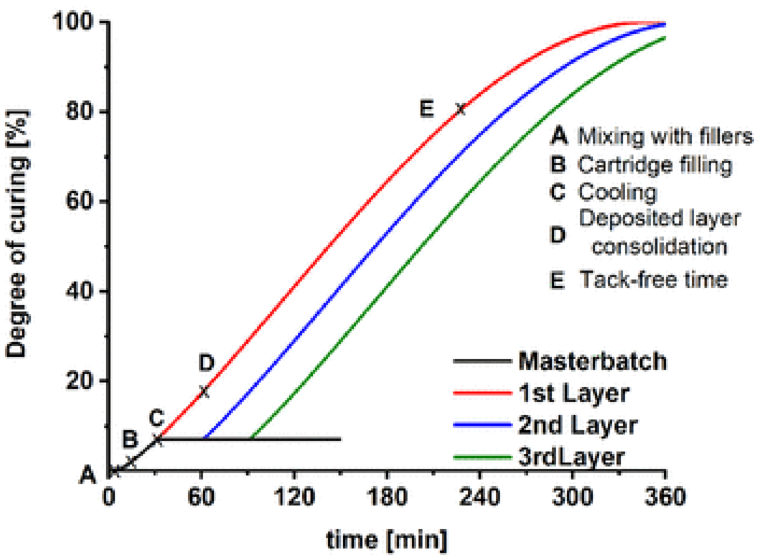

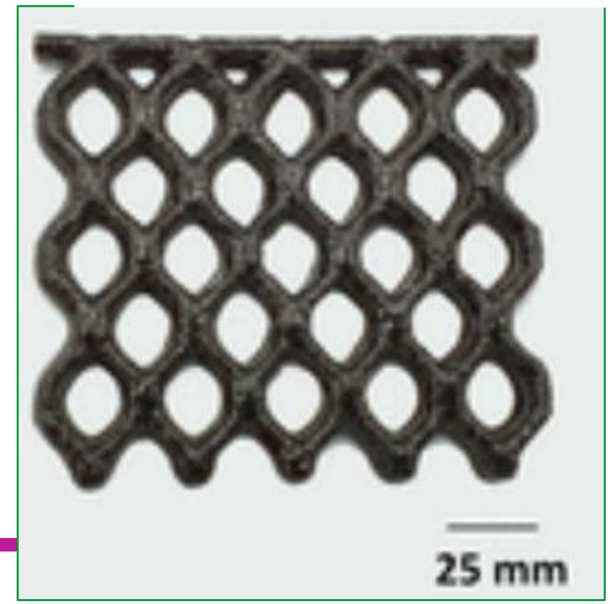

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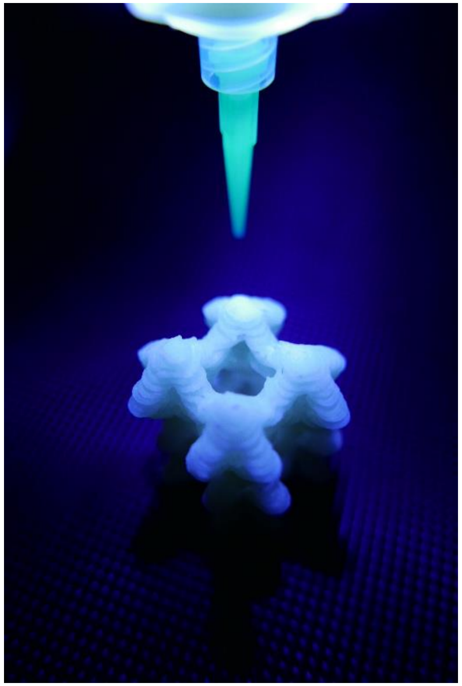
UV-assisted paste extrusion: Design & future step

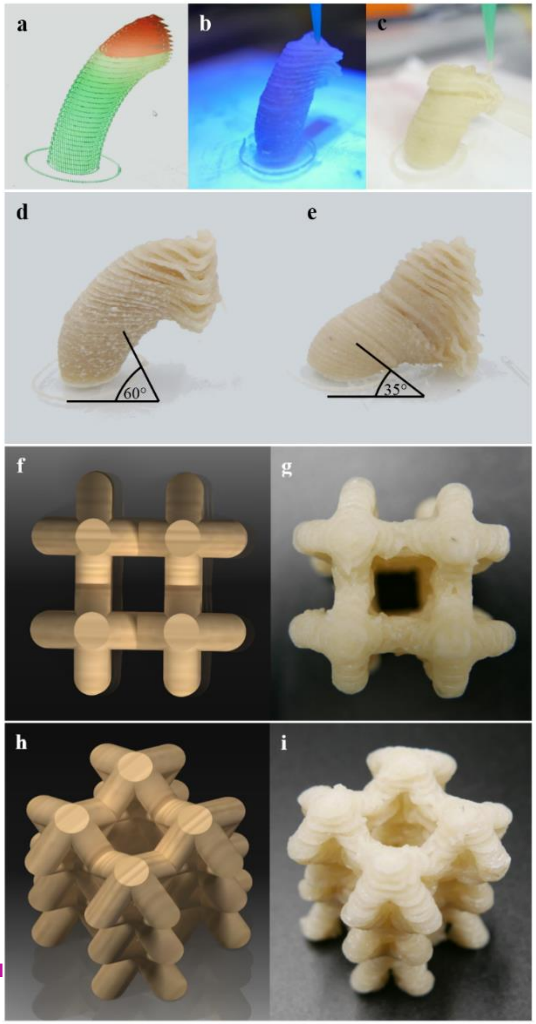
Niklas Kretschmar



- Increased overhang angle for UV-curing during the print (to 60°)
- Prevention of collapse
- Allows printing of complex structures (e.g. lattice structures), more design freedom

Next step (upscaling, larger nozzle sizes for faster production, higher UV intensities):

Robotic arms with extruder head



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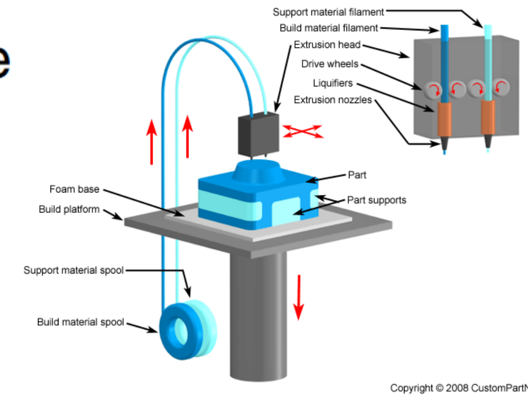
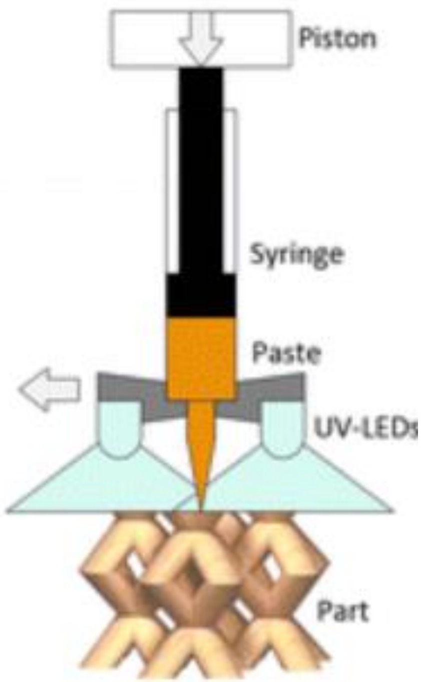
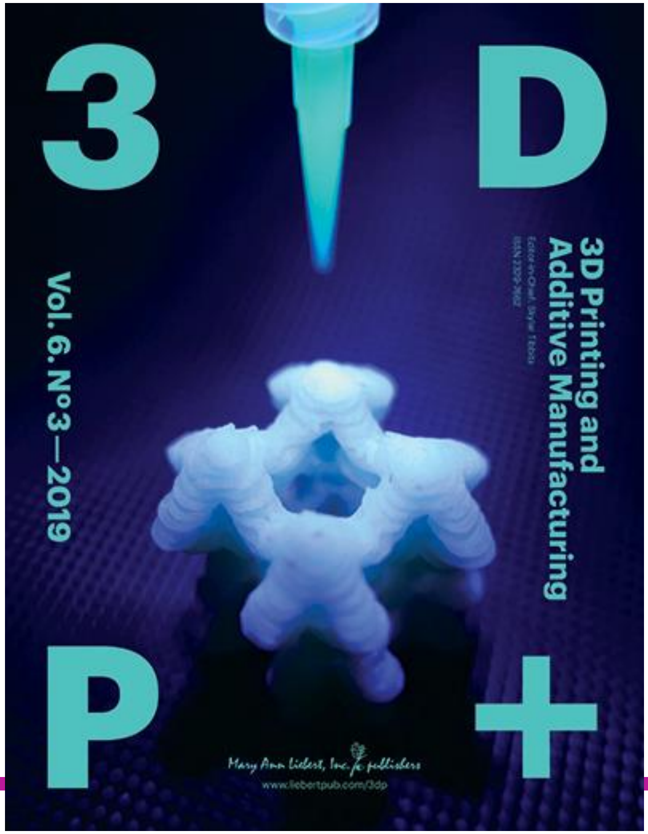
Mechanical Properties of Ultraviolet-Assisted Paste Extrusion and Postextrusion Ultraviolet-Curing of Three-Dimensional Printed Biocomposites

Niklas Kretzschmar,[1] Sami Lipponen,[2] Ville Klar,[1] Joshua M. Pearce,[3–5] Tom L. Ranger,[1,6] Jukka Seppälä,[2] and Jouni Partanen[1]







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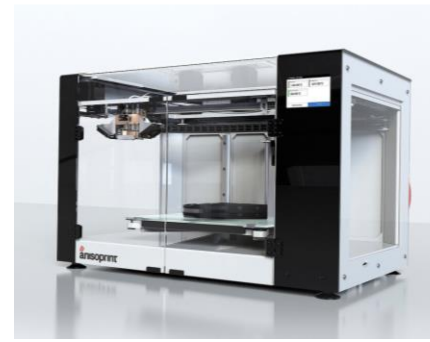
Fiber-reinforced extrusion of polyamides

- Bio-based PA11, Rilsan Besno
- Continuous carbon fiber perimeters
- 3DP at 210°C utilizing Anisoprint Composer A4



PA 11 & CCF

PA 11 & CCF

PA 11 & CCF

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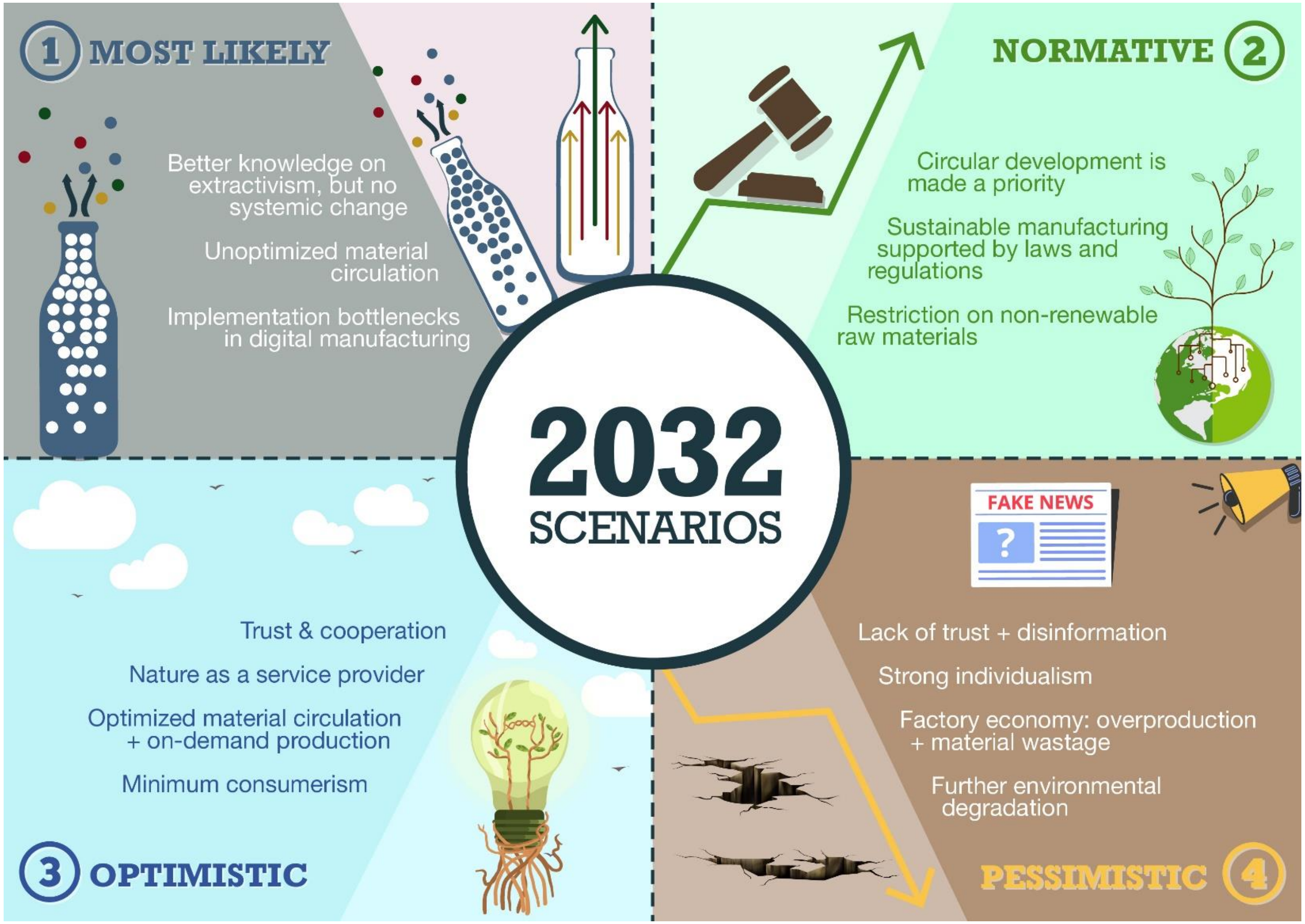
Sub Project on Extractivism



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3D Printing of Optics

- In Collaboration with University of Eastern Finland, Joensuu
- Professor Jyrki Saarinen
- Material Deposition Technology
- GRIN (Graded Index) Optics

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Thank you!

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