Guest Lecture:

Additive Manufacturing (AM) at the service of R&D

28/04/2026

COMPOVERT Project:

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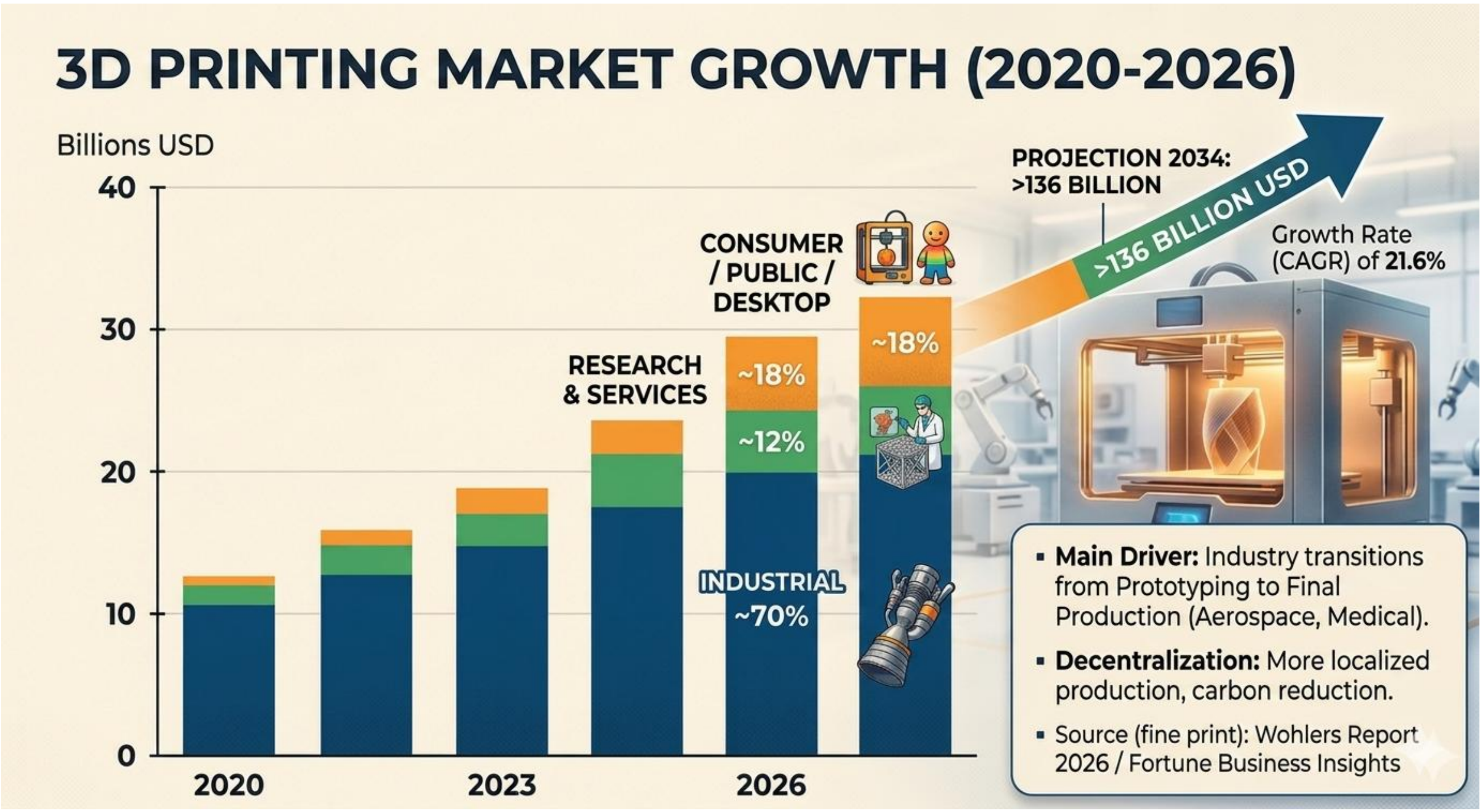
Context


3D PRINTING MARKET GROWTH (2020-2026)
Billions USD
40
30
20
10
0
2020
2023
2026
CONSUMER / PUBLIC / DESKTOP
RESEARCH & SERVICES
~18%
~12%
~18%
INDUSTRIAL ~70%
PROJECTION 2034: >136 BILLION
>136 BILLION USD
Growth Rate (CAGR) of 21.6%
Main Driver: Industry transitions from Prototyping to Final Production (Aerospace, Medical).
Decentralization: More localized production, carbon reduction.
Source (fine print): Wohlers Report 2026 / Fortune Business Insights

Summary

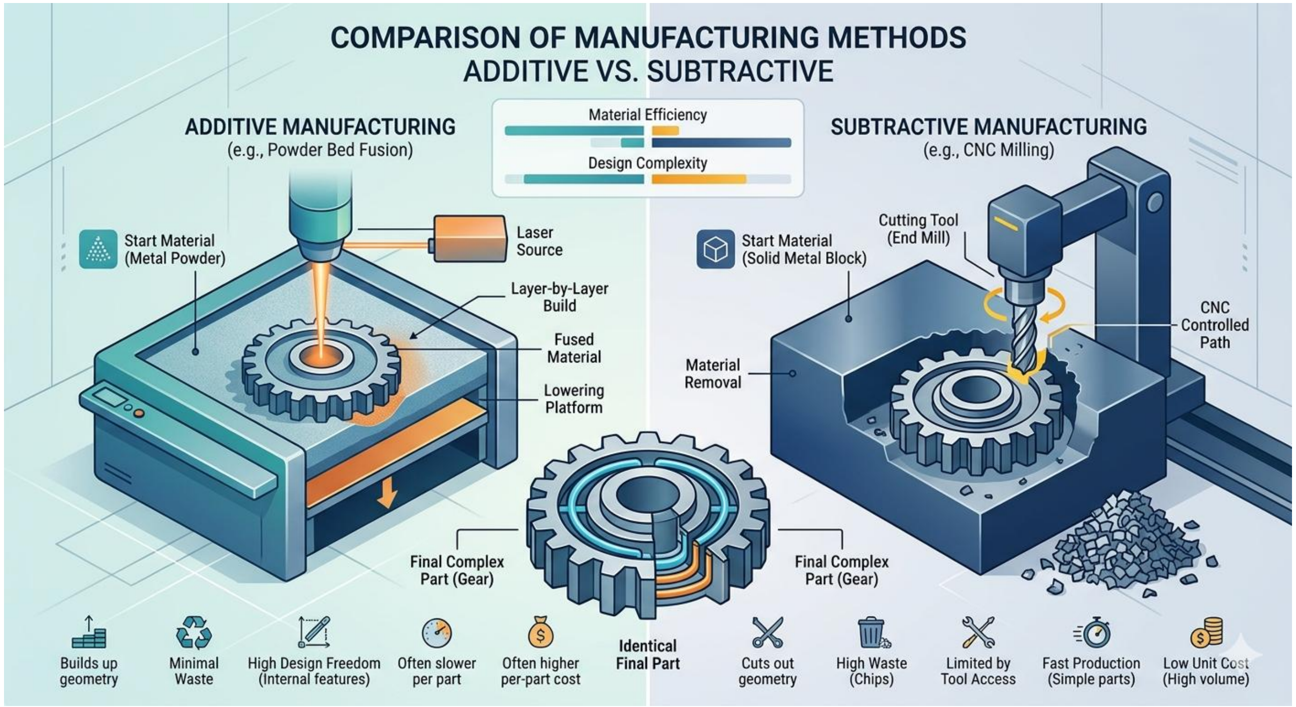
1. *Fundamentals of Additive Manufacturing (AM)*
2. *AM in action: Prototyping, research and industrial study cases*
3. *Current perspectives: The INTERREG COMPOVERT Project*
4. *Conclusion and Q&A*

1. Fundamentals of Additive Manufacturing (AM)

Defining AM

According to the **ISO/ASTM 52900** standard, Additive Manufacturing (AM) is defined as:

- **"A process of joining materials to make parts from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing and formative manufacturing methodologies."**



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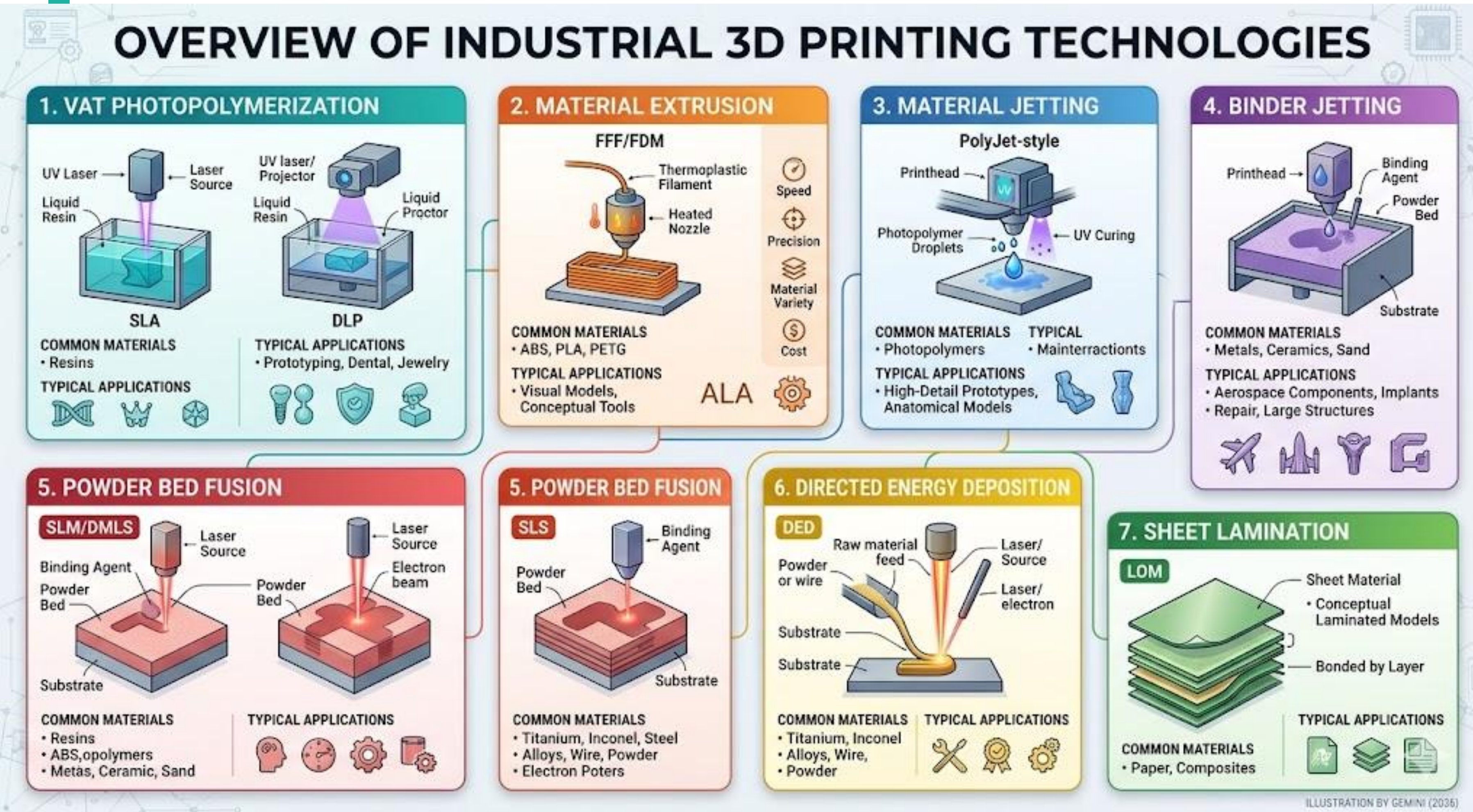
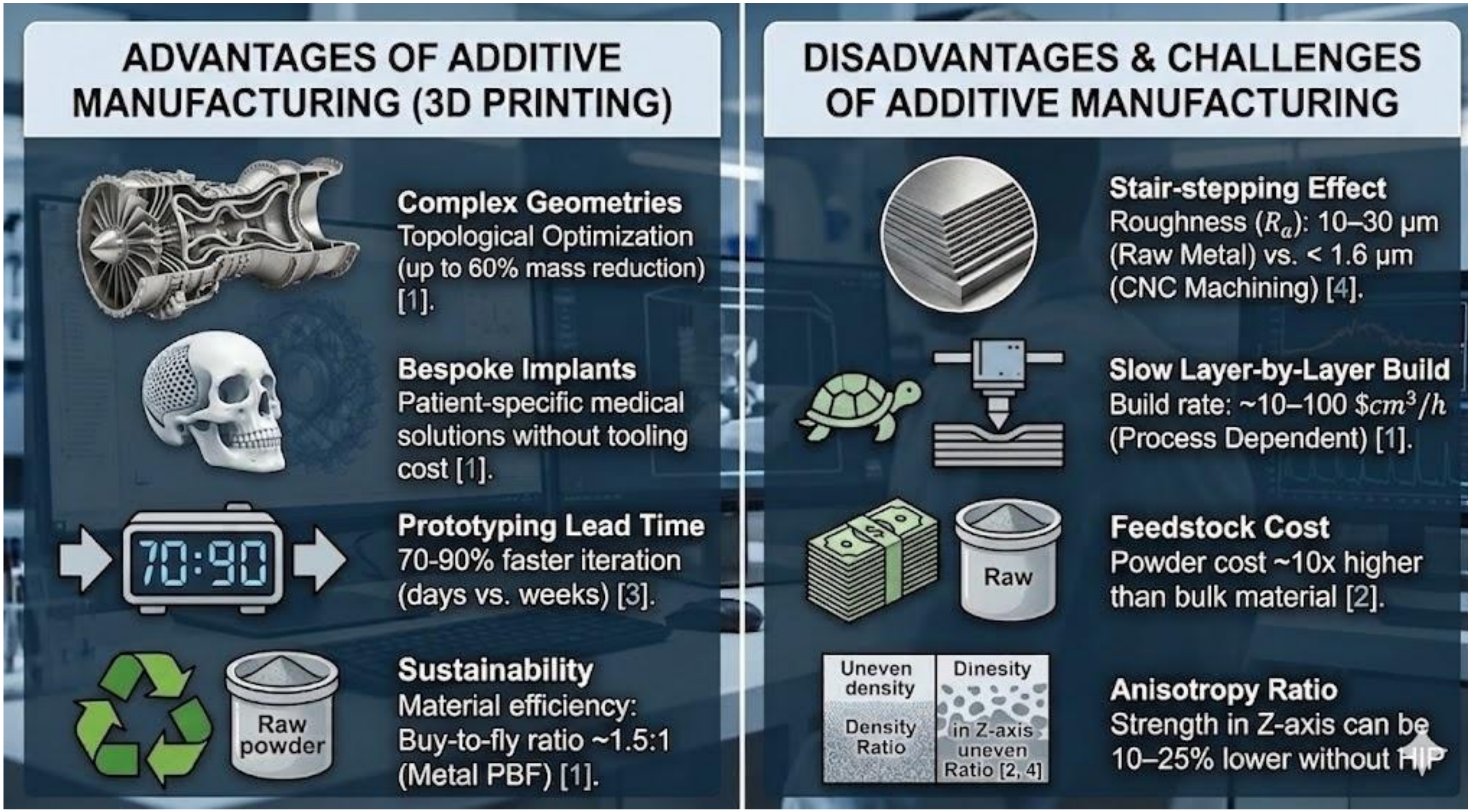
Spectrum of Technologies



Avantages and Disadvantages



1. **Abdulhameed, O. et al. (2025).** *A review on additive manufacturing: its applications and future directions*. Rapid Prototyping Journal.
2. **Shirzad, M. et al. (2023).** *A Review of the Metal Additive Manufacturing Processes*. Journal of Manufacturing and Materials Processing.
3. **Gökçekuş, H. et al. (2024).** *A Critical Systematic Scoping Review on the Applications of Additive Manufacturing (AM)*.
4. **Zid, S. et al. (2023).** *FDM technology and effect of printing parameters on the mechanical behavior of 3D printed parts*. ISTE OpenScience.

Avantages and Disadvantages

Category	Advantages (Data-driven)	Disadvantages (Data-driven)
Geometry & Design	**Topology Optimization:** Can reduce part weight by **30% to 60%** while maintaining structural integrity [1]. **Complexity for Free:** No cost increase for complexity; 100 holes cost the same as 1 [1].	**Surface Roughness (R_a):** Typically, **10–30 µm** for Metal PBF vs. **< 1.6 µm** for standard CNC machining [4]. **Support Volume:** Supports can account for **20% to 50%** of the total material used [4].
Production & Costs	**Lead Time Reduction:** Can reduce prototype lead times by **70% to 90%** (days vs. weeks) [3]. **Buy-to-Fly Ratio:** Often near **1.5:1**, compared to **10:1** or higher for traditional aerospace machining [1].	**Build Rate:** Relatively slow, typically **5–100 cm^3/h** depending on the process (SLM vs. DED) [1, 3]. **Mass Production Break-even:** Usually only cost-effective for batches below **1,000–5,000 units** [3].
Materials & Ecology	**Material Savings:** Up to **90% reduction** in raw material waste compared to subtractive methods [1]. **Supply Chain:** Can reduce inventory costs by **up to 70%** via "on-demand" digital warehousing [3].	**Material Premium:** Powdered metals (e.g., Ti6Al4V) can cost **\$200–\$500/kg**, vs. **\$30–\$80/kg** for bulk ingots [2]. **Energy Intensity:** Specific Energy Consumption (SEC) is often **10 to 100 times higher** than injection molding per kg [3].
Mechanical Properties	**Consolidation:** Can replace assemblies of **20+ parts** with a single printed component (e.g., LEAP engine fuel nozzle) [1].	**Anisotropy Ratio:** Yield strength in Z-axis can be **10% to 25% lower** than in X/Y axes without heat treatment [2, 4]. **Porosity:** Industrial parts typically aim for **> 99.5% density**, but micro-pores still impact fatigue life [2].

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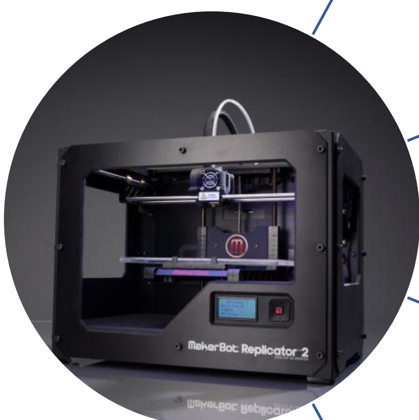
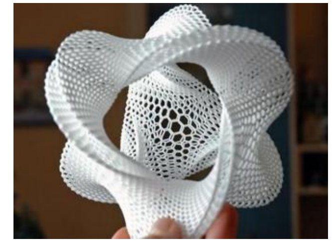
Materials Landascape



Polymer
- PLA, ABS
- PEEK, PEI, PPS
- Resins



Metal
- Copper
- Steel
- Titanium

Ceramic
- Zirconia
- Alumina
- Bioceramic: TCP, HA

Other
- Food
- Human tissue
- Concrete

2. AM in action

Rapid prototyping in Lab

Support and holder for IR Camera, temperature control of microwave debinding and sintering (CERAMATHS, Maubeuge, France)

- *prototypes in PLA*
- *3 iterations*
- *Printed with Creality CR10s Pro (500€ in 2019)*

Bechers holder for a reactor in PPS-CF

- *Temperature*
- *Pressure*
- *Organic solvents vapor (hexane, toluene,…)*
- *Printed with a Bambu Lab H2D pro (3500€)*

Some realizations in IMT NE

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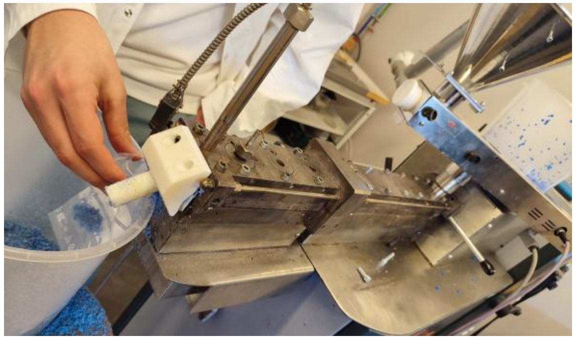

Twin screws extruder outlet

Filament 3D printed demonstrators in (from left to right) Copper, 316L stainless steel, Zirconia, PA6-CF.

3D printed demonstrators in Bronze: (brown) printed, bright (printed, debinded and sintered)

Tubular Heat Gaz exchanger for Ozone, in PA6-30GF, PhD IMT NE.

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Wallonie

Supporting companies in becoming agile
Implementation of technical and reinforced polymers through 3D printing for maintenance and rapid tooling applications

AGILITY

Accompagner les entreprises à devenir agiles
Mise en œuvre de polymères techniques et chargés par impression 3D pour des applications de maintenance et de fabrication rapide d'outillages.

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FA for Rapid Tooling (RT)

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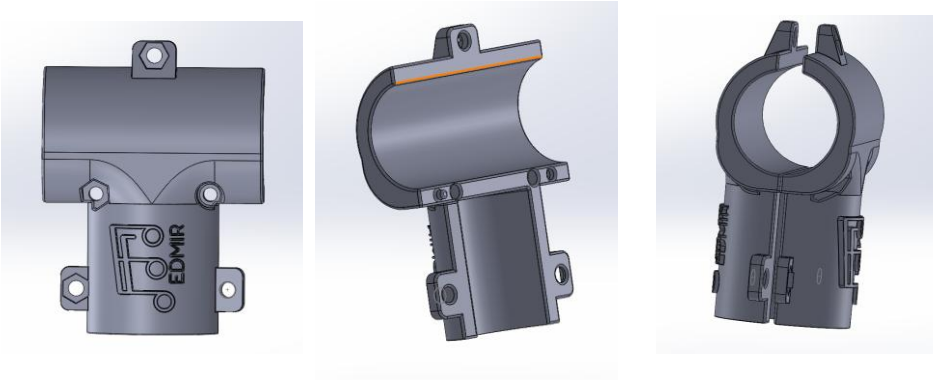
- *Demonstrator n°1: Injection Molding*

Existing part

New design CAD



Aims:

- ***New injected part***
- ***Conception and 3D printing of the <u>mold</u>***
- ***Produce around 40 parts***

FA for Rapid Tooling (RT)

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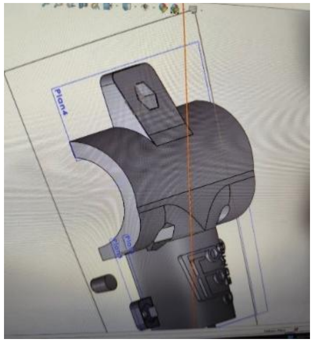
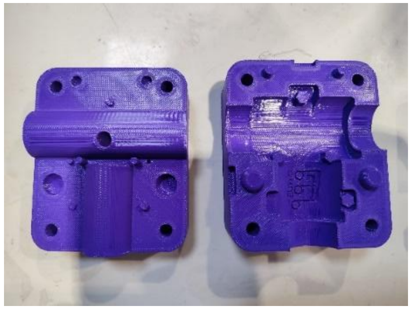
1. CAD



2. Prototype in PLA



3. Mold with SLA resin (High Temp V2 Formlabs)

4. PP manual Injection (220-225°C) >40 pieces

New iteration if needed

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- **3 designs** (less than 2 weeks): conception, 3D printing and injections
  - ➔ Efficiency, agility
  - ➔ Customisation

1. First design

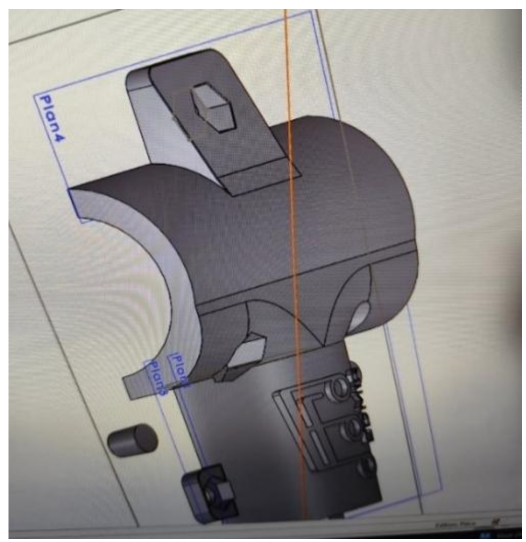
Problem: breaking at the top

2. ***Thickening at the bolt***

Problem: overheating of the mold

3. Adding of conformal cooling inside the part

➔ More than 40 pieces

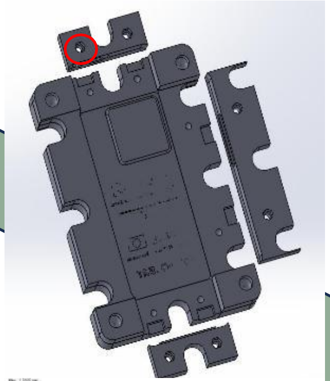


FA for Rapid Tooling (RT)

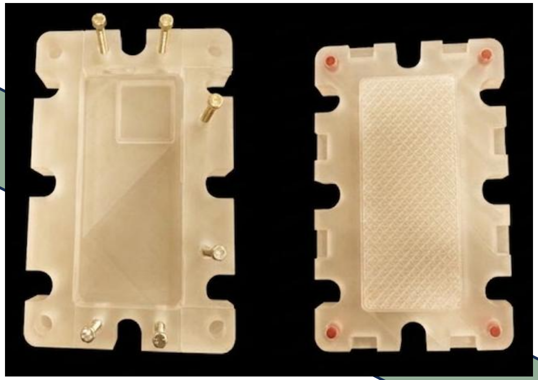
GSM case

- ➔ Phone protection
- ➔ Dust protection
- ➔ Antibacterial

Conception of the mold
+
Injection simulation



Additive Manufacturing (SLA, Formlabs, High Temp resin) of the mold



Injection (Holypress16) of PLA/5% lignin at 215°C
+
Laser engraving
(Snapmaker Artisan, 40W diode module)

AM for FFF with metal???

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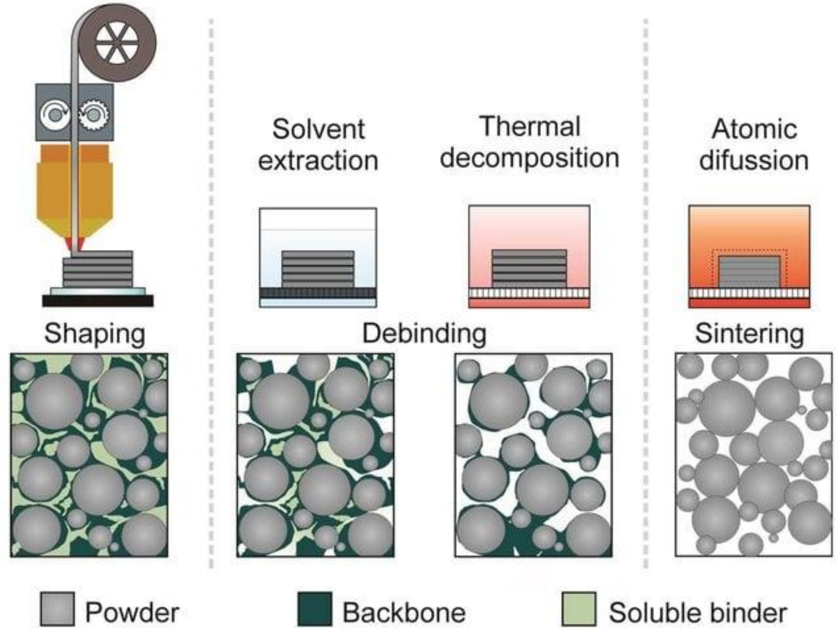
Copper loaded filament printed by FFF

Copper loaded filament (Virtual Foundry)			
			
	3D printing ***Bambu Lab A1,*** ***Hardened steel nozzle*** ***0,8mm*** ***215°C*** ***Layer thickness 0,2mm*** ***Infill 40% gyroid*** ***2 walls***	***Thermal debinding,*** ***485°C,*** ***0,5°C/min,*** ***dwell 5h,*** ***under air,*** ***Alumina Powder***	***Sintering*** ***1052°C*** ***2°C/min*** ***Dwell 5h*** ***Atm Ar/H2 (3%)*** ***Talc Powder***

AM for FFF with metal???



Additive Manufacturing of Metallic and Ceramic Components by the Material Extrusion of Highly-Filled Polymers: A Review and Future Perspectives, *DOI: [10.3390/ma11050840](10.3390/ma11050840)*

Example of old research projet: FARBIO (UCCS (LILLE)x 4D Pioneers)

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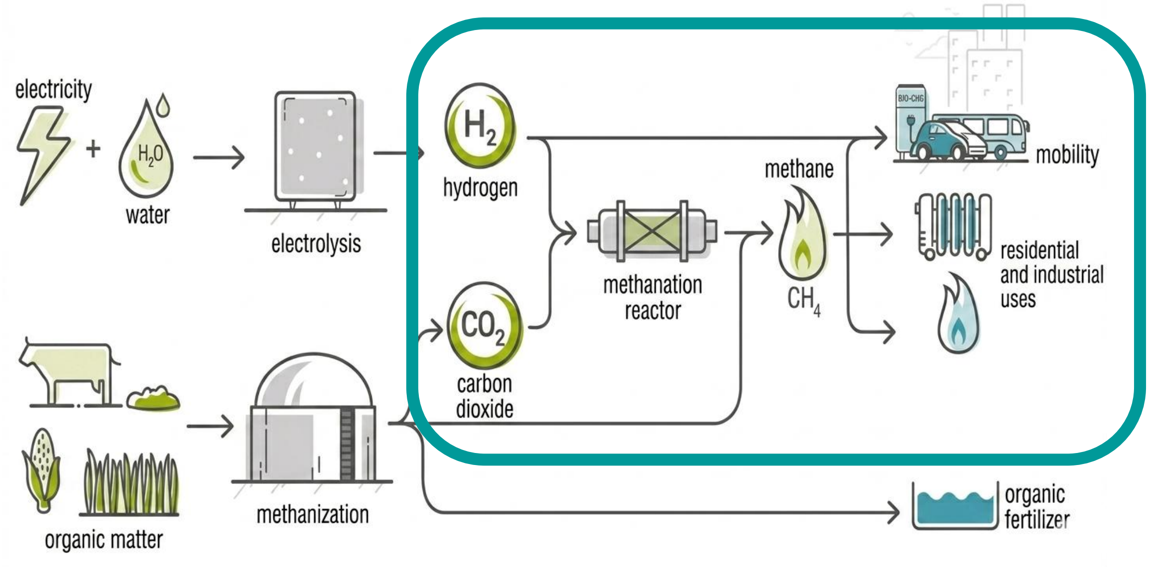
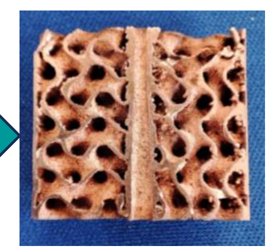


Improve methanation process by using C02 without filtration (from methanisation)

- *Using of structured metallic 3D printed reactor*
- *Thermal control of the reaction*
- *Exchanges improvement*
- *Put a catalyst on the surface*

(a) **(b)** **(c)**

Copper structured reactor, (a) printed, (b) debinded and (c) sintered



Example of structured infill

3. Current perspectives: The INTERREG COMPOVERT Project

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Cross-border development of natural fiber-reinforced functional composites. Valorization of local by-products.

Benedicte GOFFIN, Françoise BERZIN, Loubna LEMKHANTER, Trystan DOMENECH, Marie-France LACRAMPE, Luc ORDYNSKI, Maxence RENAUX, Maxime DORCHIES, Aurore RICHEL, Mohamed BOUDIFA, Bruno CAUWE, Julien ESTAGER, Clément LEMENU

Consorsium

Associated partners

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COMPOVERT and AM

The **COMPOVERT** project develops eco-designed, functional biocomposites by upcycling **local natural fibers**. Using 3D printing and injection molding, these **smart, recyclable materials** offer advanced properties (antibacterial, antistatic) for new regional industrial applications.

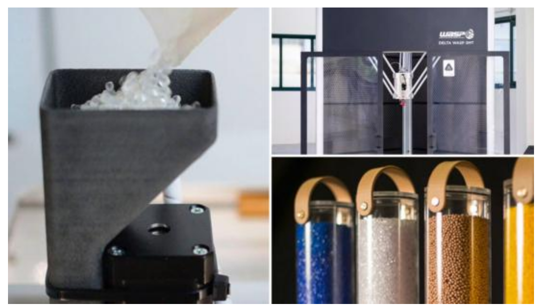
- **Matrix:** PE, PP, PLA…
- **Fiber particule:** hemp, flax, jute, starch…
- **Processing:** FA, thermopress, injection…

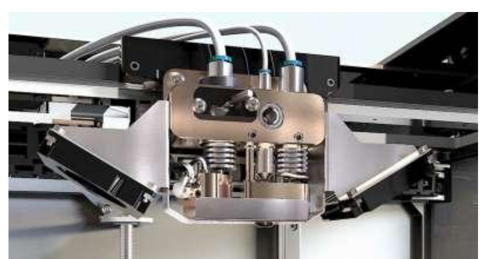
Example of process with AM

Compound with particules or short fibers


Filament 3D printer

Pellet 3D printer





Continuous Fiber Printer

4. Conclusion and questions

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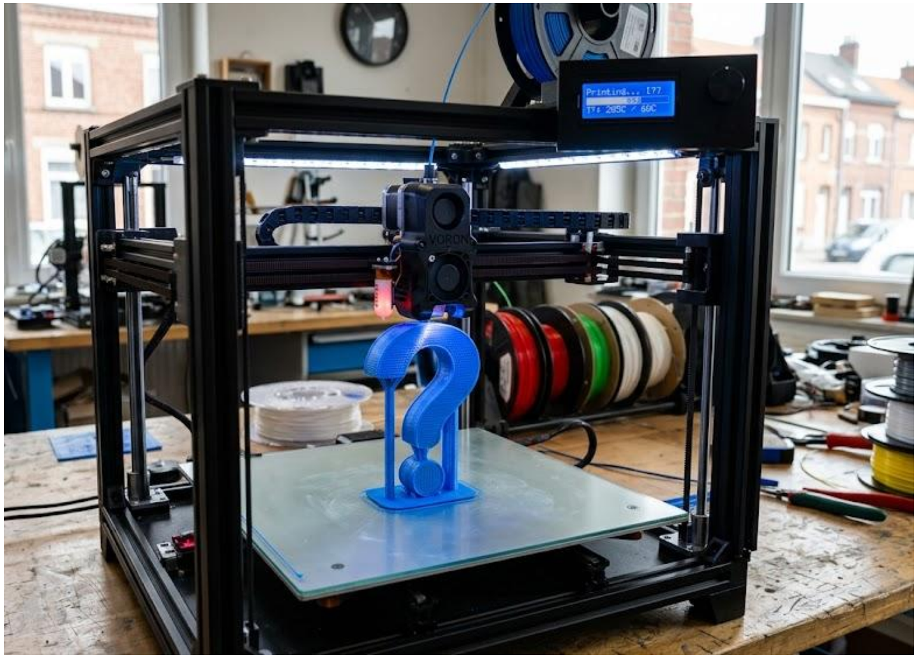
Conclusion

- AM is a real advantage in R&D
  - Rapidity and efficiency
  - Customization
    - Quickly change dimension and try again
  - « Low cost process »
    - FFF machine could cost less than 200€
    - In house making
  - Large panel of materials and possibilities
  - In COMPOVERT we will print demonstrators with properties of formulated biocomposites (antistatic, antibacterial…)
    - Particules or short fibers
    - Continuous fibers



Questions?