AFPR AEFA 2013

Design for Additive Manufacturing

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SIRRIS

sirris
driving industry by technology

SIRRIS T-ADD capacities & competencies

T-ADD (1990 – 2013)

- 15 engineers and technicians
- Two locations: Liège (10 p.) and Charleroi (5 p.)

In-house AM technologies

- Stereolithography (normal & hi-res)
- 3D Printing of plaster powder (Z-Corp)
- Laser sintering of polymeric powder (PA,…): P360 & P390
- Objet Connex 500: bi-material
- 3D Printing of wax (Thermojet)
- Makerbot Replicator
- Paste polymerisation for (bio)ceramics (2 Optoform)
- 3D Printing of metal powder (2 Prometal ExOne)
- Laser Melting (MTT) SLM 250 HL
- EBM Arcam A2 (Titanium & CoCr)
- Laser Cladding (Irepa Laser EasyCLAD)
- *3D scanning & metrology (GOM, Metris, Wenzel)*










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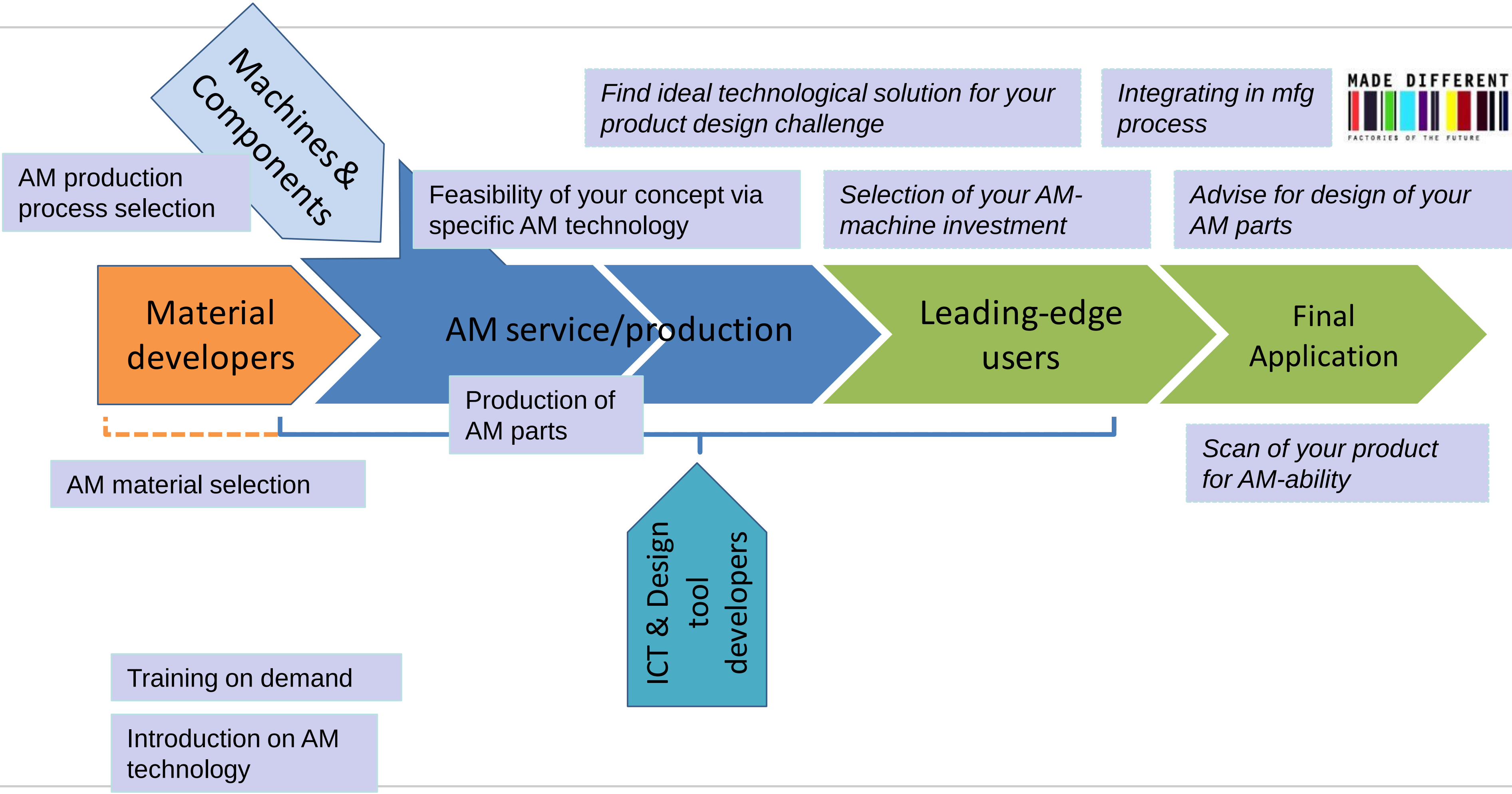
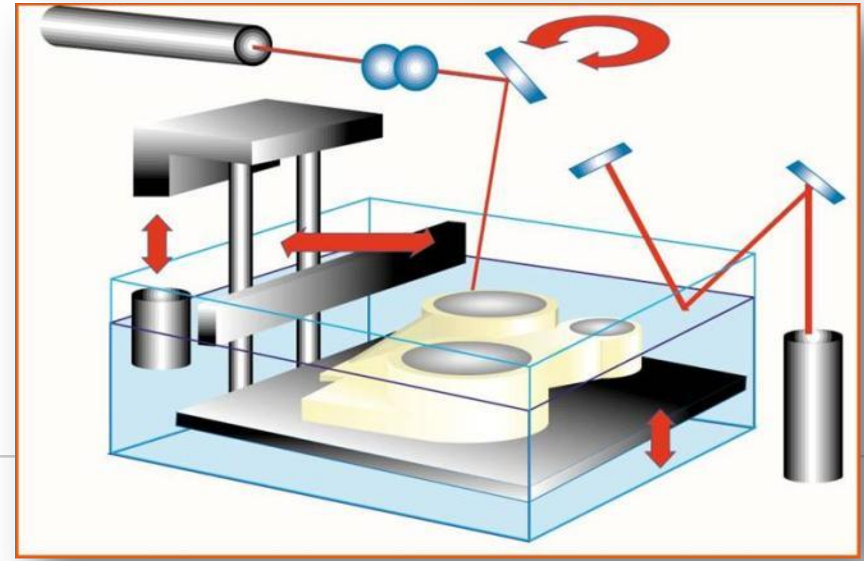
Service portfolio

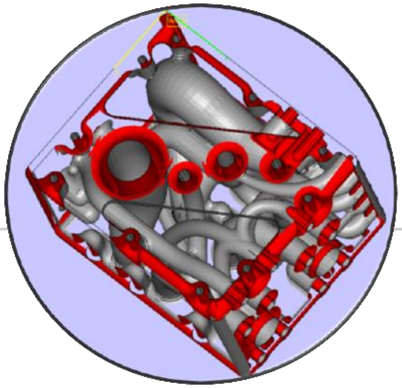


Rapid Prototyping → Additive manufacturing

- Cost reduction and short leadtime
- High geometrical complexity and freeform design
- Short series production without any tool
- Compliance with sustainable economical growth



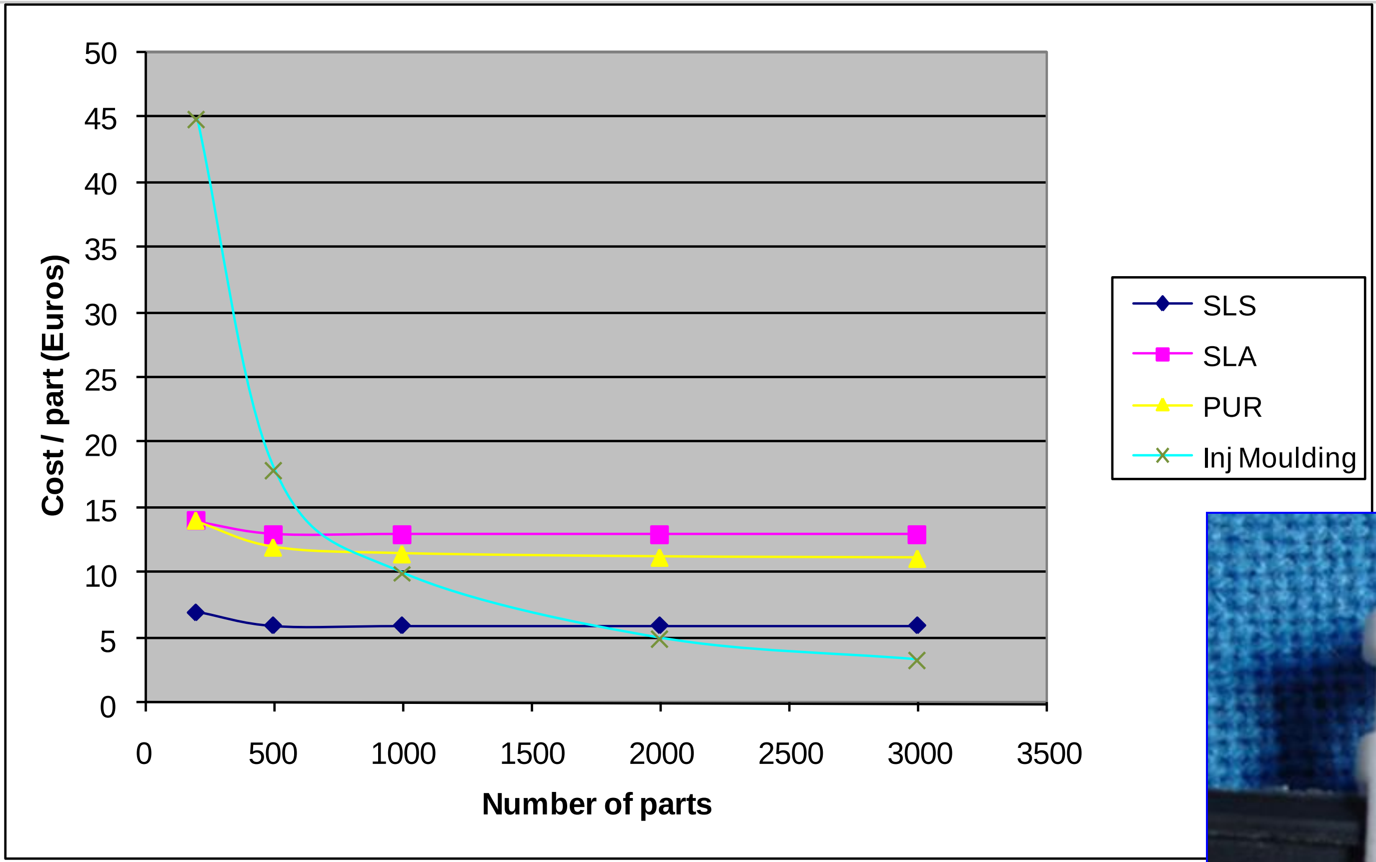
Additive Manufacturing



- Three different ways of using AM technologies
- → Prototyping for visual models or functional parts
- → Direct production of parts (light redesign, only validation)
- → Direct production of parts redesigned for AM
(no way back to conventional production)

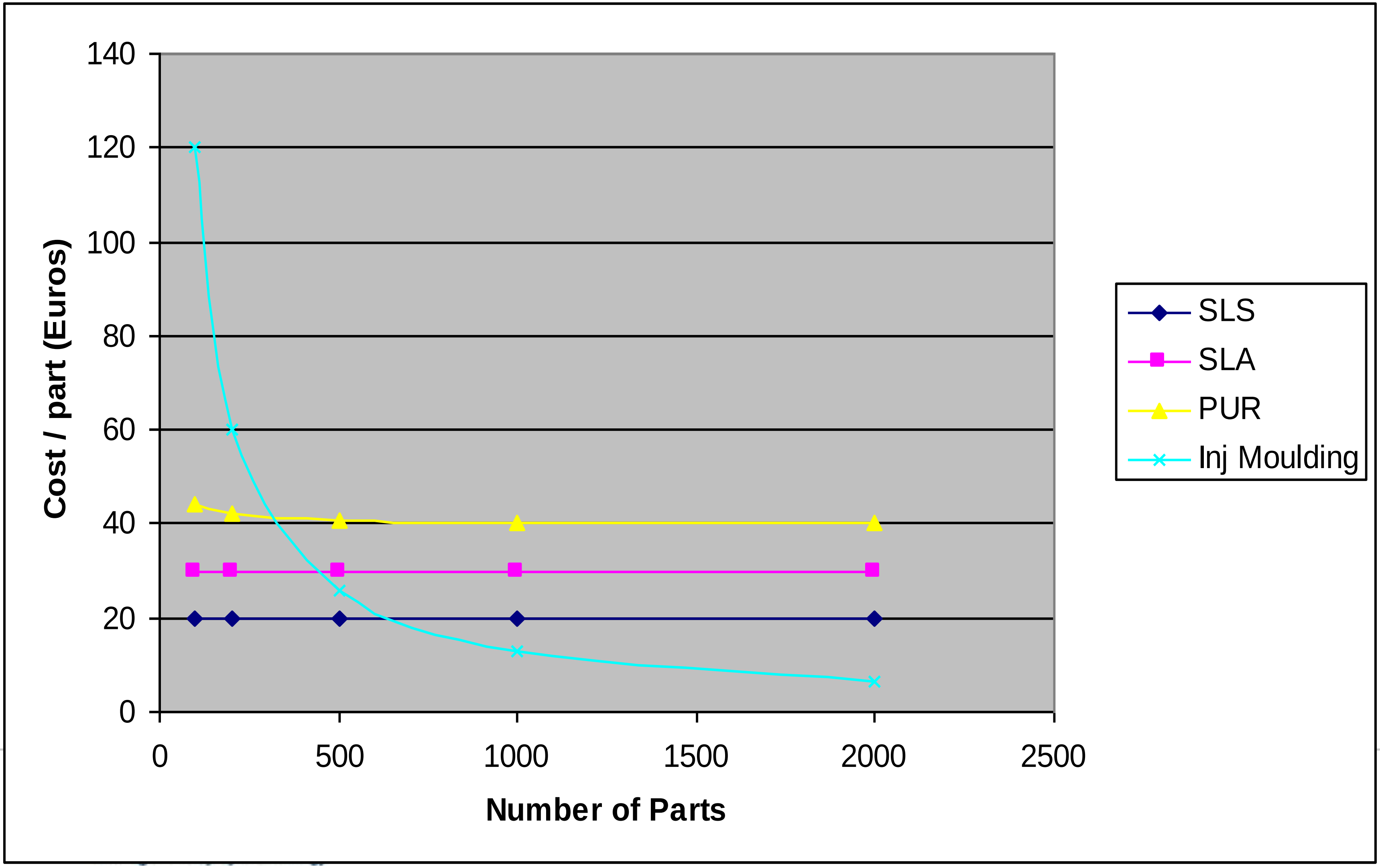
Comparison AM & conventional way

Break-even point for a small part 32 * 24 * 12 mm



Comparison AM & conventional way

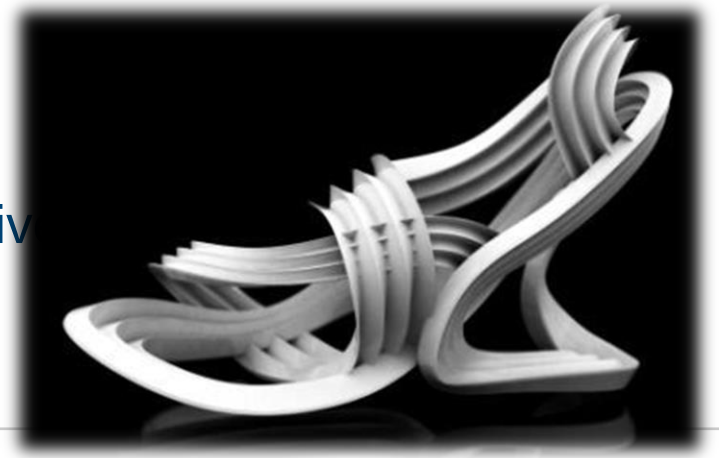
Break-even point for a phone cover - 110 * 50 * 16 mm



Additive Manufacturing % conventional techniques

- With the conventional technologies (milling, moulding), the design of a new part is usually limited by the production process
- → Technical and economical constraints
- → Limitations in the freedom of creation

- With AM:
- → Almost no geometrical limitations
- → Optimization and customization
- → Geometrical complexity is not more expensive than a simple part



Continuum Fashion : shoes, clothes,…

Additive Manufacturing Limitations

- Geometrical limitations:
  - Wall thickness: 0.3 mm – 1.5 mm
  - Length of internal channels (powder removal)
  - Max. size: 100 mm → 4000 mm.
- Anisotropy (axe Z) for the mechanical properties
- Surface quality (layer thickness, orientation)
- Support structures for 3D building with some AM techniques.
  (generation, building, removal)

- *Some understanding of the AM processes are required for*
  - *The designer (dimensioning)*
  - *The manufacturer (part orientation, support generation, shrinkage factor, warping)*

Geometrical Complexity (Polymers)

- No tool required for series production:
- → No draft angle required for demouldability
- → No mould filling problems

Freedom of Creation

Hettich: Rotolavit Blood centrifuge (< 1.000 units / year)
30 % less expensive than with injection moulding
32 components → 3 components (2 with LS, 1 with IM)
Manufacturing on demand (customization)

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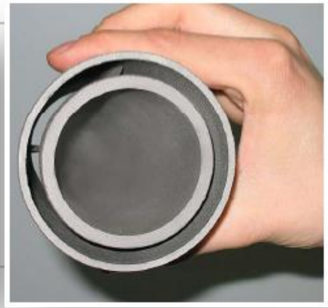
Geometrical Complexity (metal)



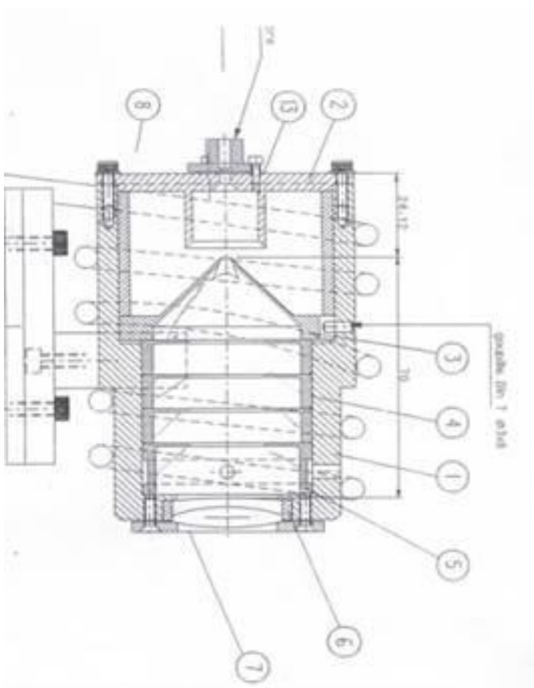
- No tool required for series production:
- → No draft angle required for demouldability
- → Internal walls and details

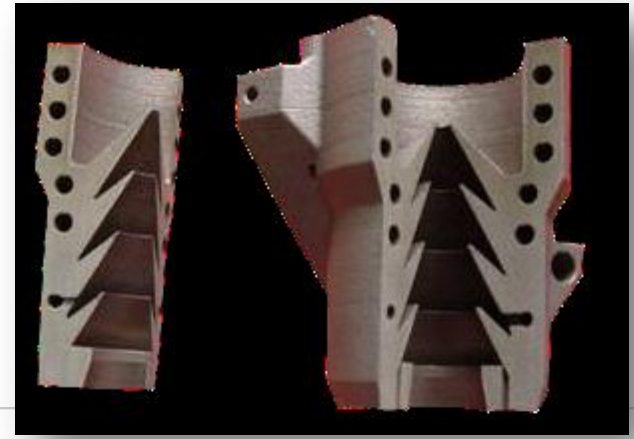
Steel part (Concept Laser)

Wim Delvoye / 3DP metal SIRRIS

Less components - Assembly reduction

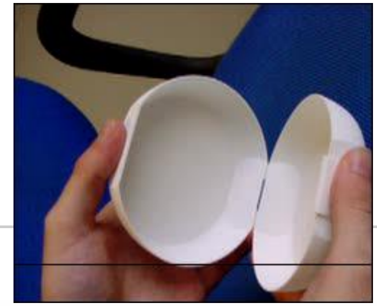
- Redesign of a laser collimator for space app.:
- 13 components → 2 components
- Cooling system and geometry optimization





Integration of functions

- Integration of snap fits, hinges,...



EBM - Oak Ridge National Lab

EOS

Materialise MGX

Integration of functions

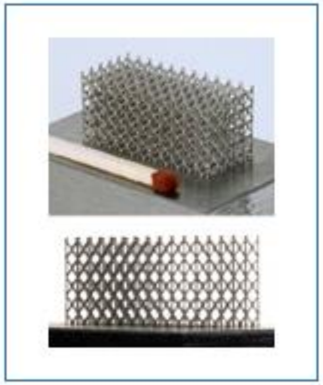
- The design of a complex part with several local functions (spring effect, damping effect) usually requires the assembly of components in different materials.

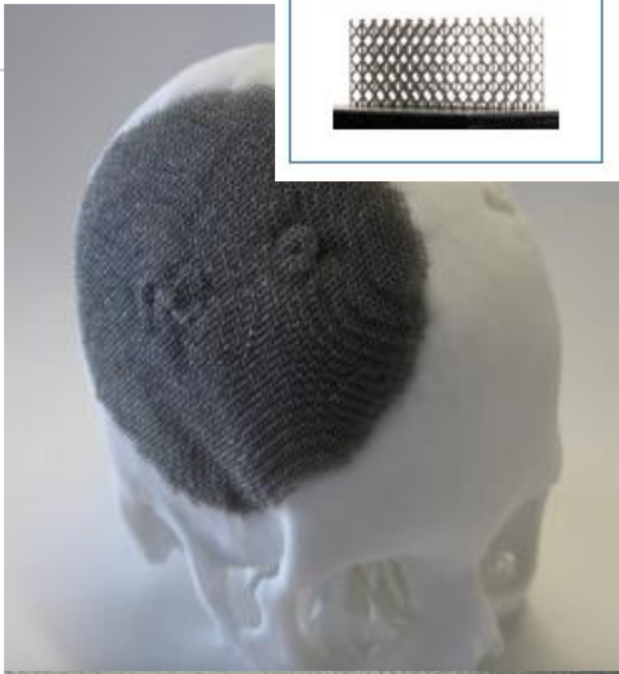
- With AM, this is possible in one step with bi-material process like the Connex machine (Objet)

Zcorp Color

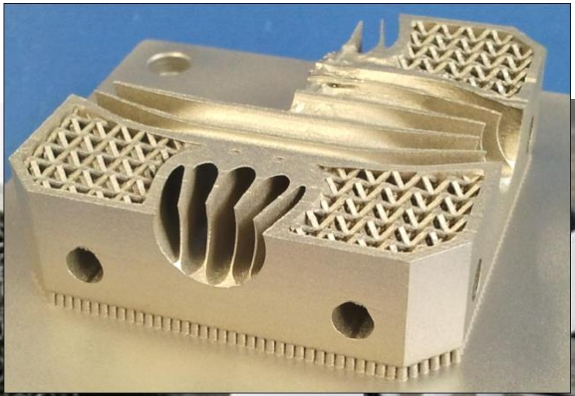
Connex (Objet)

Lightweight parts – Lattices structures

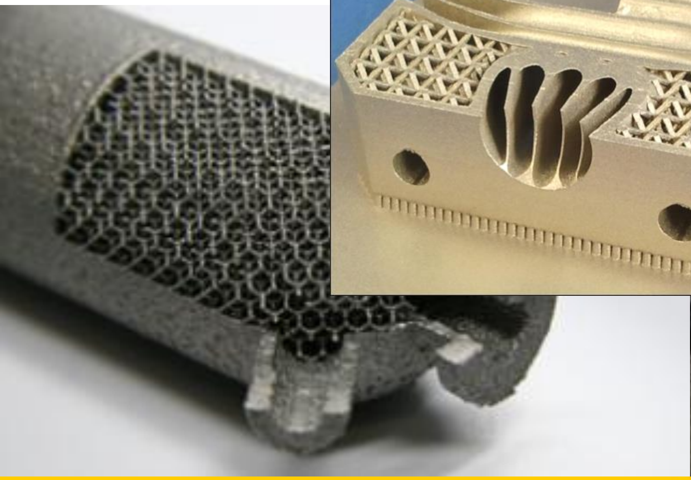




- Weight reduction using lattices structures
  with minimal strength reduction
- Local variation of lattice types
  → graded porosity
- Shock damping, vibration reduction
- Biomedical implants: bone regeneration



Hydrauvision (Compolight)



[Sirris ADD]

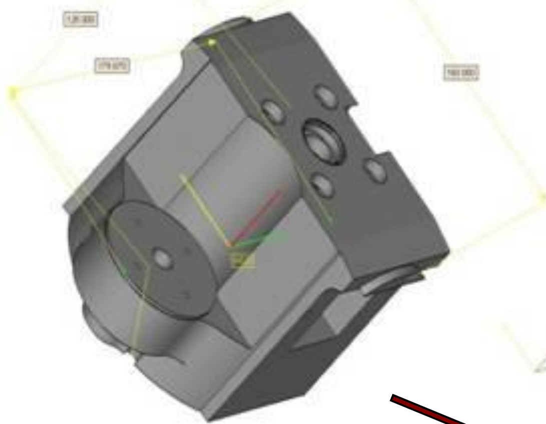
Lightweight parts - Topology optimization

- Automated design based on the applied constraints (Topol)
- Same mechanical properties with weigth reduction

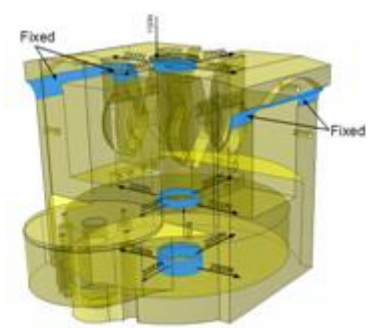
Flying Cam part - SIRRIS redesign – MBProto LBM building (Compolight)

Lightweight parts - Topology optimization

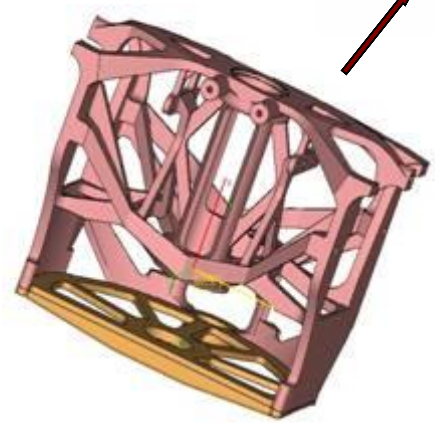
Free space definition



Efforts repartition

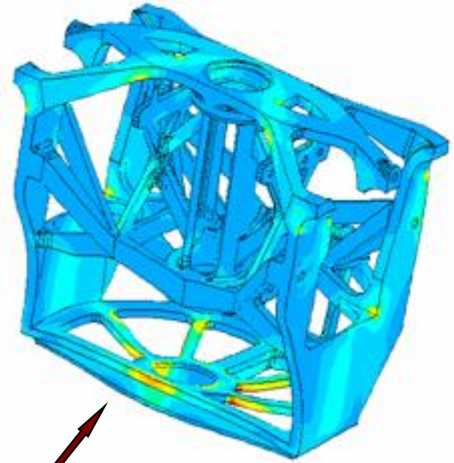


STL file



Smoothing or redesign
based on the STL geometry

Stress verification

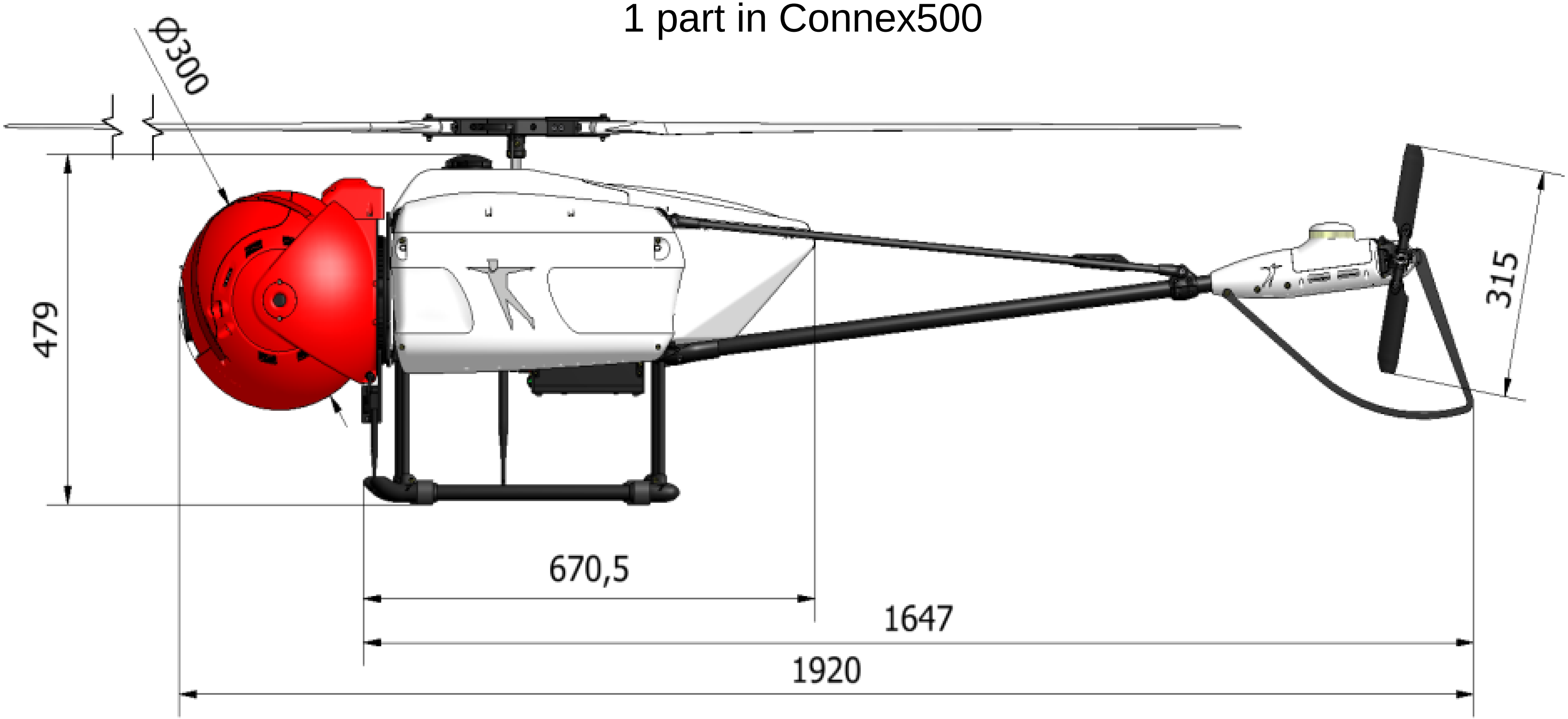


Flying Cam example (Compolight project)

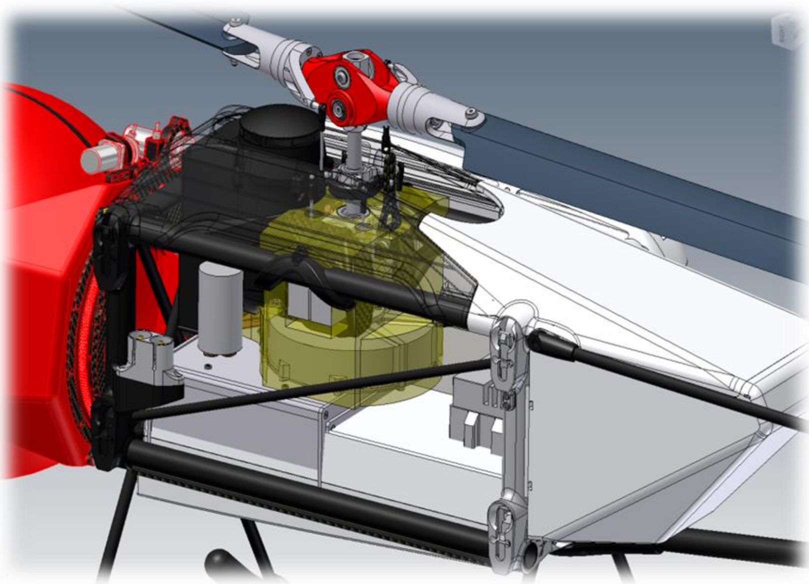
FLYING-CAM

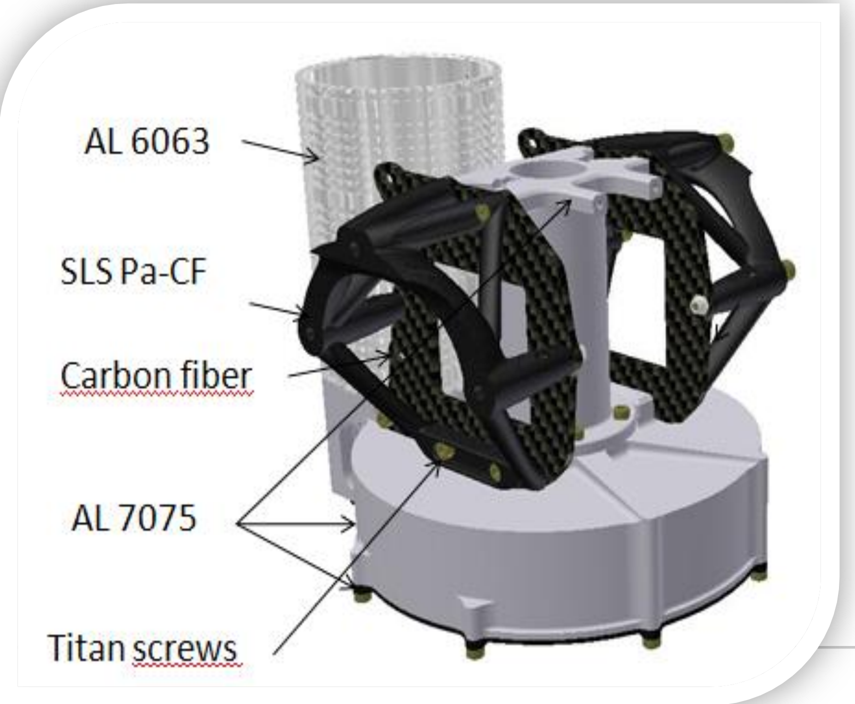
UNMANNED AERIAL SYSTEMS

Most of the components produced by AM
44 parts in PA + C
31 parts in PA (white, black, painted or not,…
1 part in Connex500



- 7 components to replace by 1
- Increasing the stiffness while reducing the mass
- Improve the thermal exchange
- Decrease the production cost





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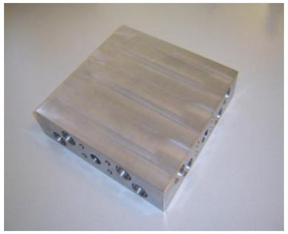
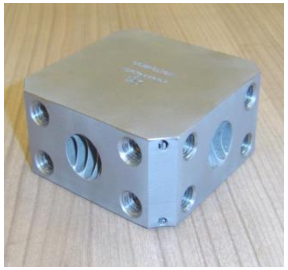
Hydrauvision: impossible crossing (Compolight)

AM techno: LBM & 3DP metal

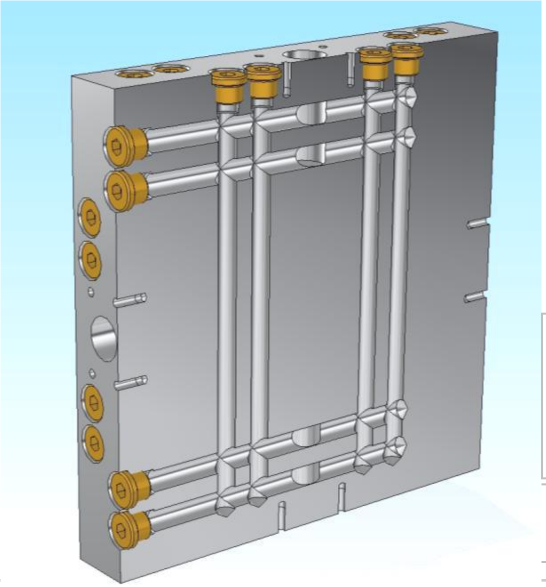


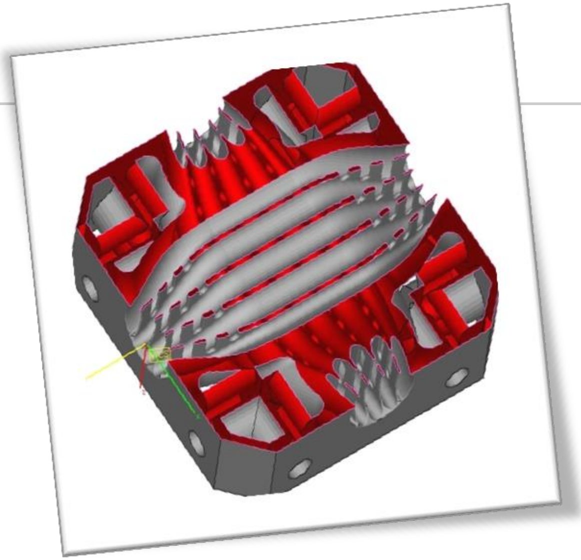


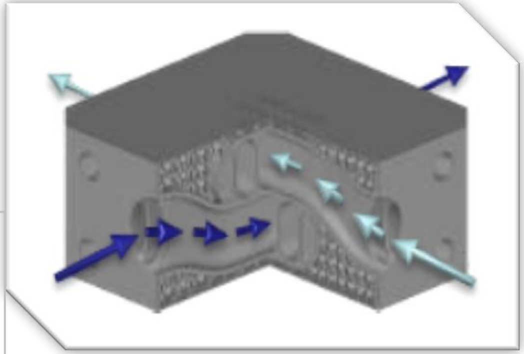
Volume: 2.900 cm³

Mass: 19.2 kg

External size: 210 x 210 x 70 mm





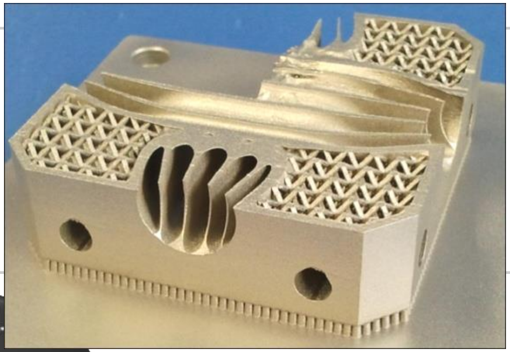


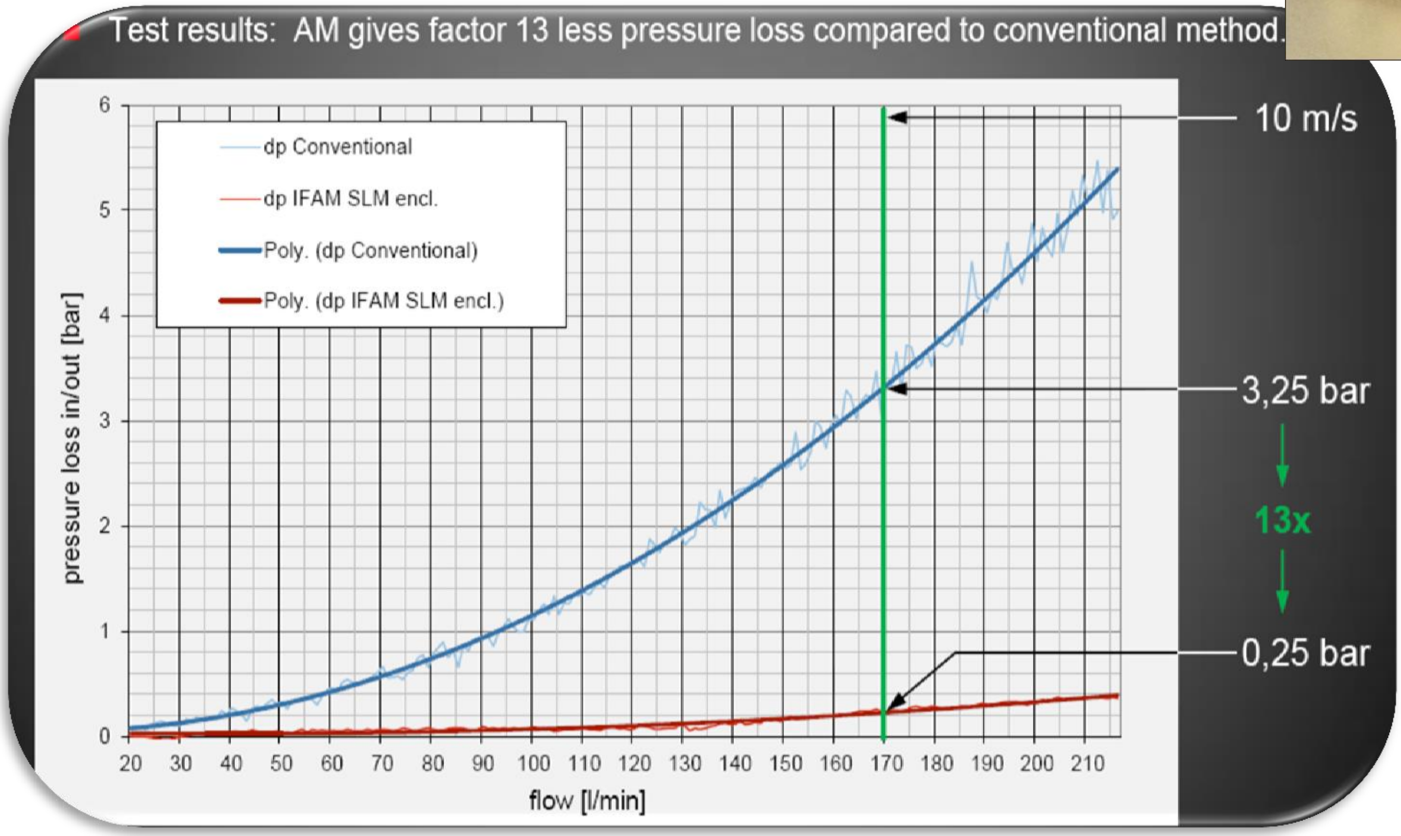
Volume: 244 cm³

Mass: 0.74 kg

External size: 85 x 85 x 38mm

Pressure loss





Very important reduction of pressure loss and also high pressure resistance

Hydrauvision: Big & complex manifold

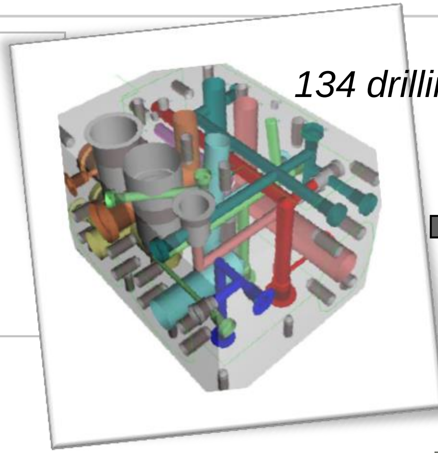
AM techno: 3DP metal

Volume: 2.334 cm³

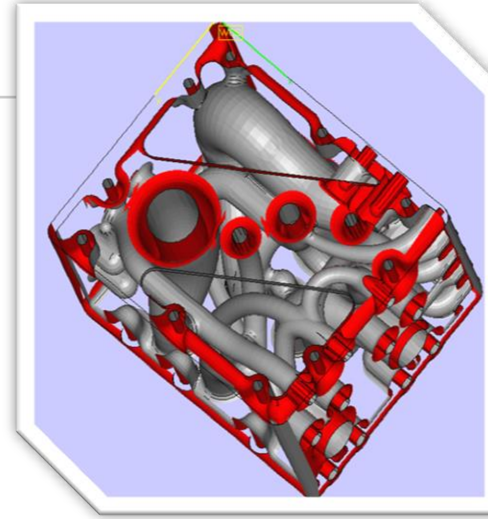
Weigth reduction : 64 % (55 → 20 kg)

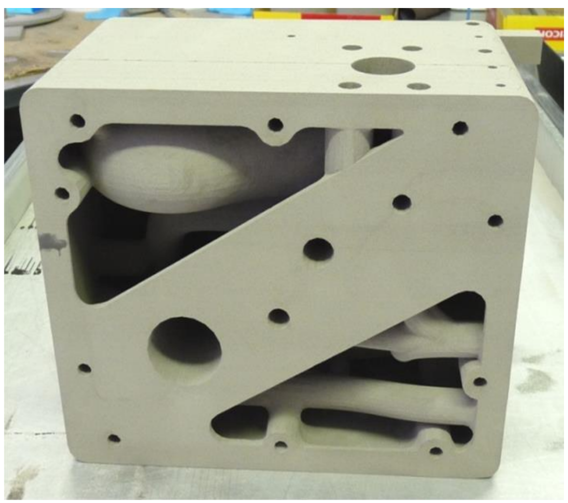
External size:

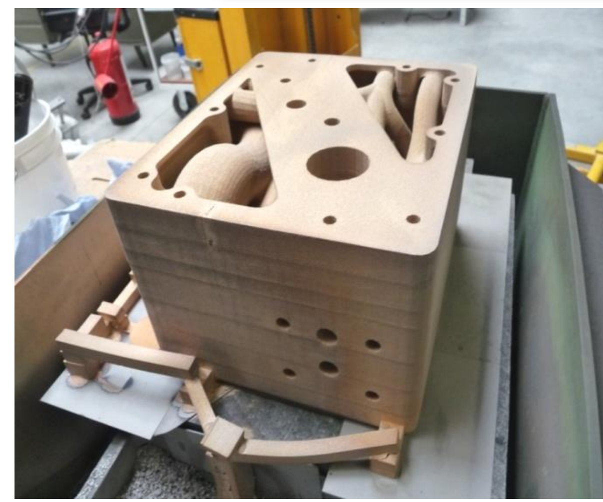
265x200x165 → 240x200x150 mm



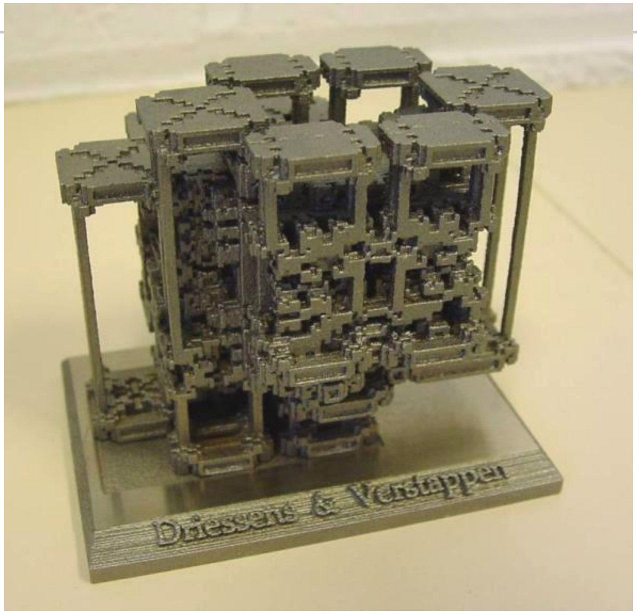
134 drillings







Customization – unique parts & short series



- Unique parts for art, aerospace, biomedical (hearing aids)
- Mass customization: variants for each country

Customization – unique parts & short series

- Olaf Diegel

(Massey University)

Design: presets or user defined

Customization – unique parts & short series

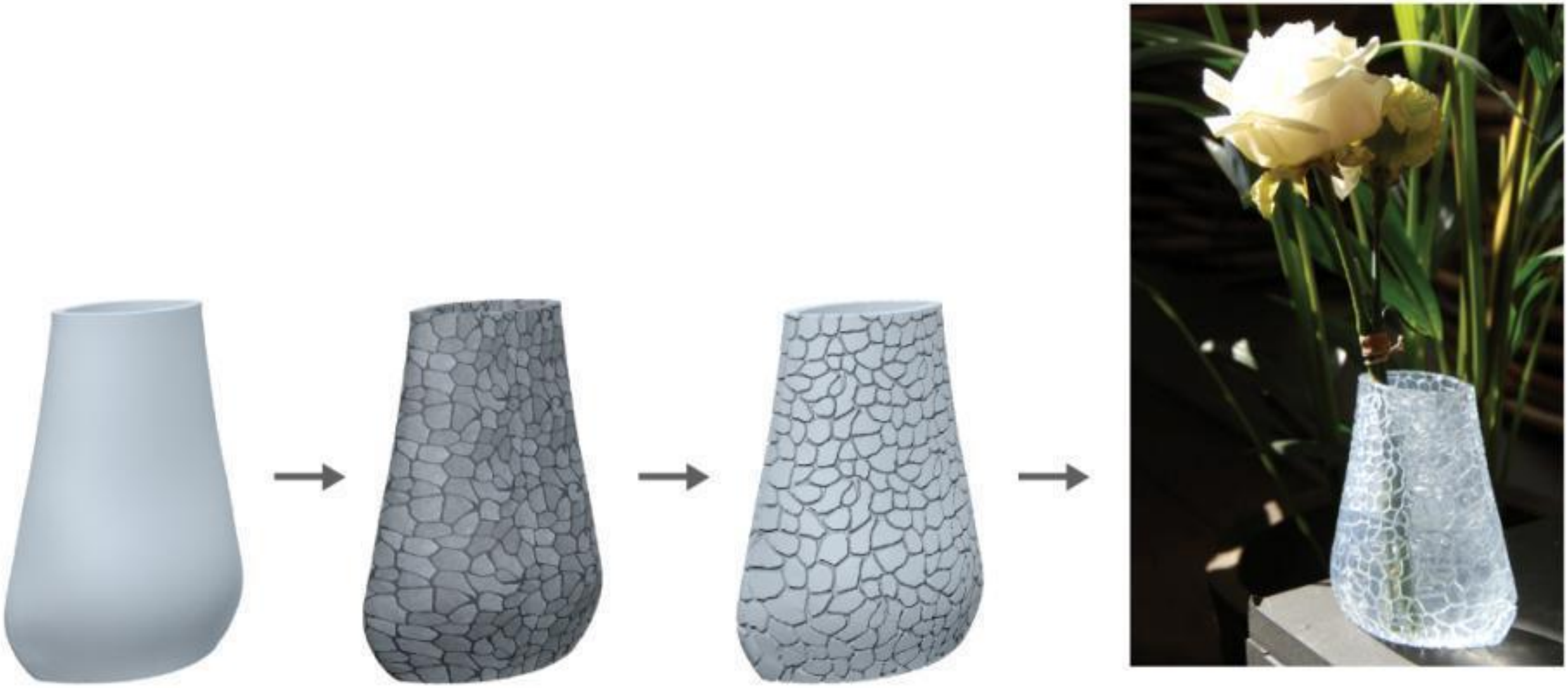
Aline Salmon
3DP métal (Sirris)

Sac féminin haut de gamme
YAMM (200 pièces)
Anne Valérie Bribosia
3DP métal (Sirris)

3D surface texturing

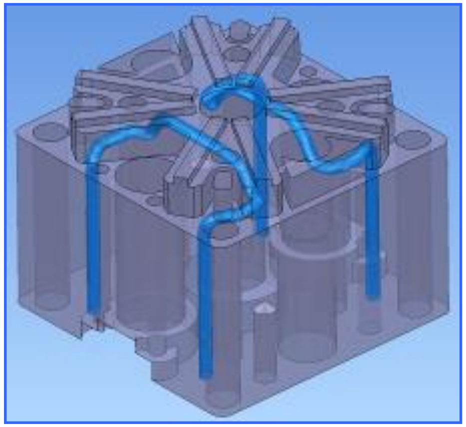
- Library of texturing types available for the designer
- Stone, wood, marble, leather, …
- Visual effect as well as adherence & special grip

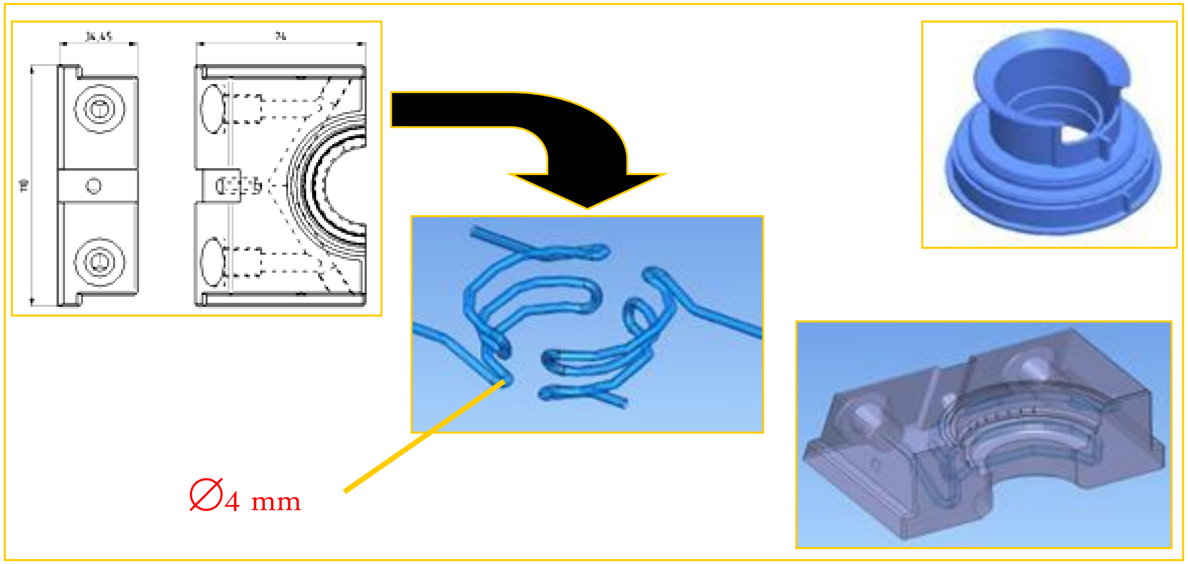
3D surface texturing

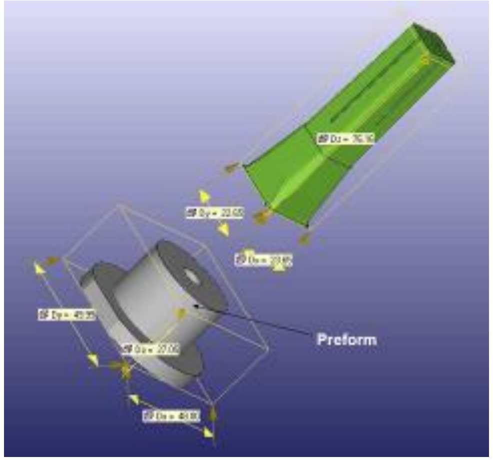


Conformal cooling channels *(Hipermoulding project)*

4 injection moulds produced with & without conformal cooling channels







Drastic reduction of the cycle time (up to 35%)
Enhancement of part quality
Enhancement of tool lifetime
Profitability up to 200.000 euros/year (prod. 6 Mparts)

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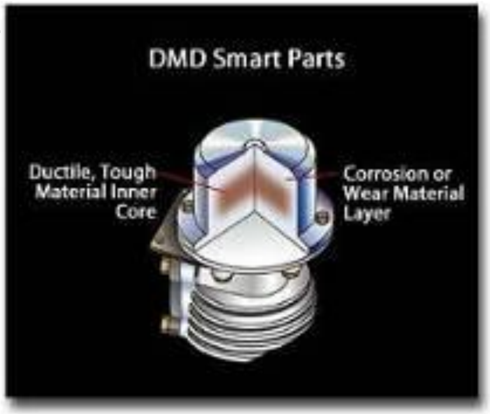
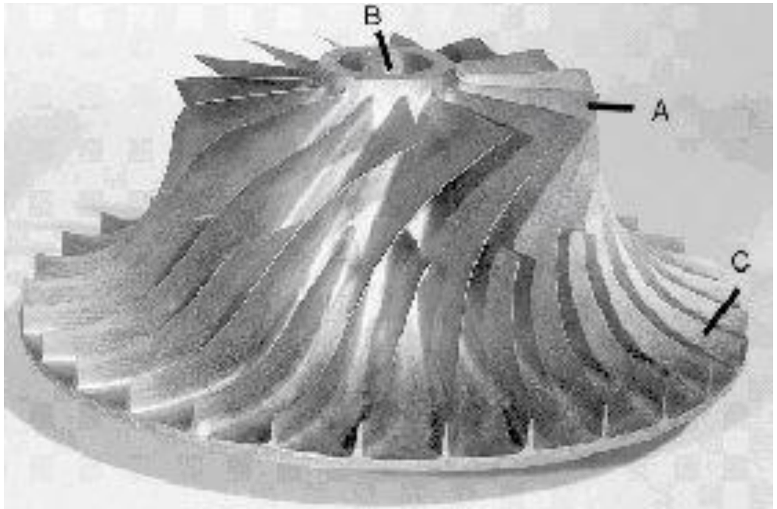
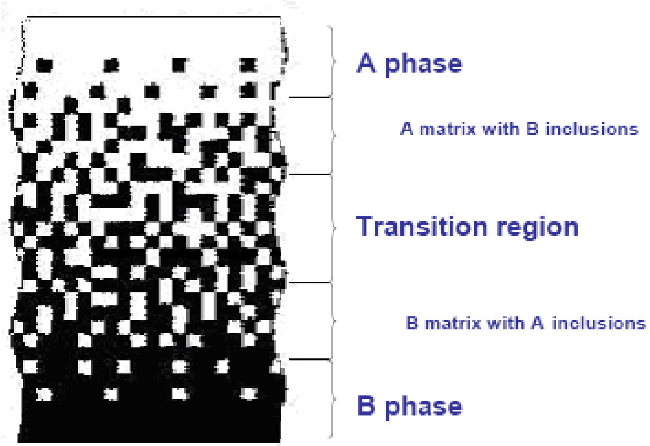
Functionaly Graded Materials *(Laser Cladding)*

Example with Ti alloys (source OPTOMEC):
3 different Ti alloys with 3 specific functions: impact resistance, fatigue and creep

Examples of material combination produced on the EasyClad (Sirris)







Porosity control

AM techno: 3DP (Prometal → ExOne)

Investigation ways to manage the porosity:
(based on the process and not on lattice structures)

- Powder composition (size, distribution)
- Addition of organic particules
- Sintering parameters (thermal cycles)

Applications: fluid control, filtering, …

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Additive Manufacturing & environnement

- Reduction of material
  - Milling sometimes 20/1
- Reduction in transportation costs & logistics:
  - Local production & decentralization (no tool)
- Reduction of energy consumption
- → Lower global C02 footprint
  - ATKINS project (EU)
  - FRED project (InterReg with Cirtes SIRRIS Inno8 Ulg TUDOR ENSAM Technifutur)

So how do our lifecycle CO_2 compare

Scenario 1 – Machined from solid **(100%)**

Scenario 2 – Selective Laser melted lattice **(37%)**

Scenario 3 – Selective Laser melted optimised design (46%)

econolyst
taking a closer look

Conclusion

- AM : huge design freedom
- Some limitations / design rules / guidelines need to be known
- AM should be considered from the product conception phase

Design for Additive Manufacturing

Merci pour votre attention

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