



**Fabrication additive appliquée**  
à la physique des deux infinis

7 juin  
2021

Colloque  
IJCLab, Orsay



CENTRALE  
NANTES

LS2N  
LABORATOIRE  
DES SCIENCES  
DU NUMÉRIQUE  
DE NANTES

FRANCE  
ADDITIVE  
FILIERE IMPRESSION 3D

ACADÉMIE  
DES  
TECHNOLOGIES

POUR UN PROGRÈS  
RAISONNÉ  
CHOISI  
PARTAGÉ

# Overview and Challenges of Additive Manufacturing

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Fellow Member of the Academy of Technologies of France  
Vice-President of France Additive



# Outline of the presentation

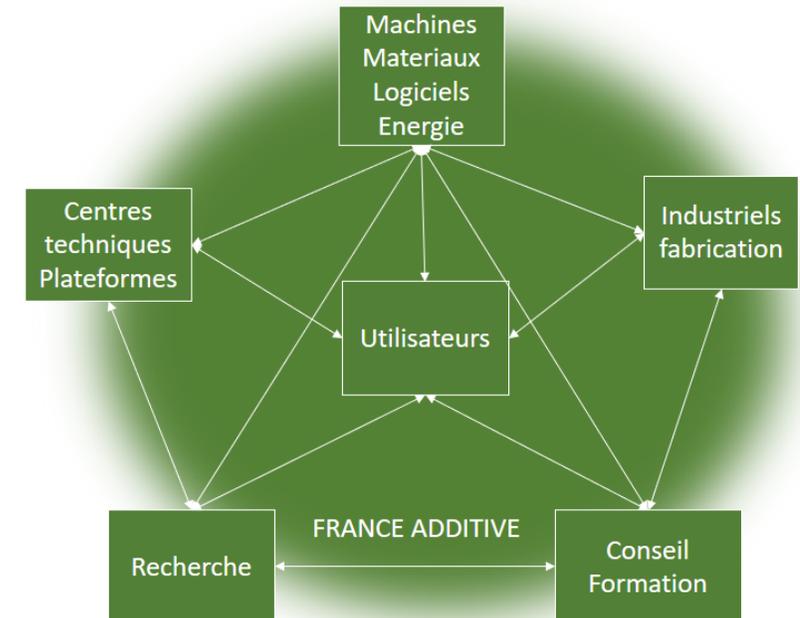
- France Additive
- Additive manufacturing: A systemic approach
- The main strengths of Additive Manufacturing
- The main future goals for Additive Manufacturing
- Conclusions

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# About France Additive

- Non profit association dedicated to AM, funded in 1992
- 100+ members. Multisectors, open, neutral
- Federate research and technical centers, education, industrials, services providers and final users
- 360° scope in an open community mode:
  - applications
  - technologies
  - materials
  - skills
  - R&D
  - digital
  - education
  - finance
  - supply chain
  - economic growth



# 100+ members

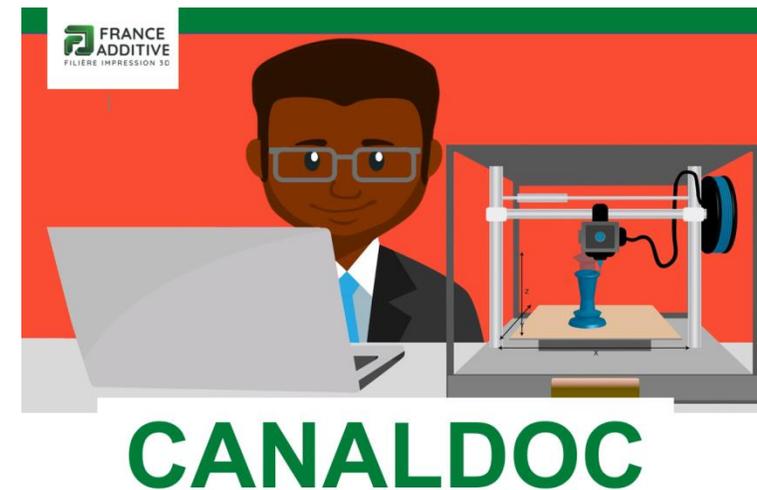


Source: France Additive, 2021

# Working groups in open community

Initiated by the members and animated by them, working groups on various topics are being proposed:

- ▣ Maintenance, repairing and repairability of parts
- ▣ Luxury – precisions and precious materials – Artisan of the future
- ▣ Automobile and new mobilities
- ▣ Large parts – DED and WAAM
- ▣ Training
- ▣ Health / Medical
- ▣ Safety at work
- ▣ SME executive club
- ▣ Program managers executive club
- ▣ Canal Doc (for PhDs and post-docs)
- ▣ ...



# Recent creation of a new Branch Strategic Contract

## SOLUTIONS INDUSTRIE DU FUTUR



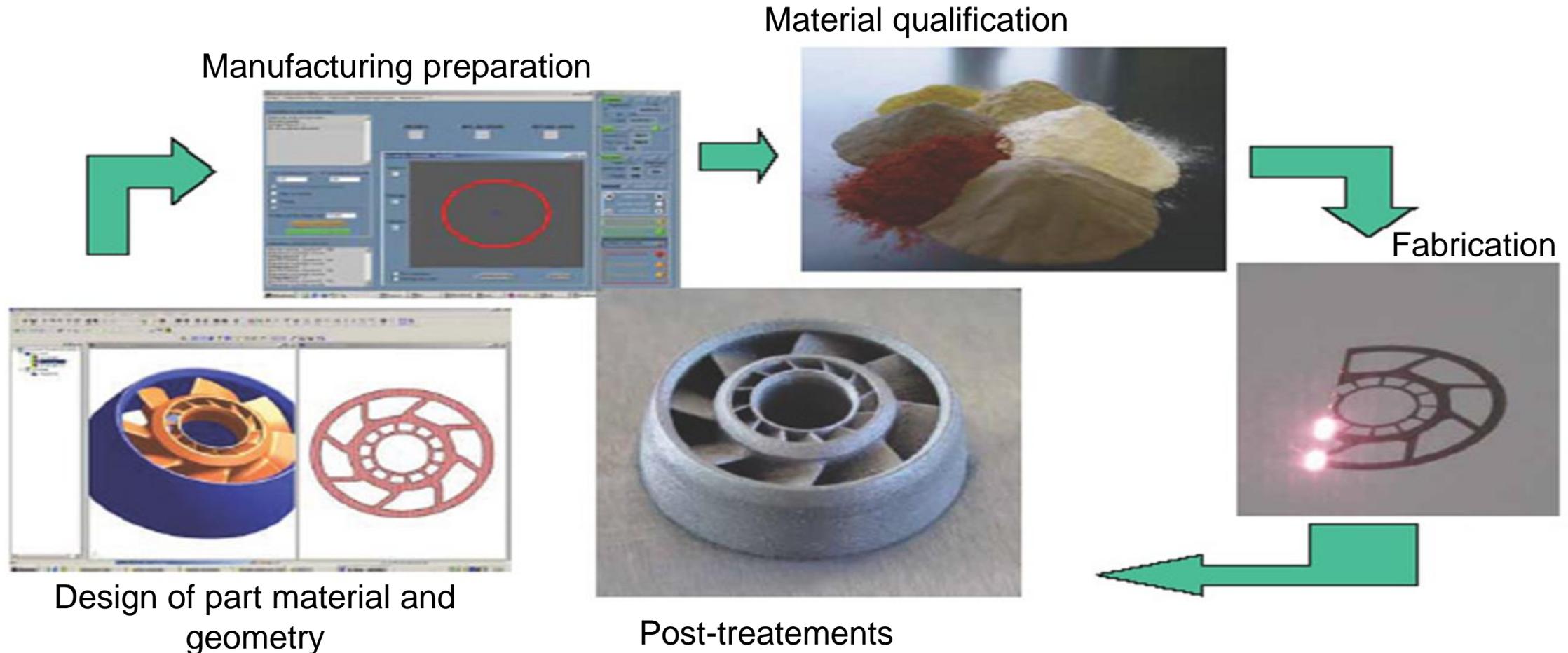
## GOALS

- Accelerate the development of AM in France
- Improve the competitiveness of French AM activities
- Improve the cooperation between all the actors of the ecosystem within complete value chains
- Boost the technical investments in the field of AM

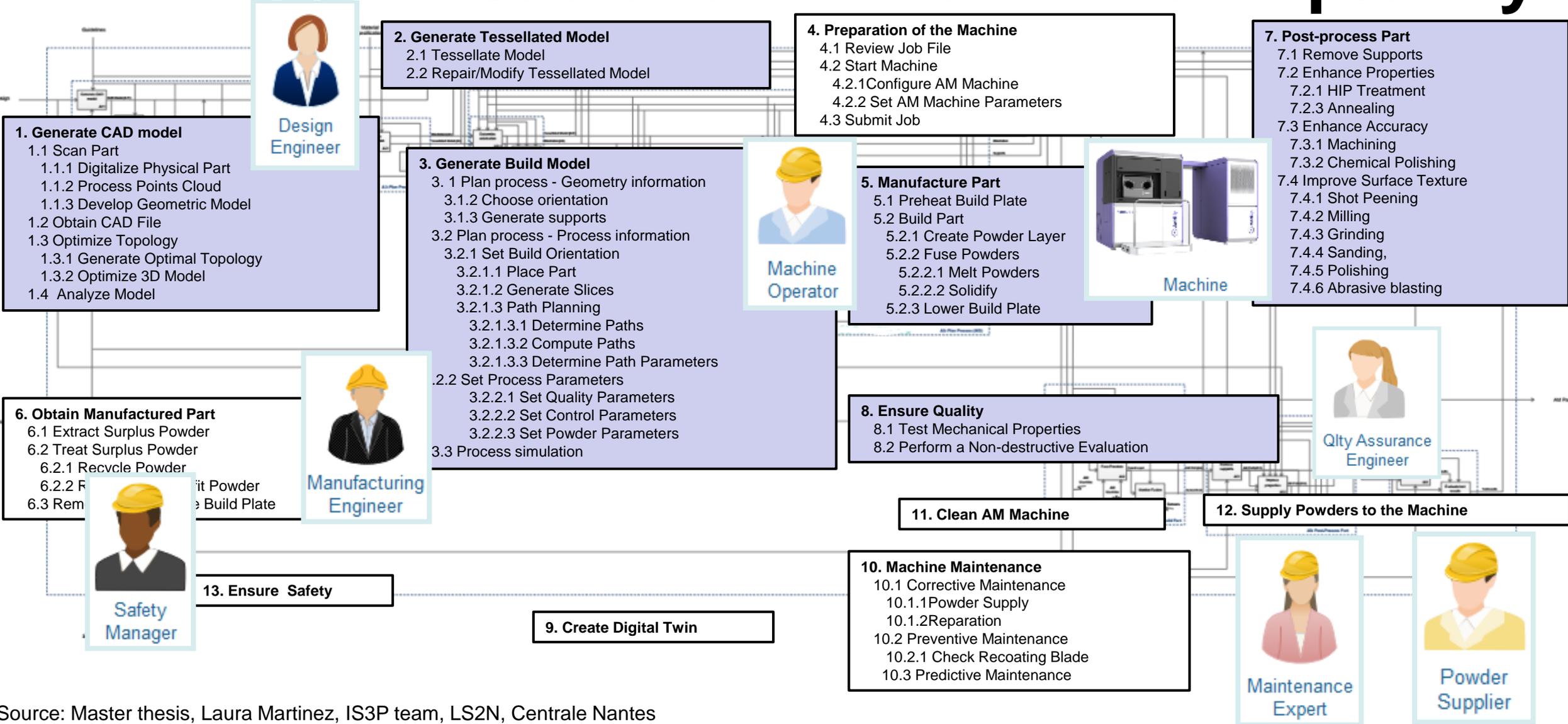
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# More than technologies : a complete value chain...

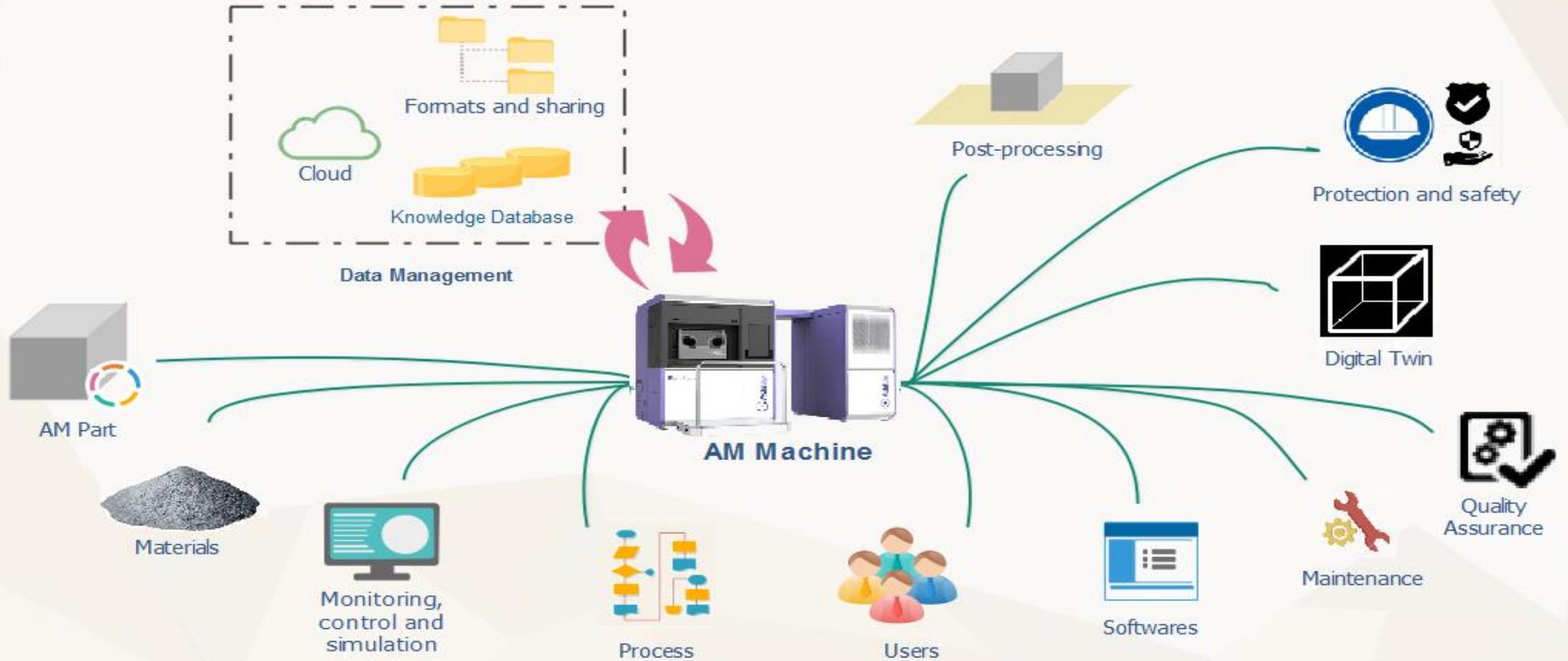


# AM-based value chain: Process complexity



Source: Master thesis, Laura Martinez, IS3P team, LS2N, Centrale Nantes

# AM-based value chain: Process complexity

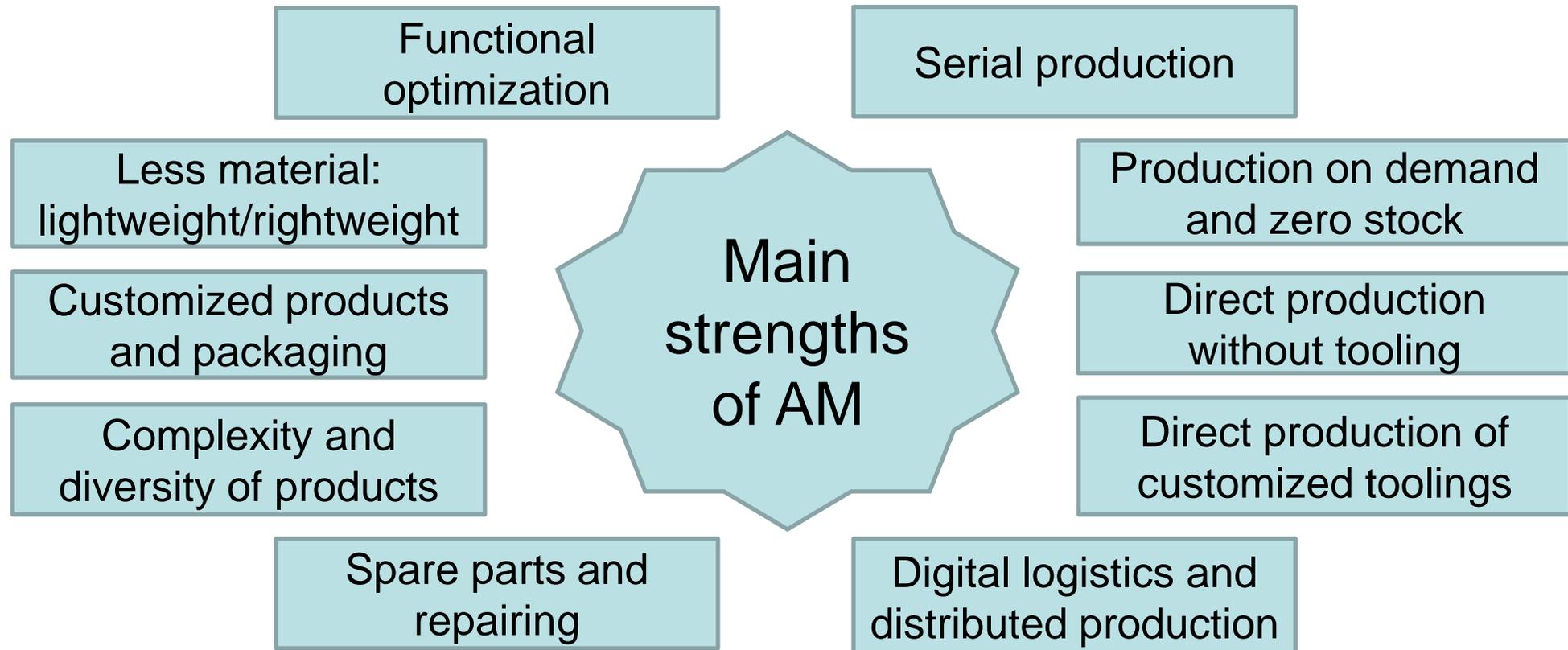


Source: Master thesis, Laura Martinez, IS3P team, LS2N, Centrale Nantes

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# Main strengths of Additive Manufacturing



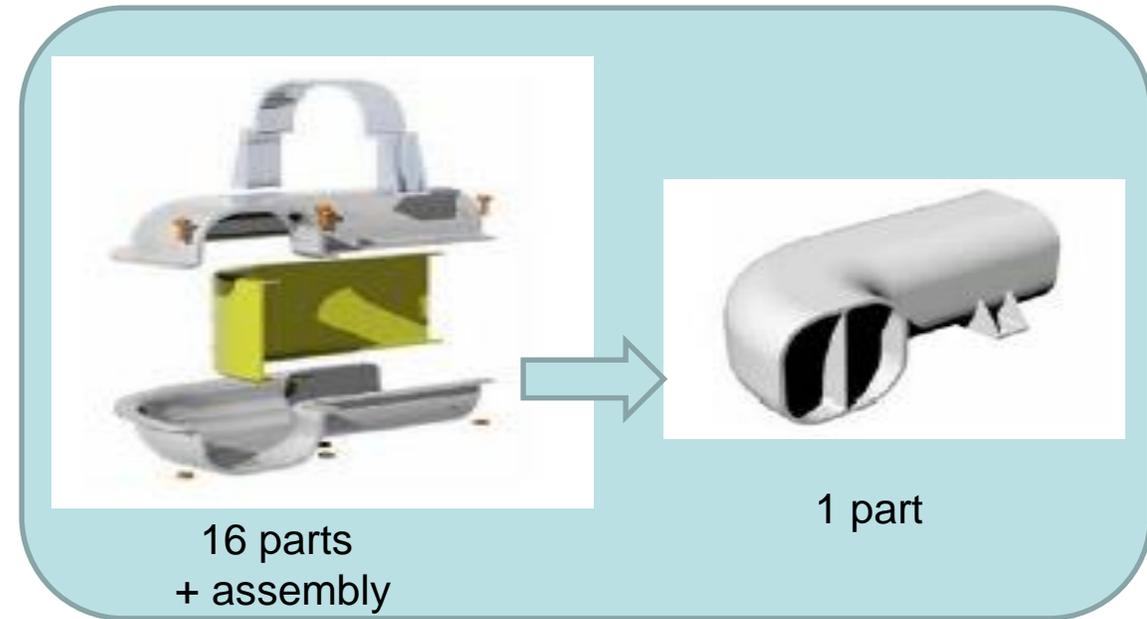
# Functional optimization



Source: General Electric

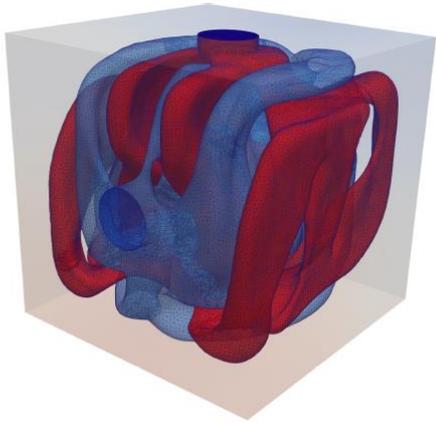


Source: Farinia Group

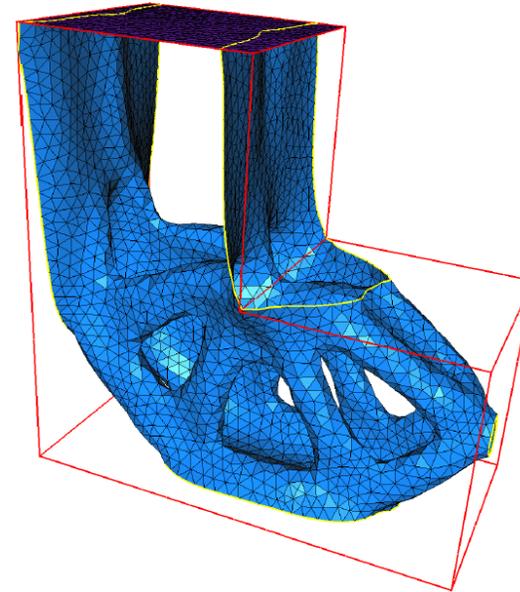
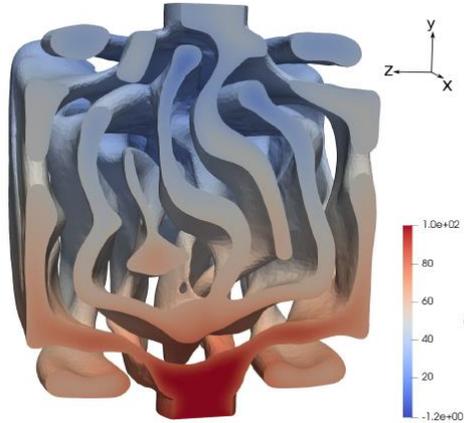


# Less material: Lightweight/rightweight

## Topological optimization/Lattice structures



Heat exchanger design



Minimal weight and compliance



Hydraulic bloc

Source: Yicha Zhang, UTBM

Source: Grégoire Allaire, Laboratoire CMAP, Ecole Polytechnique, France

# Customized products and packaging



Ot'Arts Seat (scale1)  
(Source: CIRTES)



Personnalized Packaging Pack&Strat  
(patented by CIRTES)  
Source: CIRTES

# Complexity and diversity of products



Deluxe Tapware by American Standard



Source : « imprimer le Monde » exhibition, Centre Pompidou, mars 2017



Bio-inspired design



Parts manufactured by Volum-e company



# Spare parts and repairing



Source : Beam, Courtesy : Chromalloy

Repairing



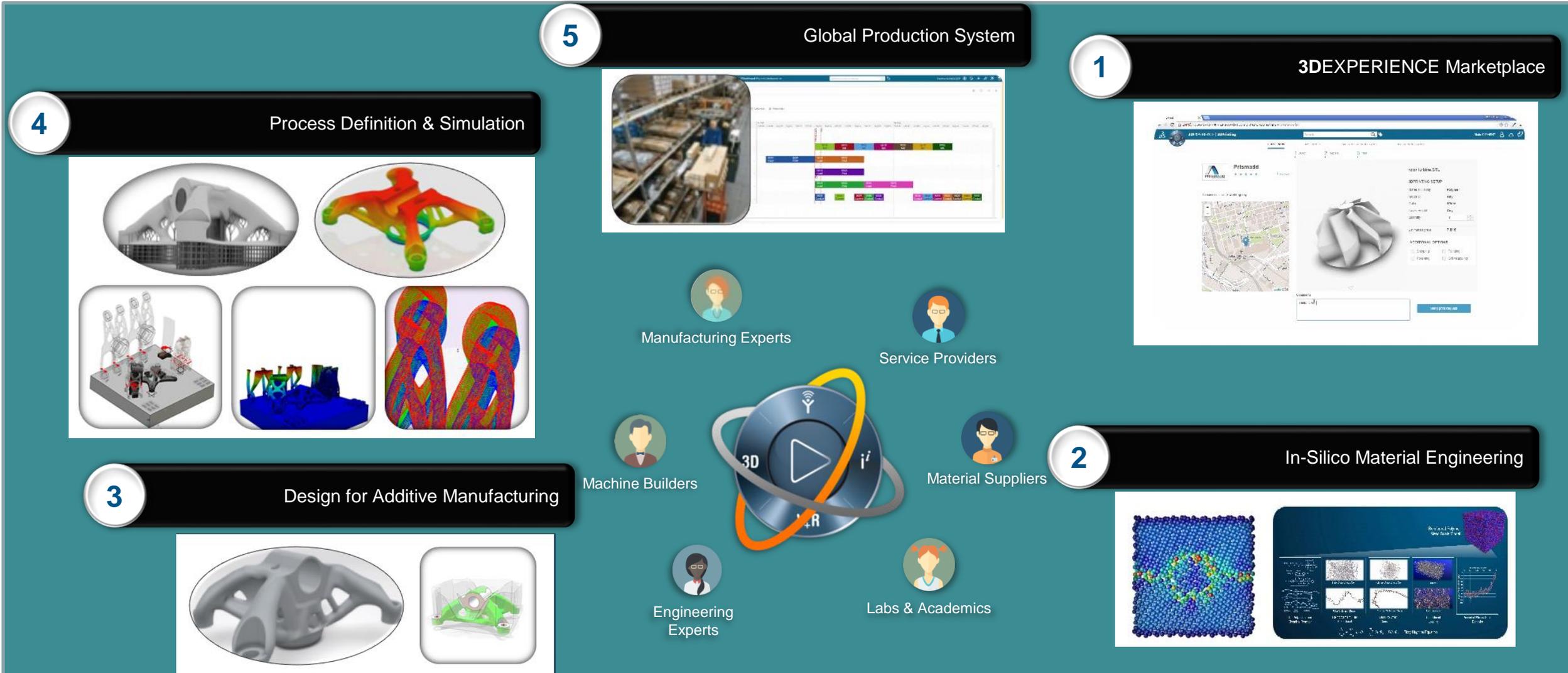
Source : Leolane,  
Courtesy : PWC (PriceWaterhouseCoopers)

Spare  
parts



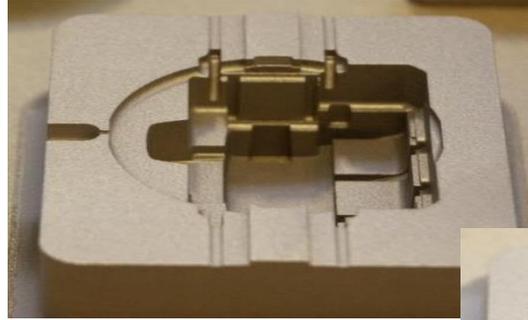
Source : Leolane,  
Courtesy : Mercedes Benz truck

# Digital logistics and distributed production

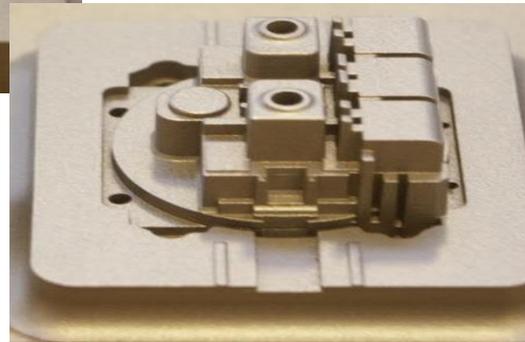


Source: Daniel Pyzak, Dassault Systèmes Additive Manufacturing solutions 3DEXperience

# Direct production of customized toolings



Inserts in molds  
Source: PEP



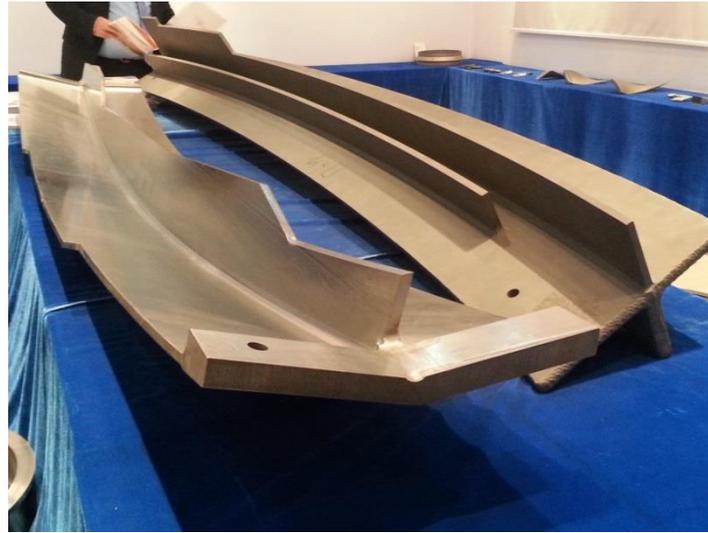
Inserts in molds  
Source: Realizer

Blowing tools  
Source: CIRTES



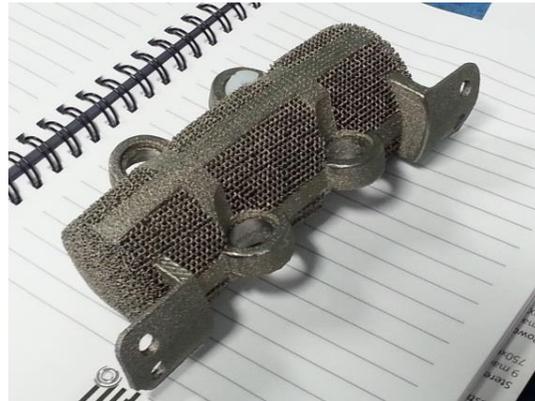
Injection molding toolings - PS Application PMP  
R&D contract PSA / CIRTES  
(Aluminium)

# Direct production without tooling



Source: Georges Fadel, AEFA 2015

Credit photo for these four pictures: Alain Bernard



Source: Volum-e, Courtesy: Airbus defense and space

# Production on demand and zero stock

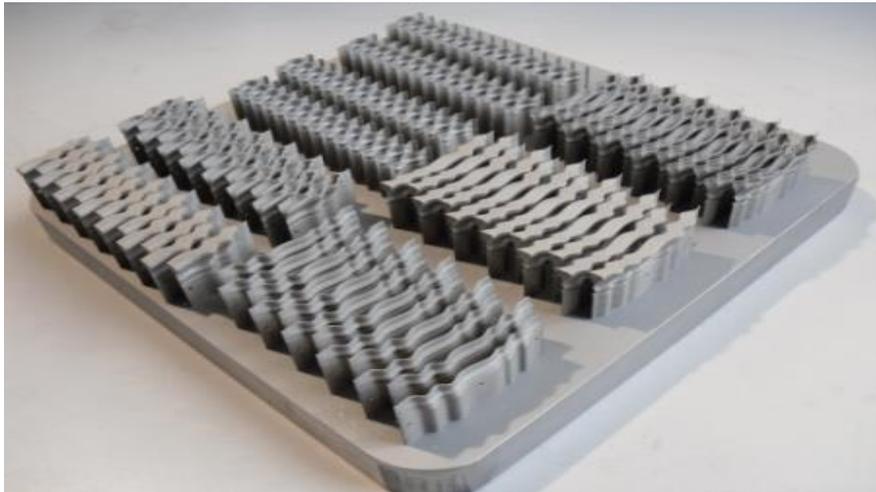


Source:<http://www.camboxisis.fr/shop/fr/content/16-3dprinting>

# Serial production



Source: Georges Fadel, AEFA 2015



Source: Phenix Systems



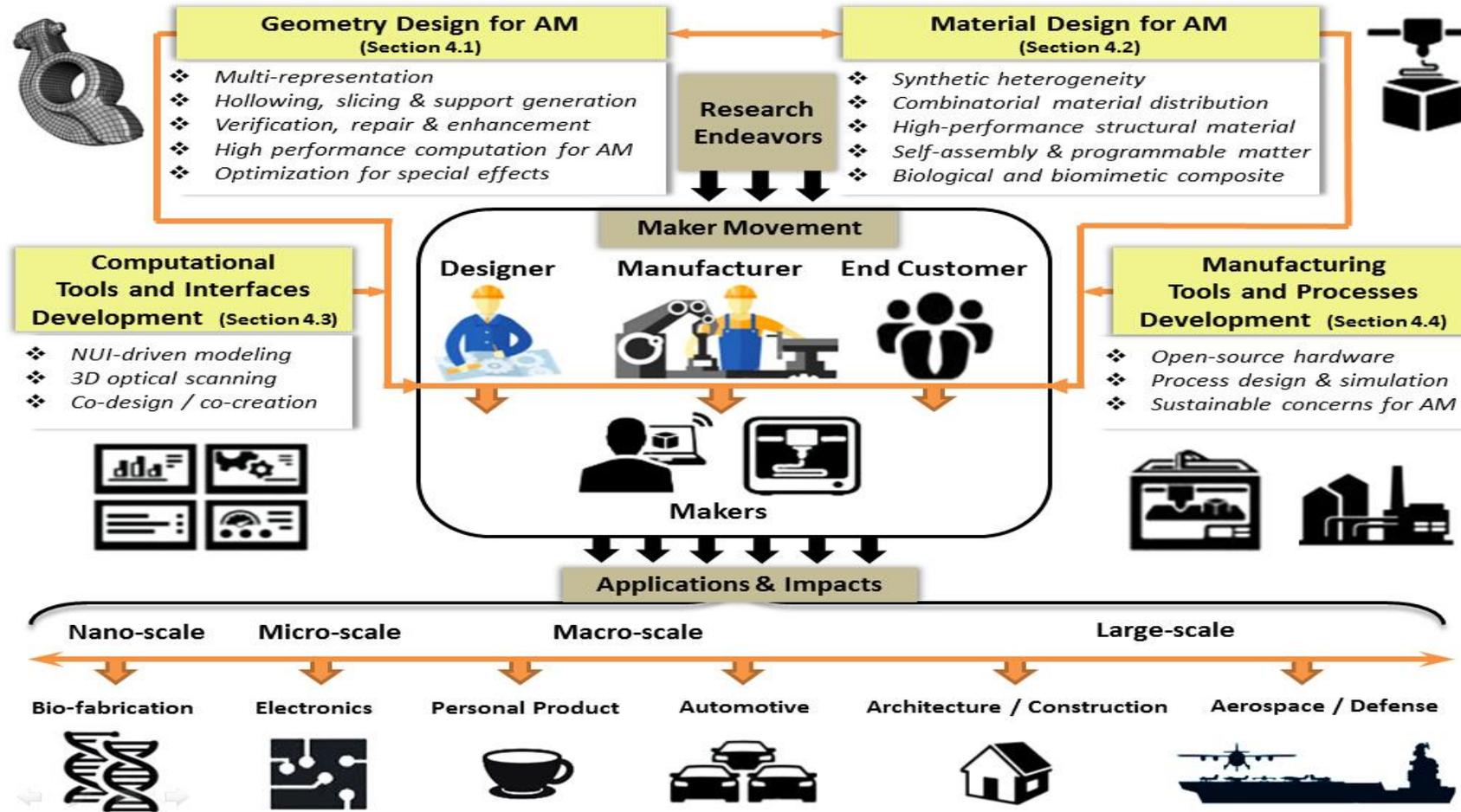
Batch production of a propeler

Source: Naval Group

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# A large impact at all scales and sizes



Source: <https://engineering.purdue.edu/cdesign/wp/the-status-challenges-and-future-of-additive-manufacturing-in-engineering/>

# Next stage of Additive Manufacturing

## ➤ Main expected evolutions

### Material

#### Enhancement of material portfolio

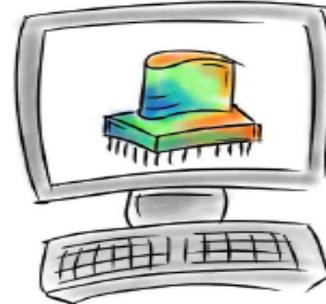
- High performance materials
- Multi-material and in-situ alloying



### Data preparation and process simulation and modeling

#### Pre-defined processing strategies

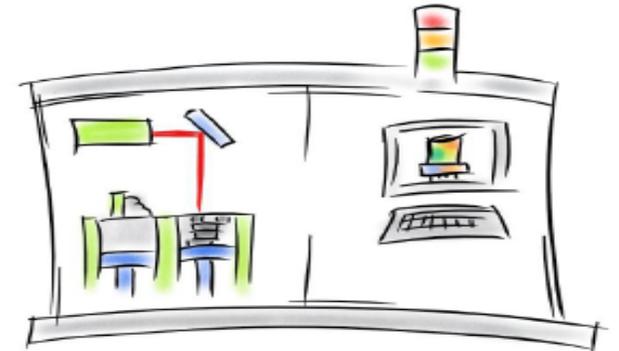
- Combining data preparation and process simulation
- Multiscale simulations & iteratively running optimization strategies



### System technology

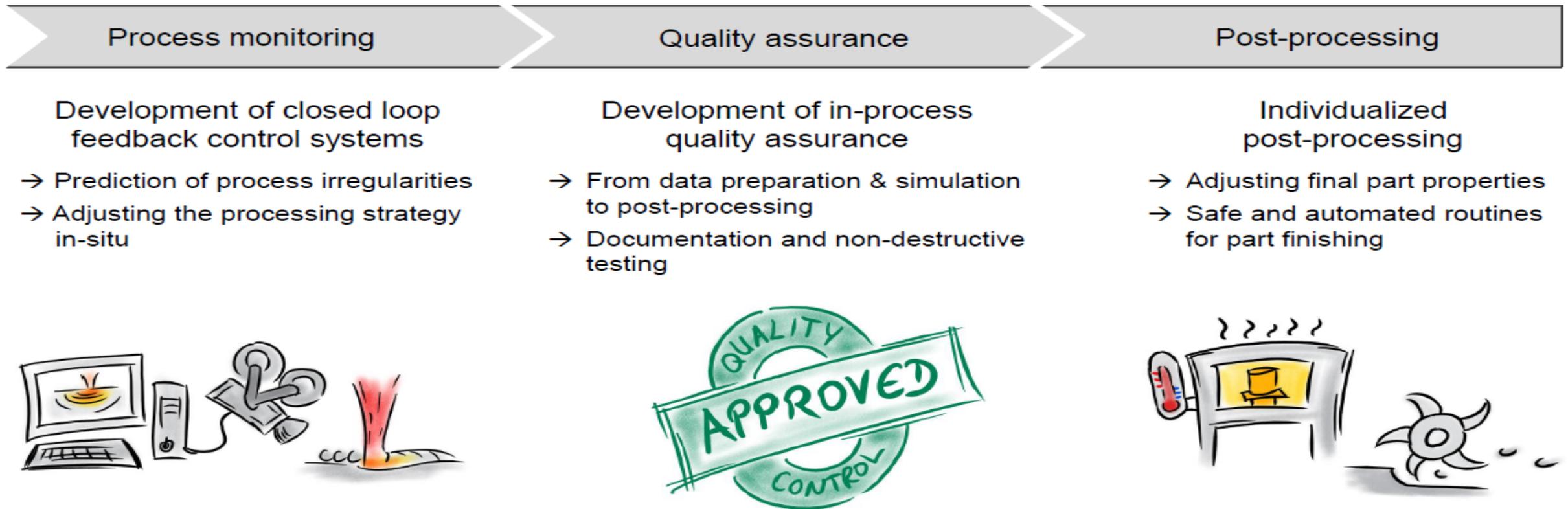
#### Automation of AM systems with increased build-up rates

- Multi-beam systems
- Enlarging build envelopes
- Beam shaping
- Integration in process chain

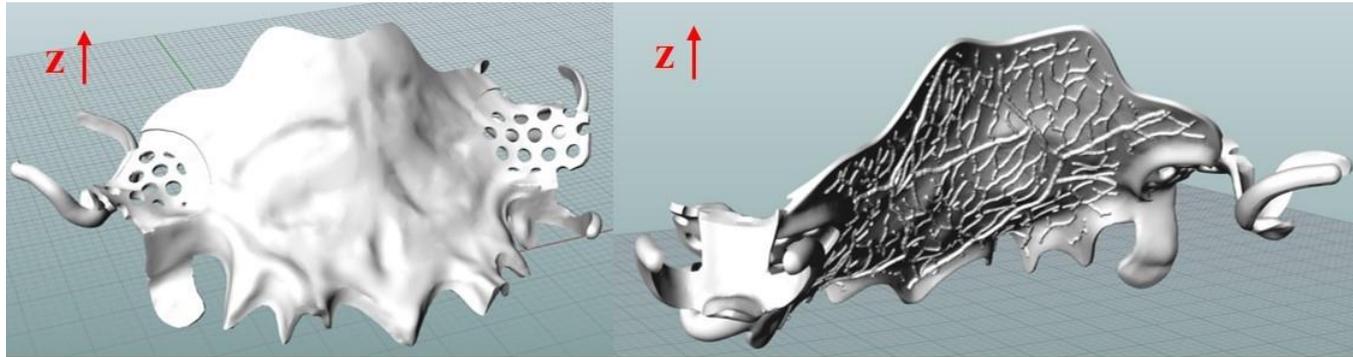


# Next stage of Additive Manufacturing

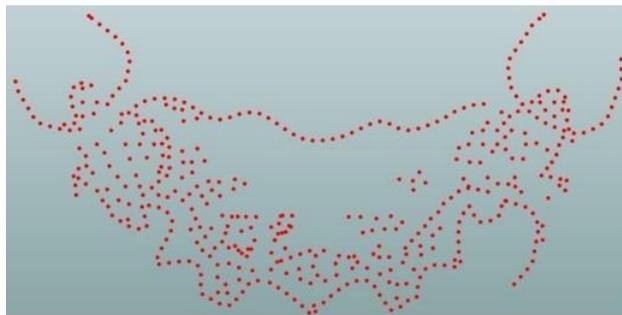
## ➤ Main expected evolutions



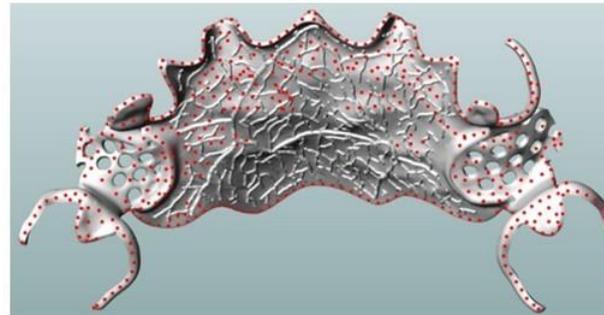
# ➤ Support point optimization result and L-system generation result



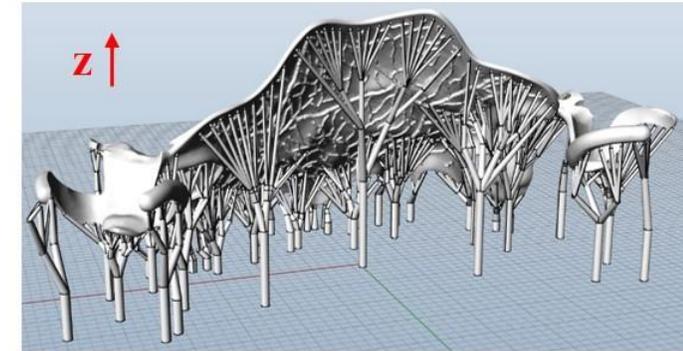
(a)



(b)



(c)

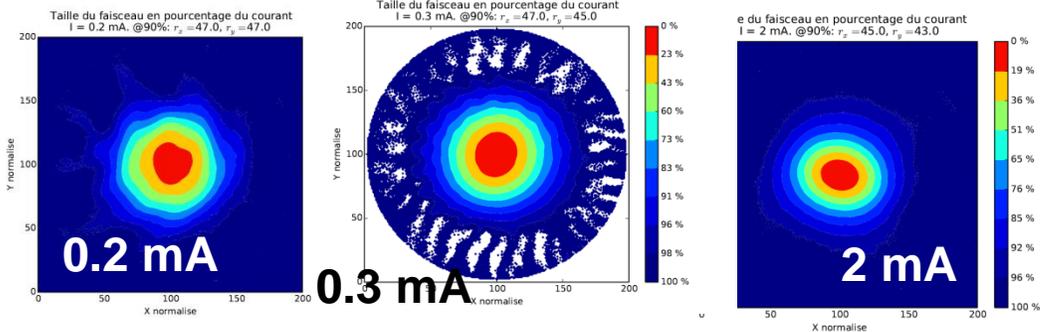


(d)

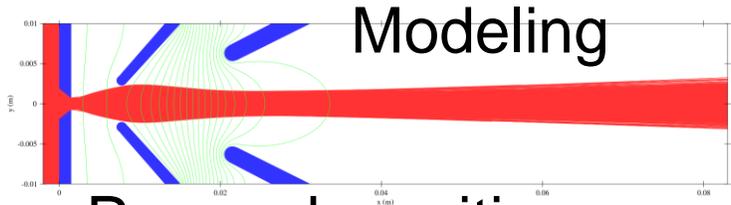
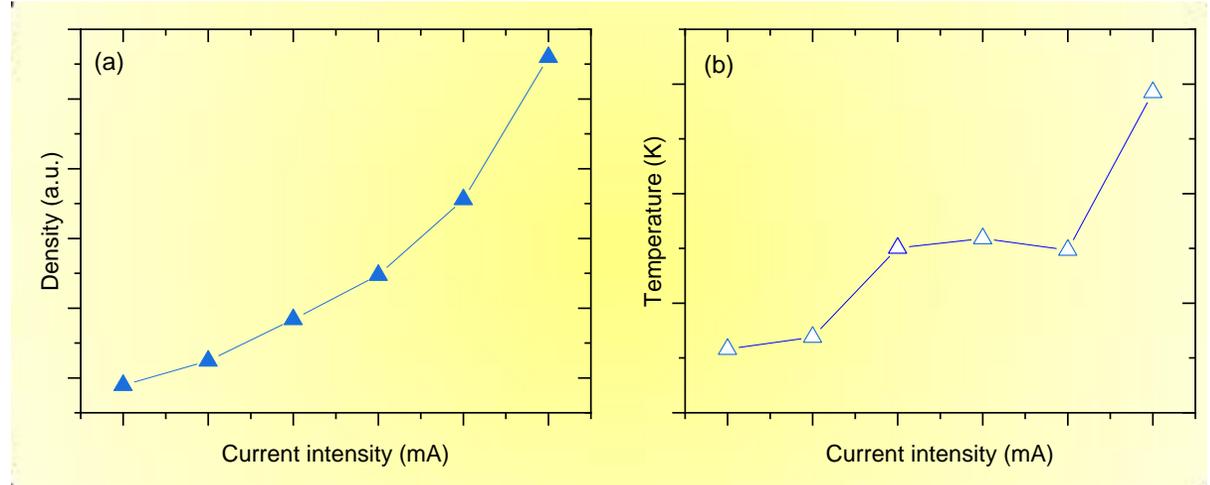
a. build orientation determination; b & c. optimized support points; d. an alternative tree structure generated via L-system rule

# ➤ Research on Electron-Powder Bed Fusion @ LPGP

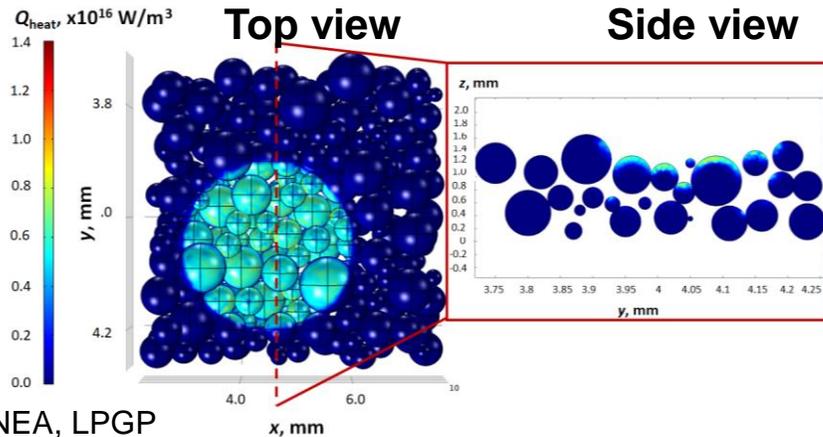
## e-gun: characterisation & design



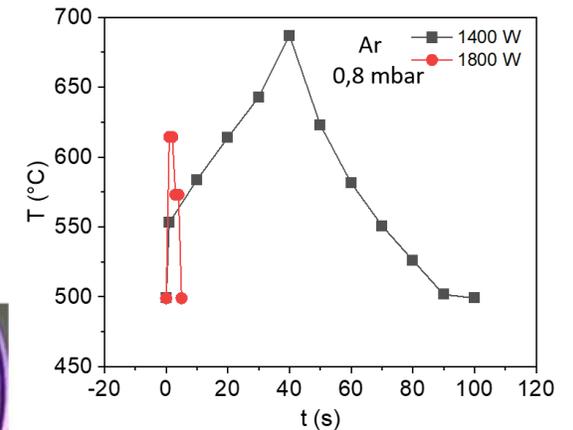
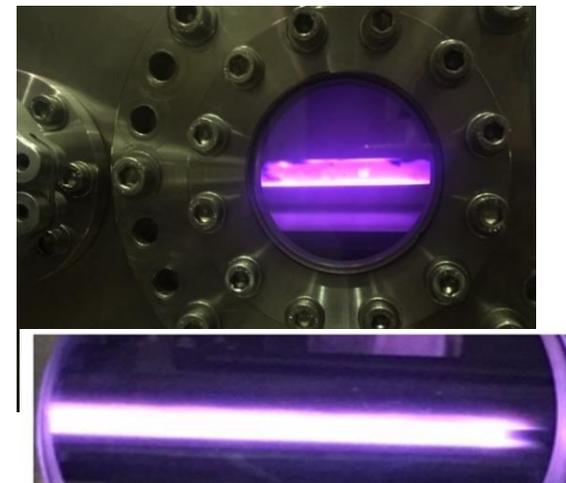
## Metal vapor analysis



## Power deposition on powder bed



## Powder preheating



Source : Tiberiu MINEA, LPGP

# ➤ New progresses in the field of technologies and materials



## Magnetic materials

À Nancy, Le 4 juin 2021

### COMMUNIQUÉ DE PRESSE

Un premier procédé direct d'impression d'aimants en 3D



Télécharger le visuel

Les équipes de l'Institut Jean Lamour – IJL (CNRS / Université de Lorraine) viennent de relever un véritable défi technologique : intégrer des propriétés magnétiques à des matériaux imprimés en 3D, sans post-aimantation. Il s'agit là d'une première mondiale avec ce niveau de performance et ces travaux ouvrent la voie à l'impression 4D d'objets magnéto-actifs. Ce procédé de fabrication d'aimants avec une imprimante 3D grand public est en cours de transfert au sein d'une entreprise du Grand Est.

#### Une prouesse technologique

Cette innovation technologique associe différentes compétences présentes à l'IJL : celles de l'équipe de recherche technologique Matériaux et Procédés Additifs, dirigée par Samuel Kenzari, ingénieur de recherches CNRS, et celles du Centre de Compétences Magnétisme et Cryogénie dirigé par Thomas Hauet, maître de conférences à l'Université de Lorraine. Le défi qu'ont relevé les chercheurs et ingénieurs est celui de concevoir une imprimante 3D de type FDM (dépôt de filament fondu) avec son fil magnétique composite pour imprimer des pièces elles-mêmes magnétiques.

Pour fabriquer le fil, ils ont utilisé des matériaux ferromagnétiques avec des formulations propres à les rendre imprimables. Pour ce qui est du dispositif d'impression, ils sont partis d'une imprimante 3D traditionnelle, à laquelle ils ont ajouté des composants permettant la mise en forme de l'aimant pendant l'impression. Les pièces produites par cette imprimante possèdent une ou plusieurs orientation(s) magnétique(s) permanente(s) sans nécessiter l'application d'un champ magnétique a posteriori pour les aimanter.

#### Une commercialisation prévue pour l'automne 2021

Une déclaration d'invention<sup>1</sup> a été déposée en 2019 et un contrat de licence de savoir-faire a été passé avec l'entreprise BB Fil basée à Heiligenberg en Alsace. La commercialisation d'une version grand public du procédé d'impression (imprimante et filament d'impression) est prévue pour l'automne 2021 : il deviendra ainsi possible d'imprimer des aimants personnalisables chez soi.

Ces travaux ouvrent la voie à l'impression 4D d'objets magnéto-actifs, qui pourront être déformés, activés ou commandés par un champ magnétique.

Ces travaux ont bénéficié du soutien du CNRS, de l'Université de Lorraine, de Lorraine Université d'Excellence, de la Région Grand Est et d'ICEEL.

<sup>1</sup> "Matériaux et procédé direct d'impression 3D d'objets magnétiques mono- ou multi-orientés" référencée à la SATT SAYENS avec le n°DISATTGE-275.

#### CONTACT PRESSE

Capucine François  
Chargée des relations presse  
06 71 00 07 80

## Desktop Metal becomes first to qualify 4140 steel for binder jet 3D printing technology



## Fully dense sinterable 6061 aluminum alloy parts

Source : <https://3dprintingindustry.com/news/desktop-metal-becomes-first-to-qualify-4140-steel-for-binder-jet-3d-printing-technology-191116/>



Digital Metal® first in the world to offer pure copper as printing material. Other materials: stainless steel 316L and 17-4PH, tool steel DM D2, super alloys DM 625 (Inconel 625), DM 247 (MAR M247) and Titanium Ti6Al4V.

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# Main strategic challenges



## An industrial challenge



## An environmental challenge



## A societal challenge



A disrupted industrial value chain. AM is intended to:

- Increase performances
- Decrease costs
- Reduce Time to market

A profound reorganisation of the 'supply chain'. Production:

- On-demand
- Close to end-use
- With the right material

Redistribution of added value across the value chain :

- National sovereignty
- Relocalisation
- Train and retain talents



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**Thank you for your kind attention.**

**Enjoy the conference.**