ESI Group

MSC Software Company

Simulation Driven Polymer Additive Manufacturing

6th International Carbon Composites Conference, Arcachon France, June 4-6, 2018

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June 4, 2018

PART OF HEXAGON

e-Xstream engineering, The Material Modeling Company

e-Xstream, The material modeling company
60 PhDs & MS Engineering 100% focused on advanced material modeling
15-year expertise

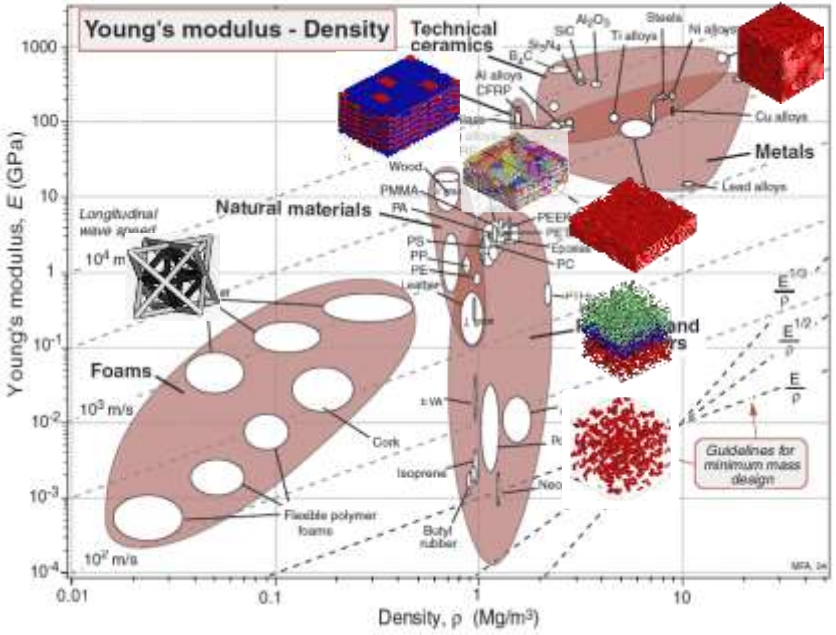
Digimat, The material modeling platform
Tools, Solutions & Expertise for modeling Plastics, Composites mainly
Wide & Deep Material & Process coverage

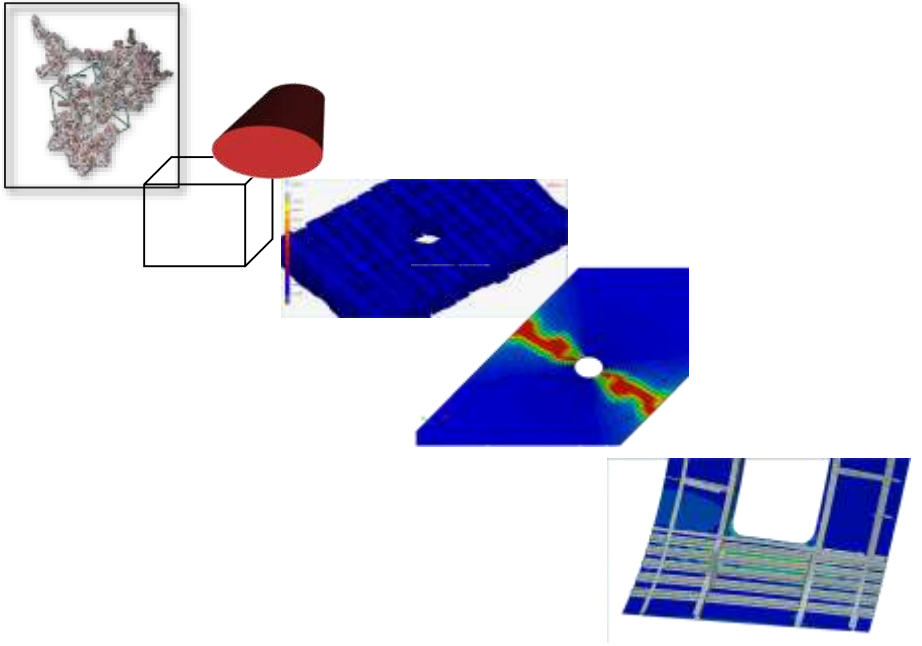
Global Market leader in Multi-Scale/Micromechanical Modeling
Market Leader in Automotive (Top OEM & Tier 1), Material Suppliers, E&E
Fast Growing in Aerospace & Defense (OEM & Suppliers)

MSC Software, 55 years of CAE (Nastran, Adams, …)
Large potfolio of software solutions
1,200 Engineers in 20 Countries

Hexagon, Leader of IT solutions to drive productivity & Quality
3.5B€, 17,000 people (3,400 R&D) in 50 countries
MSC Software & e-Xstream are part of Hexagon Manufacturing Intelligence division

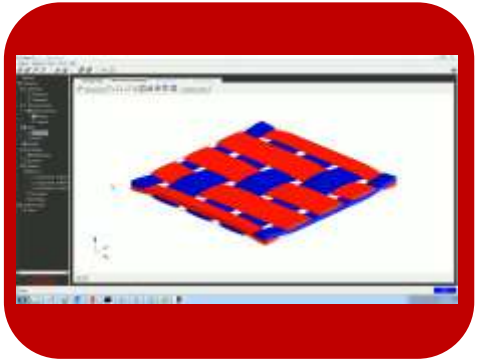
Digimat covers a relatively large spectrum of multi-phase & structured materials and connects all scales





nano *macro*

Our eXpertise empowered by Digimat

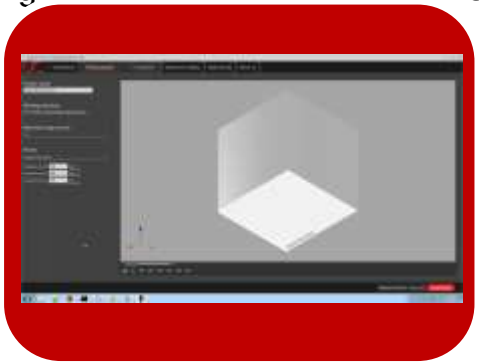


Virtual Material Engineering

Virtual Material Testing

Lightweighting & Metal Replacement

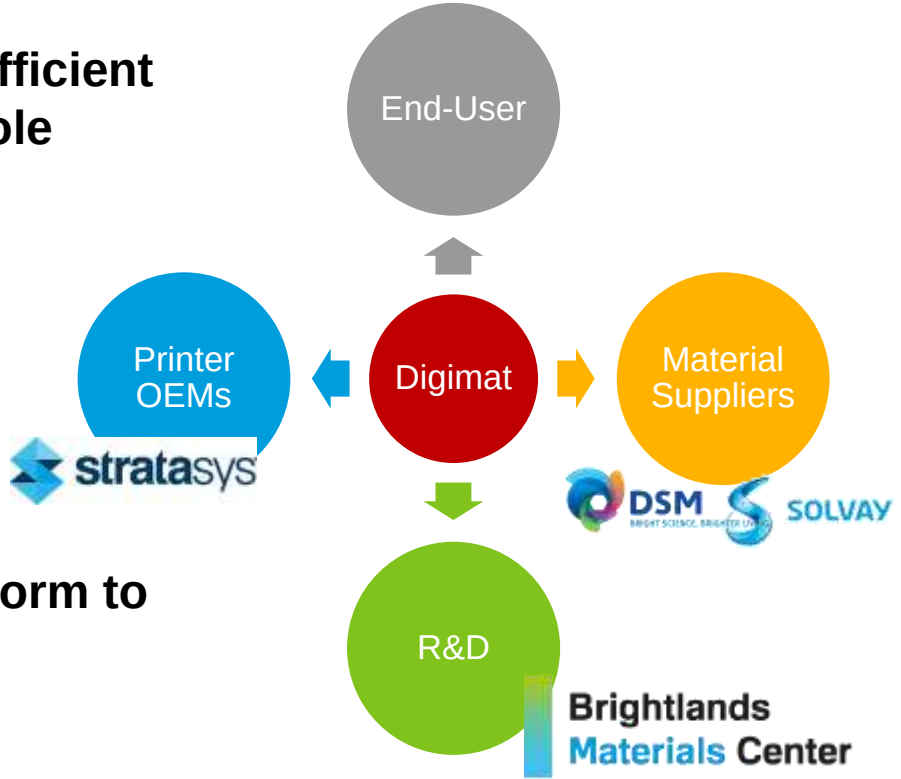
Effect of Defects & Manufacturing Process (Curing, AFP, …)



Polymer Additive Manufacturing

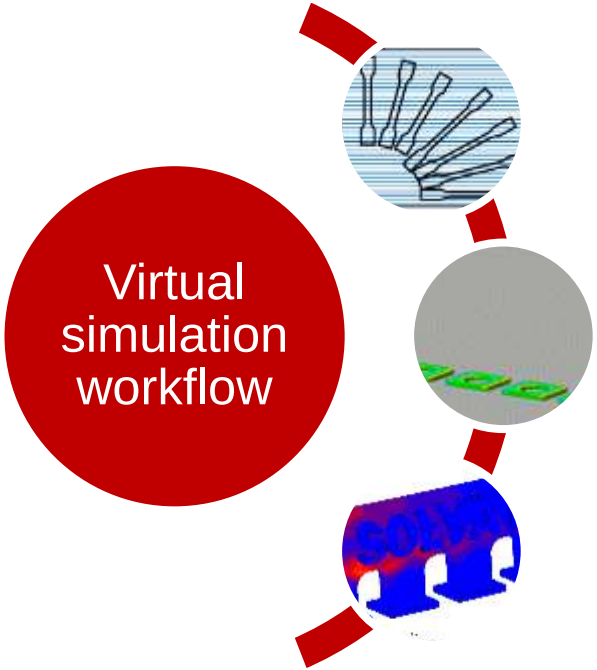
A 15-year expertise in material modeling to address (reinforced) polymer additive layer manufacturing

- **A strong eco-System for effective & efficient of ALM components covering the whole value chain:**
  - Printer OEMs
  - Material Suppliers
  - R&D & technical centers
  - End-Users



- **Building a modeling & exchange platform to address industrialization of additive manufacturing products**

The Digimat virtual twin for polymer SLS/FFF to accelerate industrialization

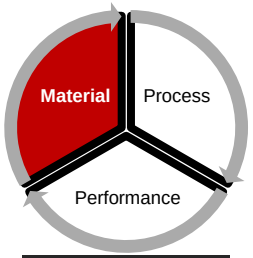


Material characterization for process & performances

Process modeling to predict & optimize warpage & residual stresses

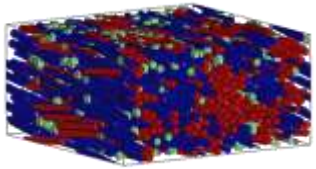
Parts' performances as a function of printing direction

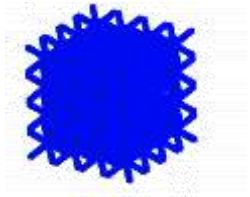
Studying, Understanding, Calibrating Materials

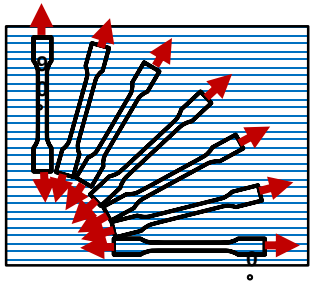


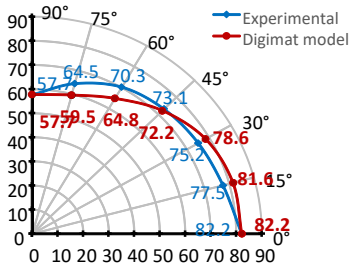
- Database
- Engineering
- Calibrating

- FDM Ultem 9085 from Stratasys
- FDM Ultem 1010 from Stratasys (new in Digimat 2018.1)
- FFF KetaSpire PEEK from Solvay (new in Digimat 2018.1)
- SLS Sinterline PA+40%GB from Solvay

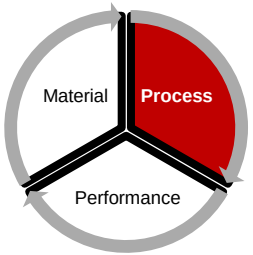






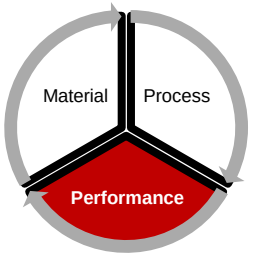


Simulating the AM Process



- Printing Machine Database
  - Fortus 900MC from Stratasys
  - Generic FFF Machine
  - Generic SLS Machine
- Printing Technology
  - Selective Laser Sintering (SLS)
  - Fused Filament Fabrication (FFF)
  - Fused Deposition Modeling (FDM)
- Printing Strategy
  - Advanced Representative Volume Element (not in official version)
  - Inherent strains (multiscale approach)
  - Full thermo-mechanical analysis (new in Digimat 2018.1)
- Printing outputs
  - Final shape (distortion)
  - Residual Stresses

Predicting Parts' Performances



- Material Anisotropy
  - Micromechanical material model
- Process specifities
  - Toolpath
  - Residual stresses
- Solver
  - Interface to most of the FE Solver
- Performance
  - Non-linear behavior
  - Strength

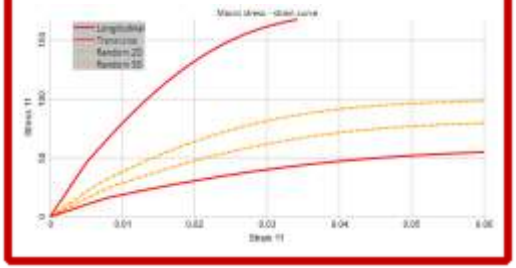
Connecting the dots to efficiently adopt polymer AM

Process

3D printing Software:

Digimat

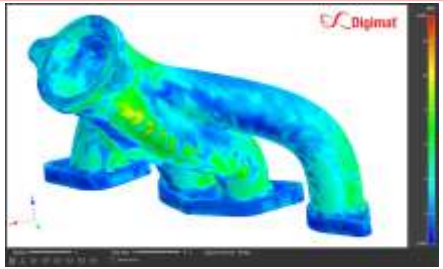
Material



Digimat

- Material database
- Mapping technology
- Multiscale FEA

Performance



Digimat interfaced with FE Software:

MSC Software

Abaqus Solution Partner SIMULIA

LSTC

esi get it right

ANSYS

Altair

SAMTECH

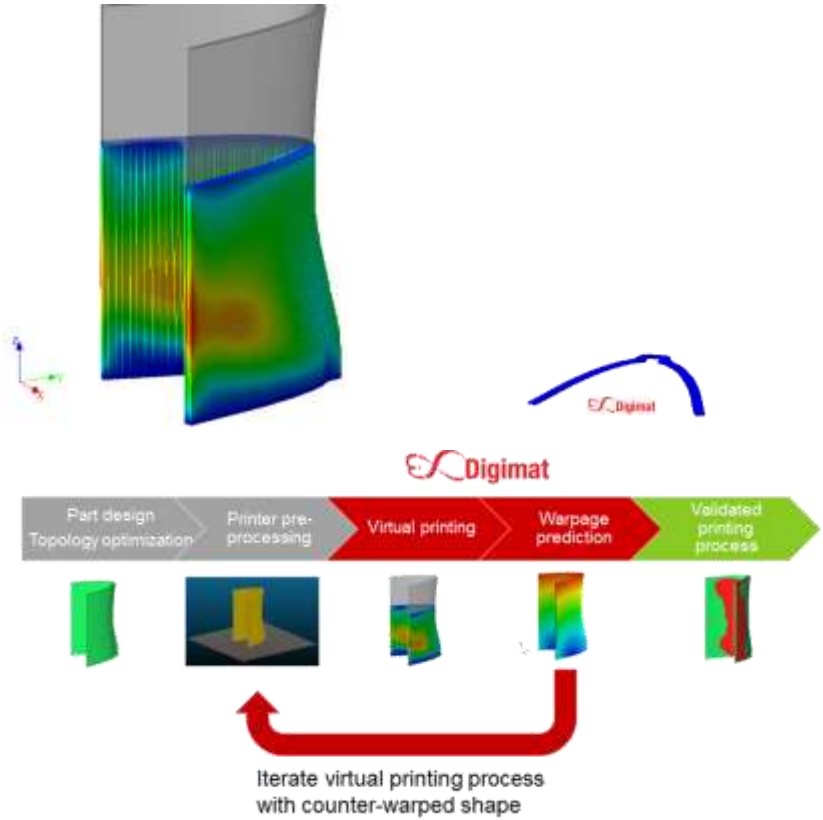
INTES

FDM Application Cases

Simulation to help matching severe tolerances of FDM composite tooling

- Framework
  - Fortus 900MC
  - Ultem 9085

- Objectives
  - AM Simulation to predict warpage & residual stresses and anticipate printing issue
  - Warpage compensation analysis to minimize warpage & match dimensional tolerances

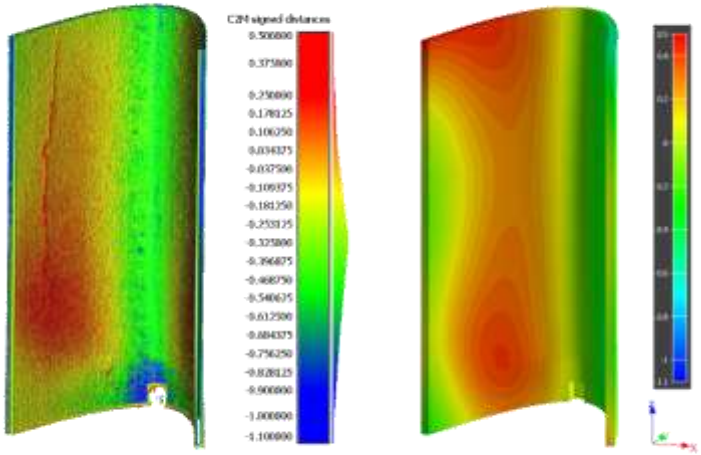


Simulation to help matching severe tolerances of FDM composite tooling

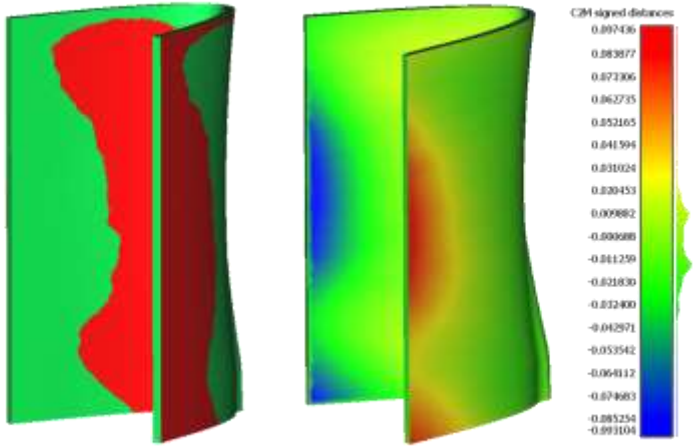
"For engineers to unlock the design freedom that additive manufacturing offers, they need tools for accurate and effective analysis. Working with e-Xstream, we're enabling 3D printing to become a high performance production technology."

– Scott Sevcik, Head of Aerospace, Defense & Automotive at Stratasys

- Results

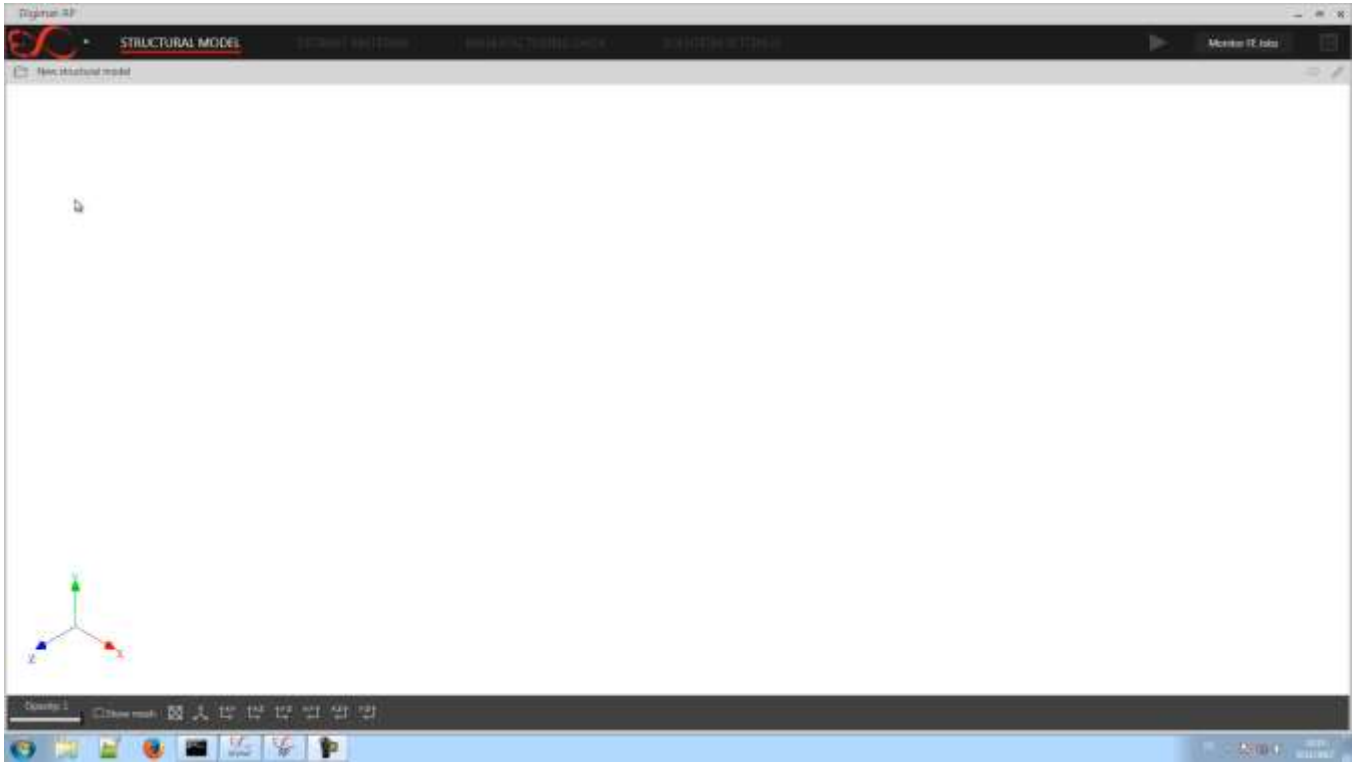


Comparison between measured warpage on a physically printed part (RMS signed distance, left) and Digimat-AM warpage prediction (X displacements, right)



Warpage prediction after geometry compensation in Digimat-AM. Left: superposition of the as-printed (red) and as-design (green) parts. Right: RMS signed distance. Maximum deviation is below 0.1 mm.

Simulation to predict the performances of FDM parts

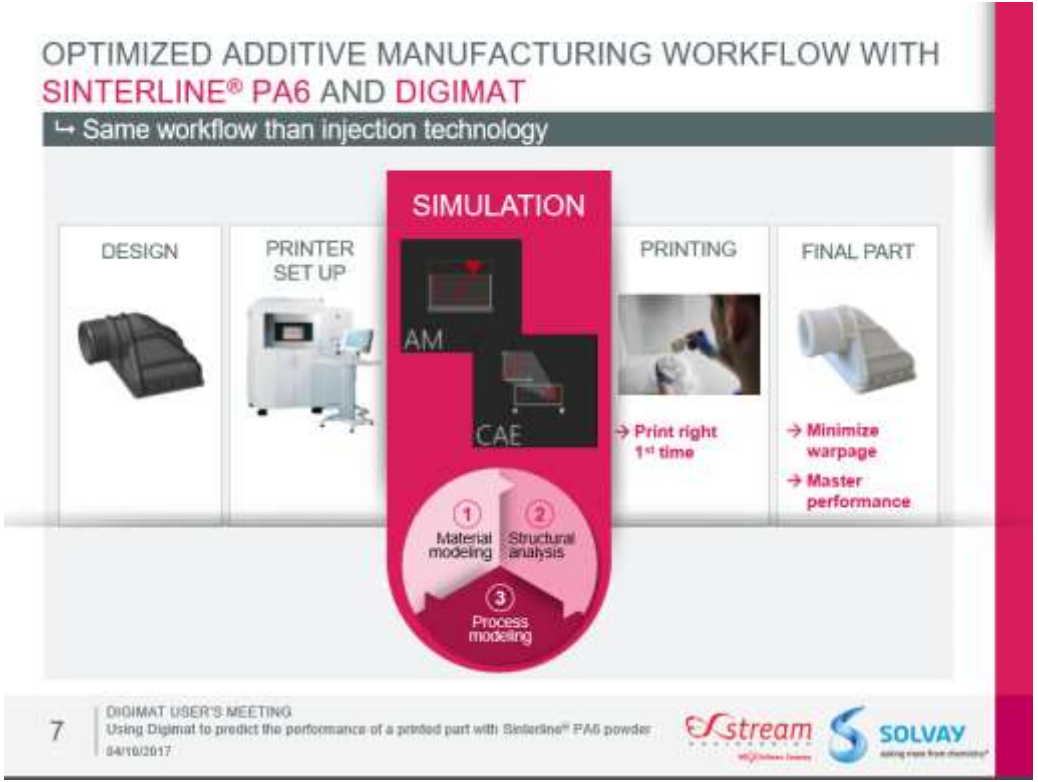


Charge Air Cooler

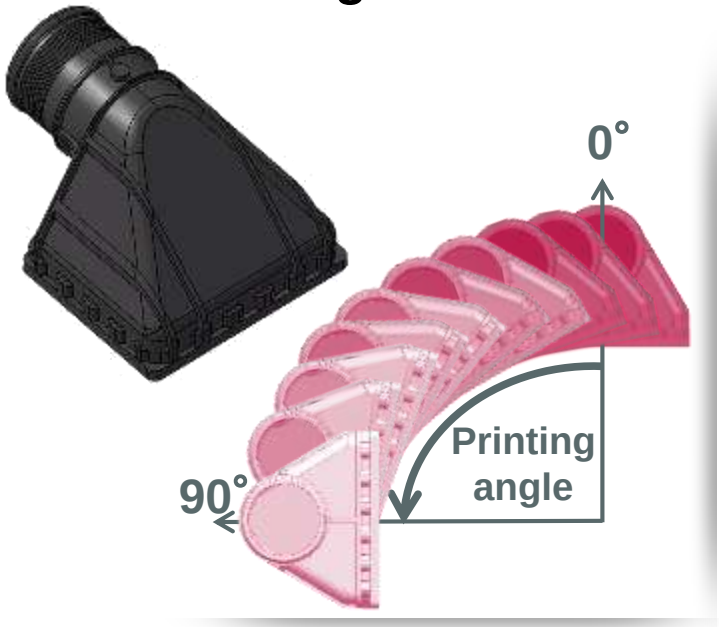
SLS Application case

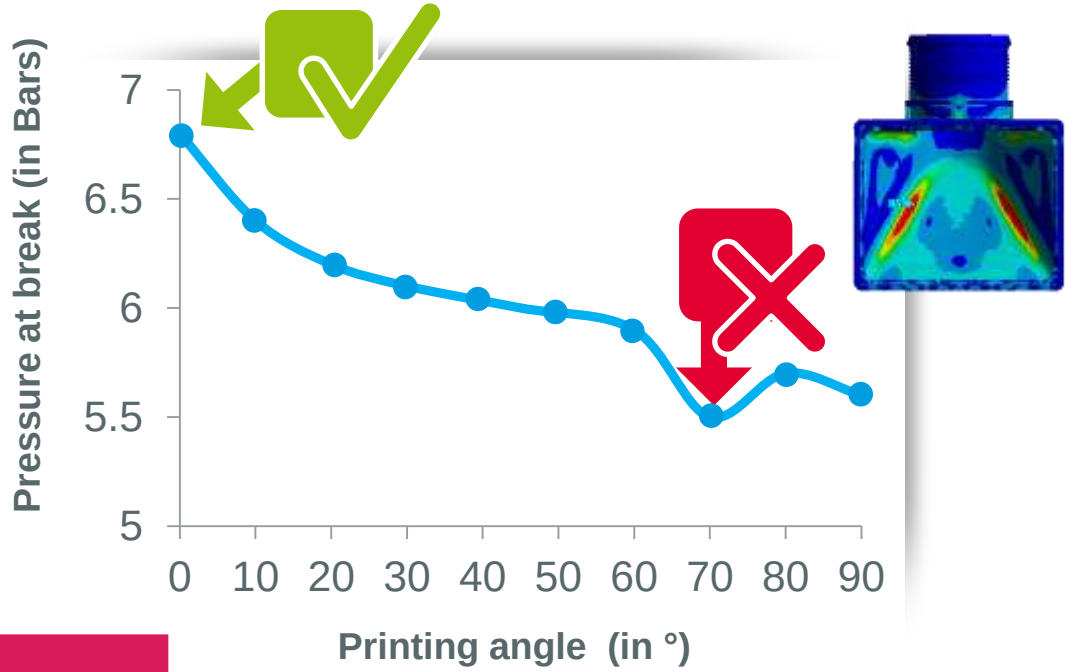
Application case from Solvay Engineering Plastics

- SLS ALM Process
- Objectives:
  - Evaluate the impact of the printing direction
  - Predict and optimize part's warpage



Simulation to quickly identify the best printing direction to ensure the highest mechanical prediction



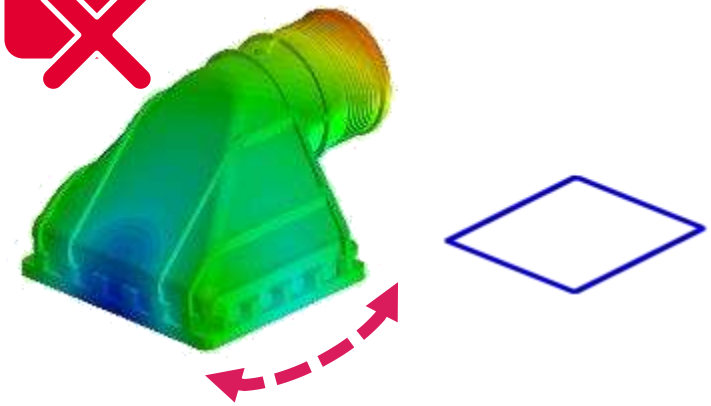


Highest mechanical resistance is obtained with preferred printing orientation 0° and 180°

Simulation to predict part dimensions to optimize build filling with selected printing orientations

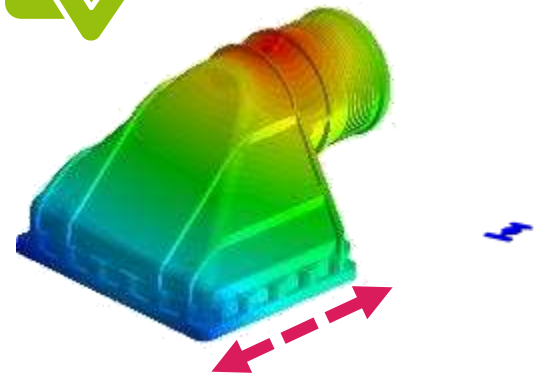
Print 0°

Deflection result



Print 180°

Deflection result

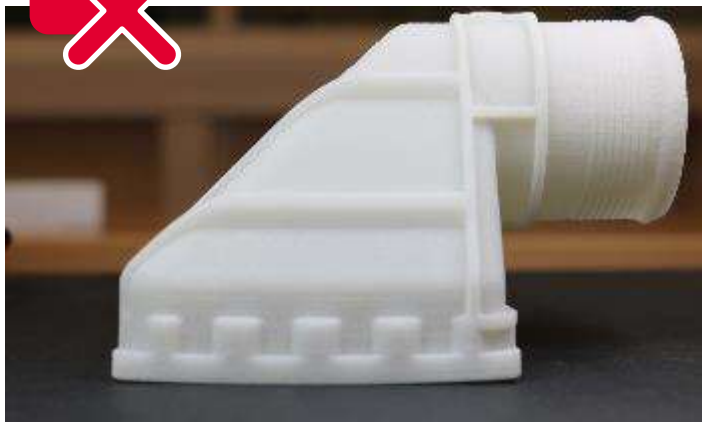


Orientations 0° and 180° show different part dimensions
➔ compensate warpage of printing 0

Real printing is aligned with the simulation prediction

Print **0°**

Without warpage compensation



NOK

Print **180°**

OK

1 iteration with Digimat to compensate warpage and ensure part quality

Print **0°**

With warpage compensation

OK

Print **180°**

OK

Conclusion

Simulation to Unlock the Potential of Additive Manufacturing

- To help to provide the right material and the right platform for specific applications to accelerate adoption of 3D Printing into manufacturing
- To anticipate printing issue and compensate distortion
- To save time & costs by avoiding unnecessary trial parts
- To build knowledge & guidelines
- To predict parts' performance as a function of material & process

Digital Thread Applied to AFP-ATP Components

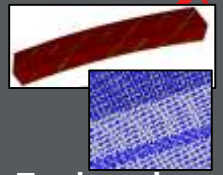
HEXAGON

DIGITAL WORLD

Data Management and Analytics

Machine Programming
Software

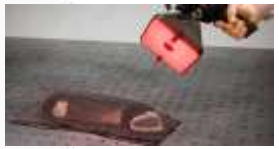
Material Engineering
Software



Engineering
Software

REAL WORLD

AFP-ATP Deposition
Manufacturing



Scanning
Hardware & Software

OUTCOMES

- ❑ As-programmed part's performances
- ❑ As-manufactured part's performances
- ❑ Analyze deviation including defects & thicknesses between as-programmed & as-manufactured part

BENEFITS

- ❑ Access real time the performances of the part
- ❑ Optimize the deposition strategy prior to manufacturing
- ❑ Optimize the deposition strategy based on in-situ measurement

We make your dreams material…

Thank You

Celebrating 15 years of material innovation

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