DMP Tech Brief Introduction

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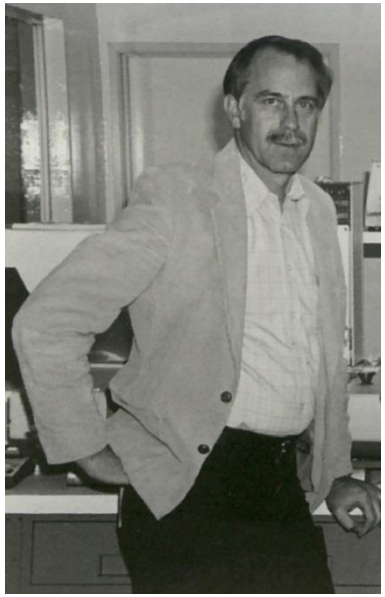
June, 2020

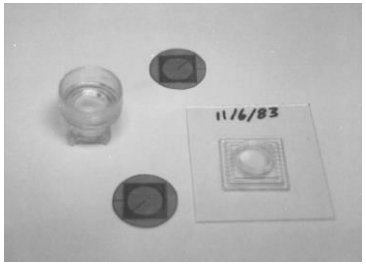
We are at an inflection point.

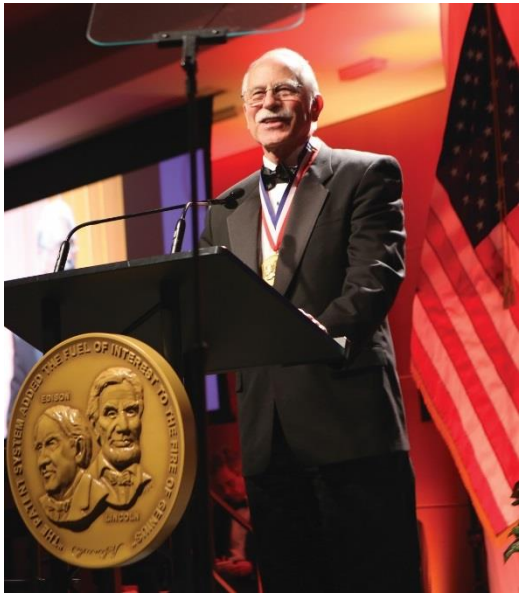
3D printing is shifting from prototyping to production.

With our technology, our talent, and our domain expertise, we are making 3D production real.

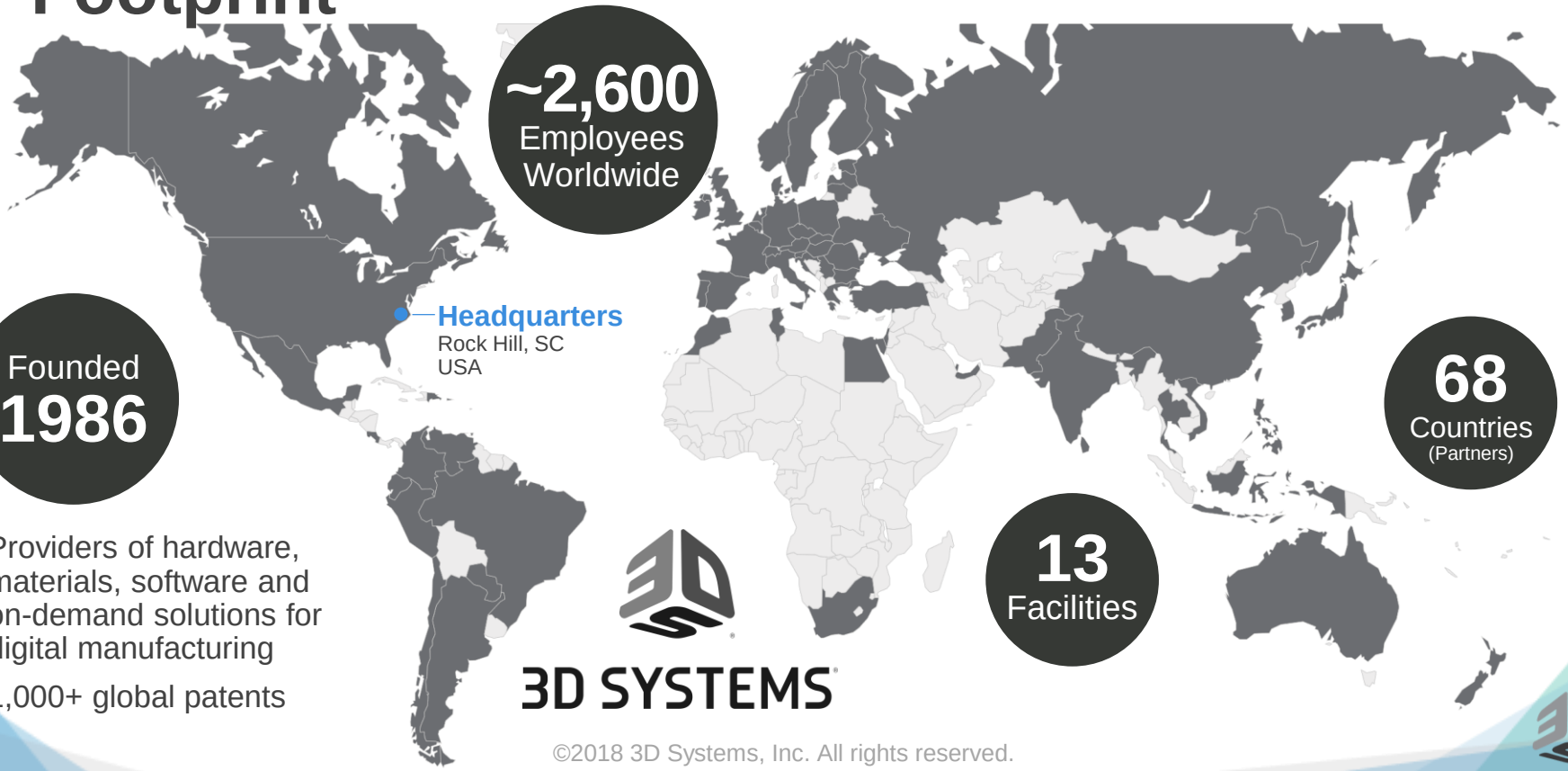
Born From a Spark of Inspiration in 1983







3D Systems—Global Footprint



- Providers of hardware, materials, software and on-demand solutions for digital manufacturing
- 1,000+ global patents

3D SYSTEMS

Making 3D Production Real

Ecosystem Enables Workflow

DIGITIZE → DESIGN & SIMULATE → MANUFACTURE → INSPECT → MANAGE

Key Imperatives for Transformation

Productivity → Durability → Repeatability → TCO

Broadest AM End-to-End Solution Portfolio

+

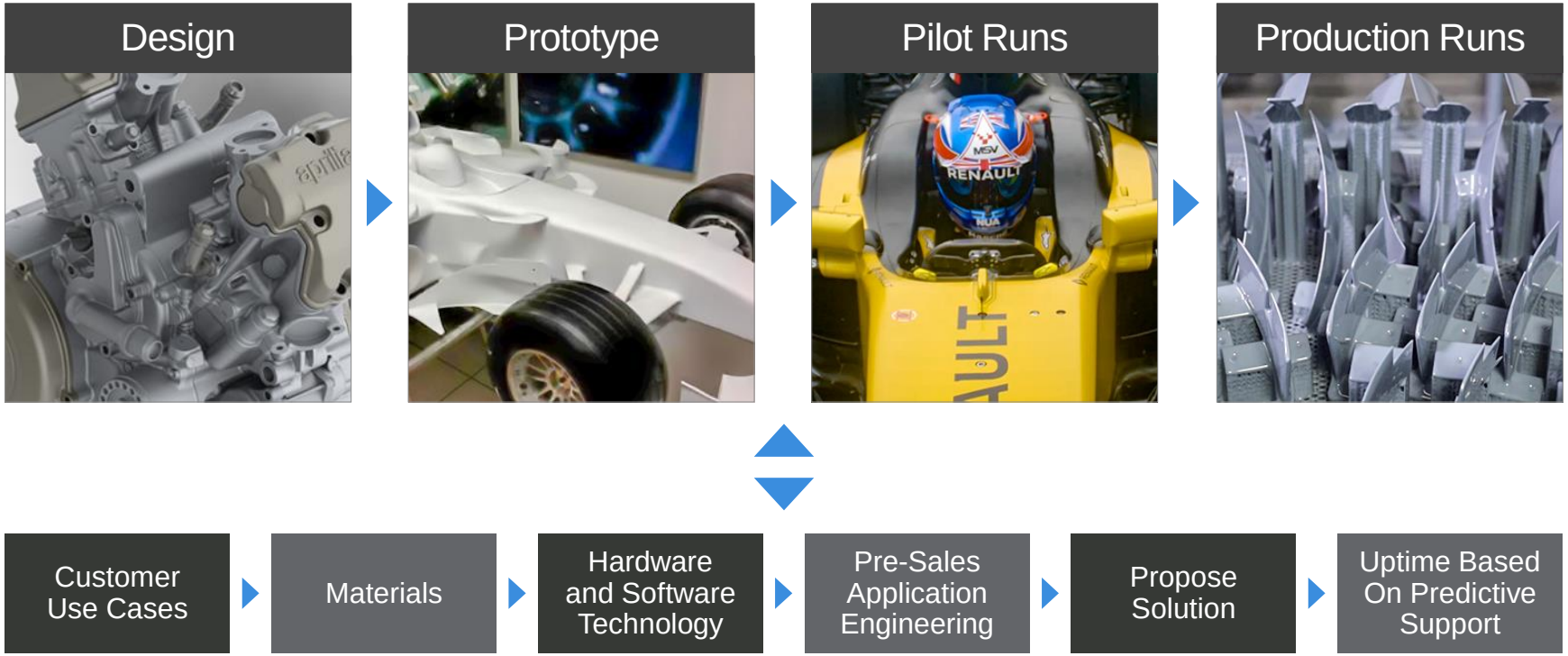
Sp 3D Sprint™ Xp 3DXpert™ Ci Cimatron® Gc GibbsCAM® Co 3D Connect™ Service

Cx Geomagic® Control X™ Dx Geomagic® Design X™ Ff Geomagic® Freeform®

+

Customer Engagement Model

- Product Lifecycle

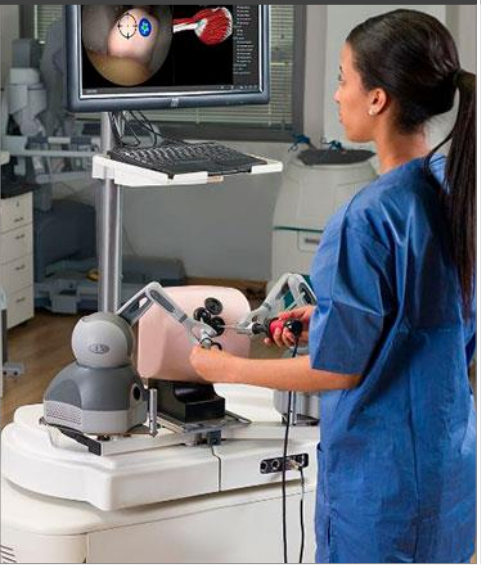
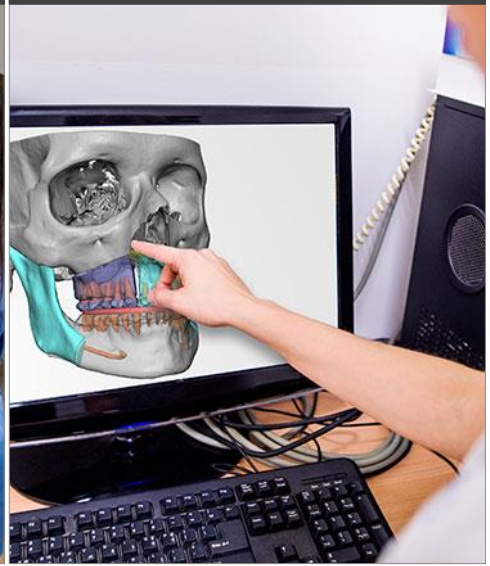
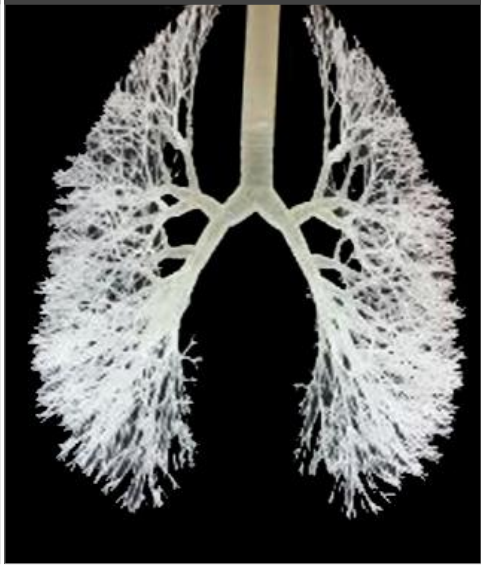


Vertical Approach and Domain Expertise

Healthcare	Dental	Aerospace	Automotive	Durable goods
				

Healthcare

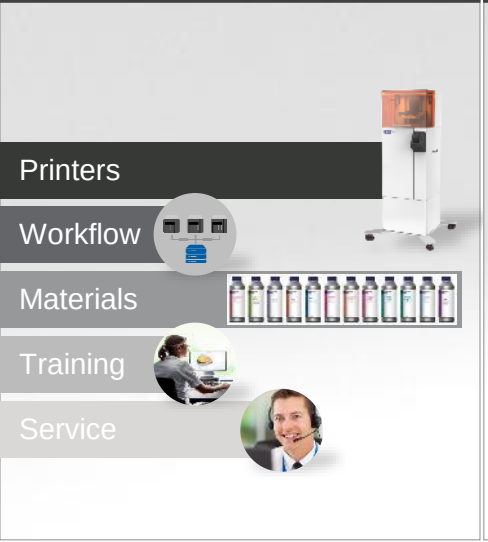
- Unmatched Expertise and Capabilities

Surgical Simulation	Surgical Planning	Design & Manufacturing	Bioprinting
			

Dental

- Redefining Digital Dentistry

Fully Integrated Solution

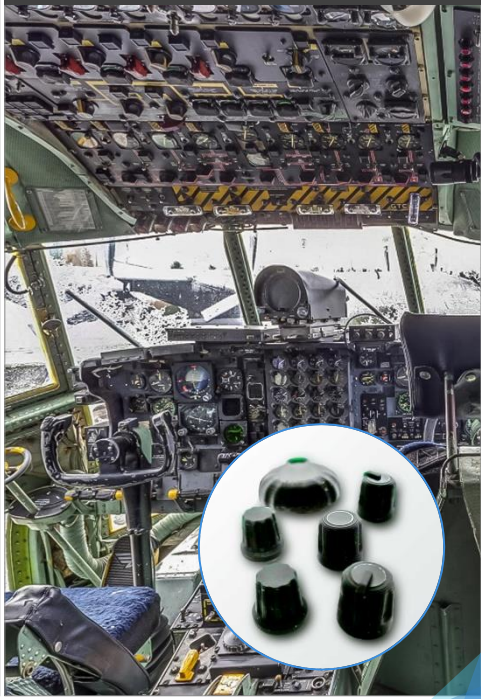


Broadest Digital Dentistry Portfolio in the Industry

30 materials for 12 indications

Clinical Validation and Regulatory Approval

Aerospace

Cert./Qualification	Fuel Economy	Airworthy Parts	Supply Chain
FEDERAL AVIATION ADMINISTRATION EASA European Aviation Safety Agency			

Automotive

Weight Efficiency

Formula 1 Vents

Improved Product Design

CAD to Car in 8 weeks

Supply Chain

Rapid Availability of Parts

Consumer Goods

- Innovation in Product Design and Production

Prototyping Design/Production

Reduce Assembly Times

Mass-Customization

Reduce Inventory and Increase Supply Chain Velocity

It Starts With Materials

- **Plastics, Nylons, Metals, Waxes, Composites, Ceramics, Etc.**

- 35+ years of experience
- 100+ plastics materials
  - Wide range of plastics
  - Wide range of applications and markets
- Customer-driven innovation
  - Partner with 3rd party formulation companies and researchers
  - Partner with chemical developers and producers, to enable novel new formulations

HIGH-DEFINITION | SNAP-FIT	ELASTOMERIC | FLEXIBLE
MULTI MATERIALS	
BIO-COMPATIBLE	DURABLE | HIGH-TEMP
CLEAR PLASTICS	FULL COLOR

Powerful Plastics Portfolio

Figure 4™
Industrial 3D Printing

ProJet® MJP 2500 Series
High quality, speed and ease-of-use

New PROJET® CJP 260Plus
Most affordable color 3D solution

ProX 800
High 3D printing throughput, highest accuracy and detail

ProX SLS 6100
Production ready for tough, functional nylon parts

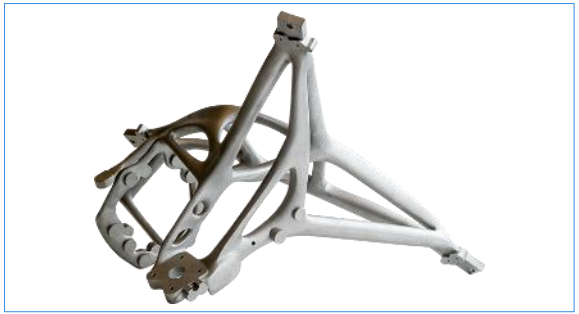
FabPro™ 1000
Entry-level industrial 3D Printing

Precise, High-Performance Metals

- Strategic relationships powder suppliers — provide powders made to specification
  - Robust parameter sets for these powders and test via ASTM, SAE, etc. requirements for the relevant alloys
  - When customers use our powders and parameter sets, we guarantee output quality
- Supply open configuration files for customers who want to develop their own materials
- Participate in R&D of new or novel alloys, both with suppliers and customers

Design Advantages

Weight Reduction



Topology Optimization

Personalization

Enhanced Fluid Flow

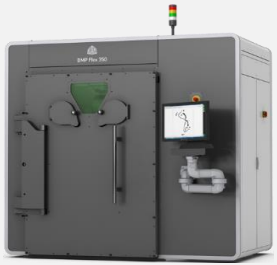
Lattice Structures

Component Consolidation

Precision Metal Printing Solutions

Flexible Solutions

INDEPENDENT PRINTERS | R&D AND PART PRODUCTION



DMP Flex 100 & DMP 200

EDUCATION | INDUSTRIAL | DENTAL

Finest Detail

Best Surfaces

Affordable DMP

DMP Flex 350

HEALTHCARE | AEROSPACE
INDUSTRIAL/CONTRACTORS

Robust printer

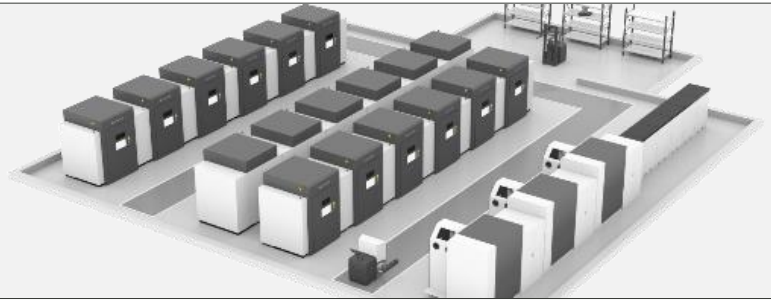
Repeatable Quality

Low TCO

Upgradable to DMP Factory 350

Factory Solutions

SCALABLE | HIGH LEVEL OF AUTOMATION
FULLY INTEGRATED MODULES



DMP Factory 350 & DMP Factory 500 Solutions

OEMS | LARGE PART CONTRACTORS

Medium volume production

Largest part diameter in the industry

Repeatable quality, high productivity, low TCO

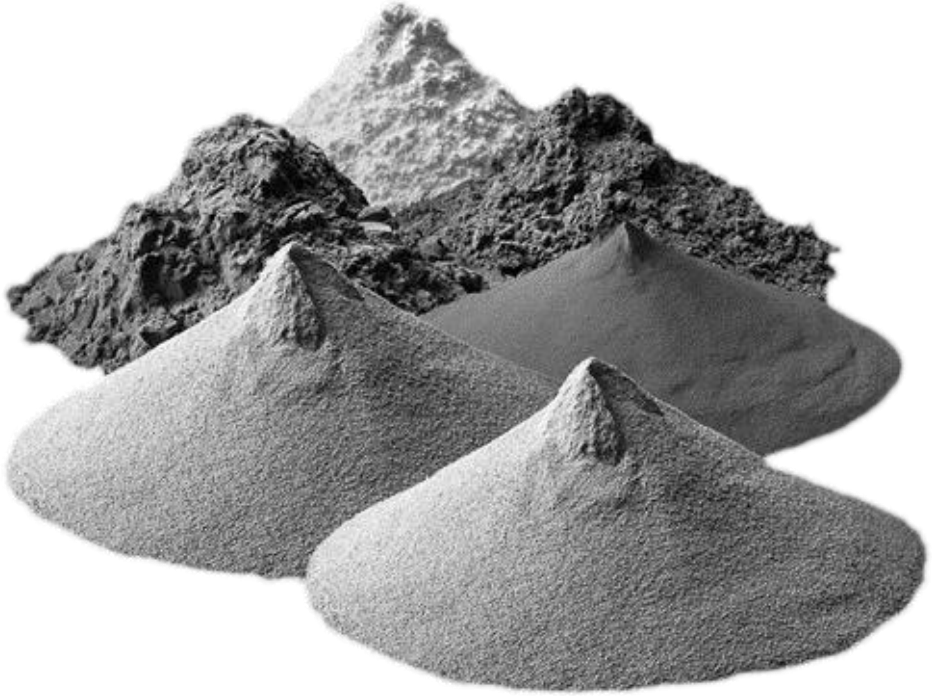
DMP Flex 100

- Affordable, Entry Level Solution

- Ideal for first hands-on metal experience
- Education & research departments
- Small part manufacturers
- Dental labs

Robust Material Portfolio

- Critical number of standard metal alloys can be successfully processed:
  - 17-4PH
  - Stainless 316L
  - CoCr
  - Others
- Repeatable, stable mechanical properties that exceed relevant ASTM standards can be achieved



DMP Application Case

- ***Dental:***

⇨ Double production efficiency VS Pro X100

⇨ Typical 90 teeth per Plate in 4 hrs. VS 8 hrs. on Pro X100 Dental

⇨ Due to increased 50 W laser power and faster laser scanning

Pro X100:
8h

DMP Flex 100:
4h

- ***Education:***

⇨ Matching most college bid demand basic require minimum (100 w)

⇨ Greater diversity of materials

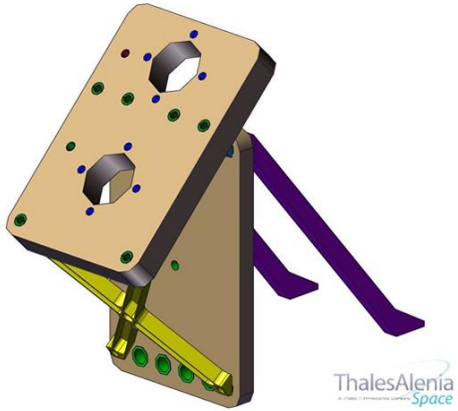
- ***Jewelry:***

⇨ Layer thickness10μm，High printing precision

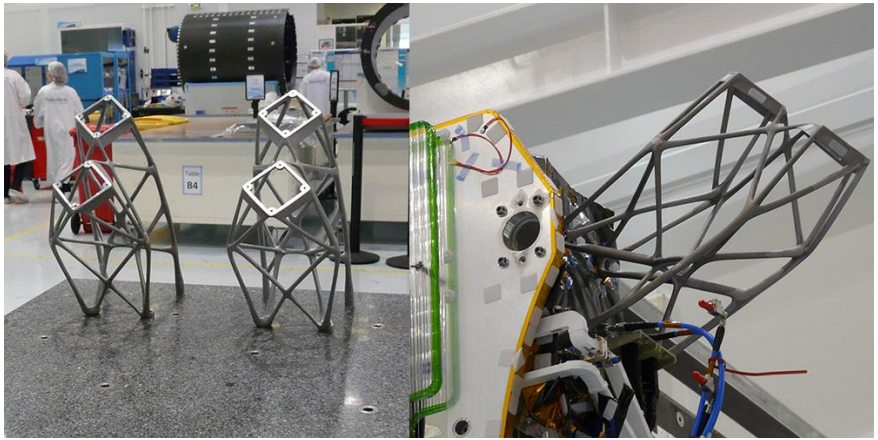
⇨ Enable 3D-Systems obtain more market share in Italy, India and Turkey

Additive redesign of Satellite antenna bracket

In 2015, the French Thales Alenia space company manufacturing remote communication satellites: Koreasat 5 a and Koreasat 7, adopting the innovation of bionics concept.



▲Origin design

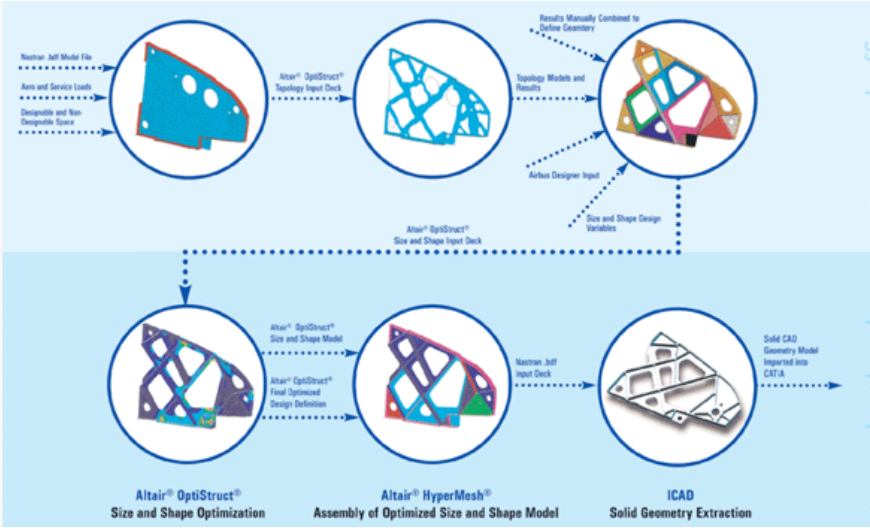


▲additive redesign

Parts weight loss 22%;Cost saving 30%;Shorten the production cycle in 2 months

Innovative design of airbus A380 front wing ribs

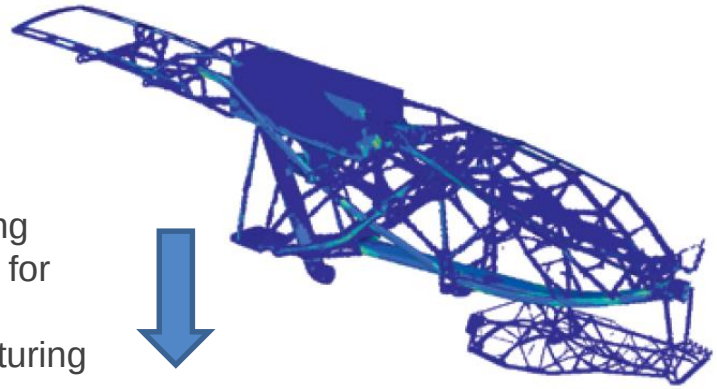
Altair Product Design has been selected to assist in developing the airbus A380, eliminating a lot of material from the plane wing ribs.



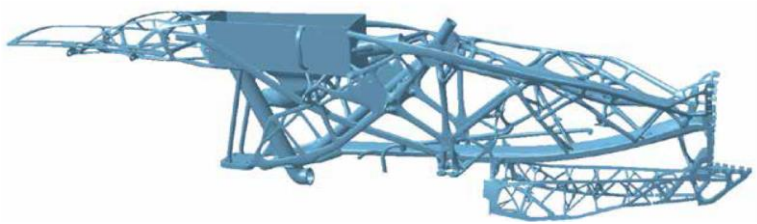
With the help of innovative frame design, the net weight reduced more than 500 kg per aircraft.

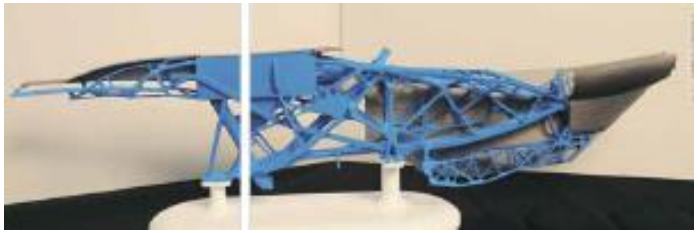
Topology optimization design of aircraft engine pylon

SOGECLAIR aerospace company developed a new concept of engine pylon, using Additive manufacturing and topology optimization.



Optimizing structure for additive manufacturing



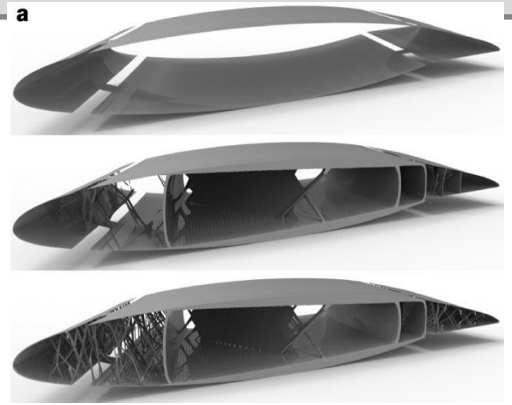


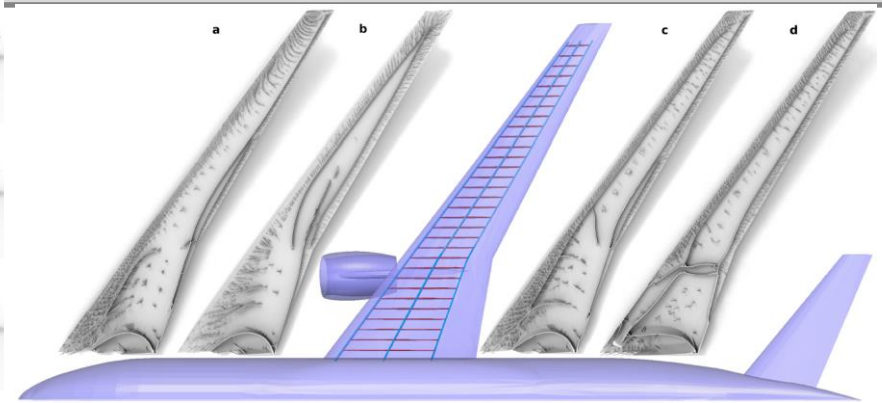
20% reduction in weight

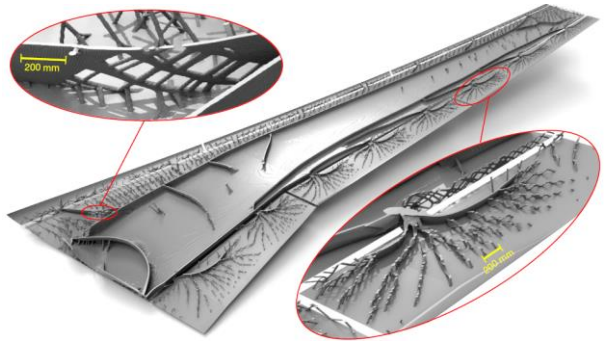
Decrease in the number of parts by 97%

Full-size wing topology optimization design

In 2017, Nature magazine published an article by Niels Aage, Professor of Mechanical Engineering Department of Danish University of technology, he cut a 27m long wing by 1.1 billion elements, calculated the full-scale wing with topology optimization, and solved the optimization calculation of large-scale structure.

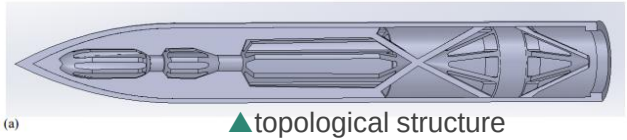




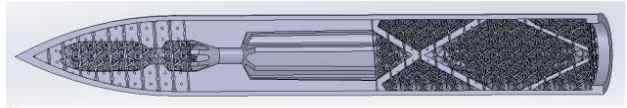


Redesign of topological lattice for penetrator warhead

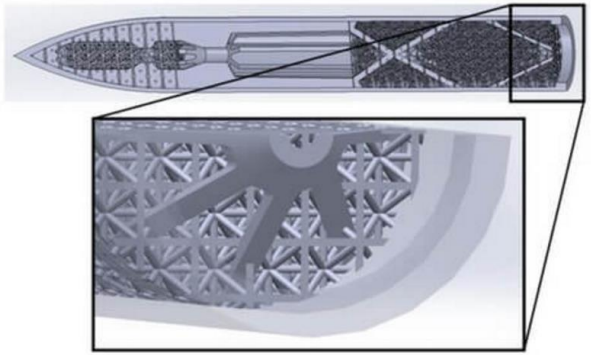
In 2015, Hayden K. Richards and David Liu designed a topology optimized lattice enhanced penetration warhead.



▲topological structure

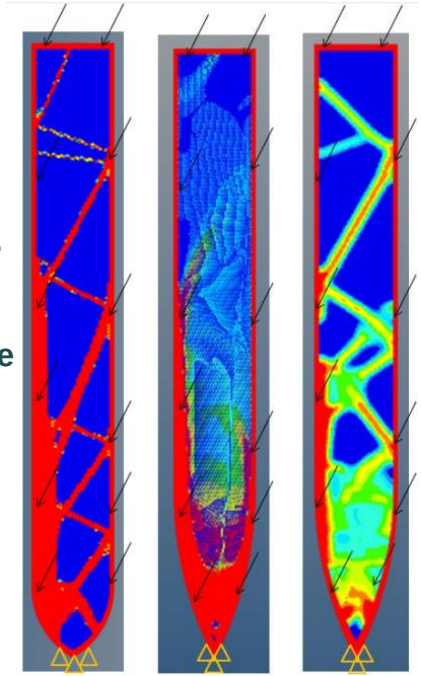


▲ topological lattice structure

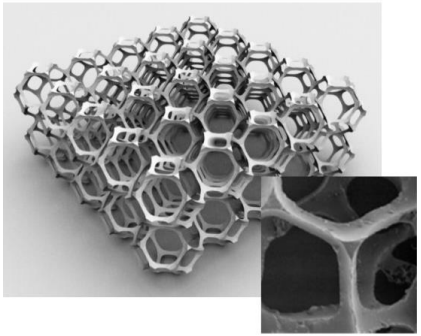


Two warheads were tested at Eglin Air Force Base in Florida.

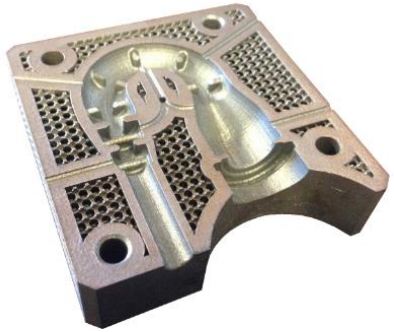
The lattice structure has good performance in the impact load environment. The practicability of topology optimization method for warhead design is verified.



Other redesign of lattice structure



▲Loughborough University
octahedral lattice structure

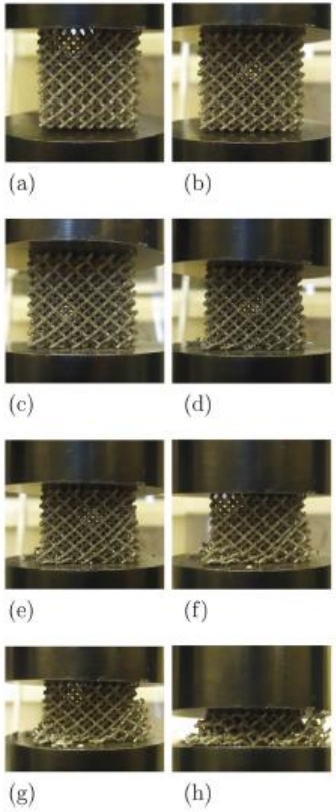


▲U.S.A 3DMFG —Lattice radiator

▲Lattice titanium alloy engine blade

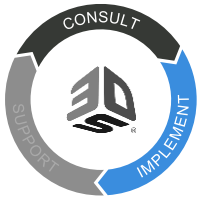
▲Fit production, Germany
Engine with bionic lattice structure

The engine cylinder weight reduced from 5.1kg to 1.9kg; the weight loss is 66%.



▲University of Sheffield
Bearing capacity test of tetrahedral lattice structure

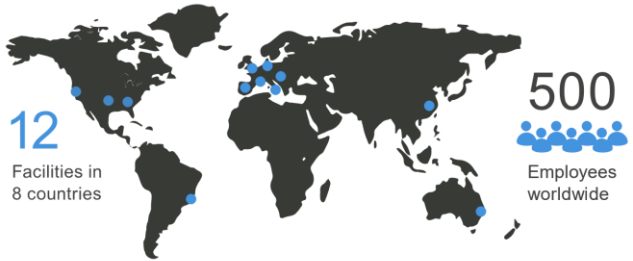
On Demand Manufacturing



Rapid Prototyping

Time + Money

Explore look and feel before committing to costly production



24 Parts produced in as fast as 24 hours

2,000,000+ Parts manufactured every year

Low-volume Production

3D SYSTEMS
On Demand Manufacturing

Functional Prototyping

Beyond Look and Feel

Assess real-world usability, ergonomics, manufacturability, and materials before production

14 Different processes available for functional prototyping

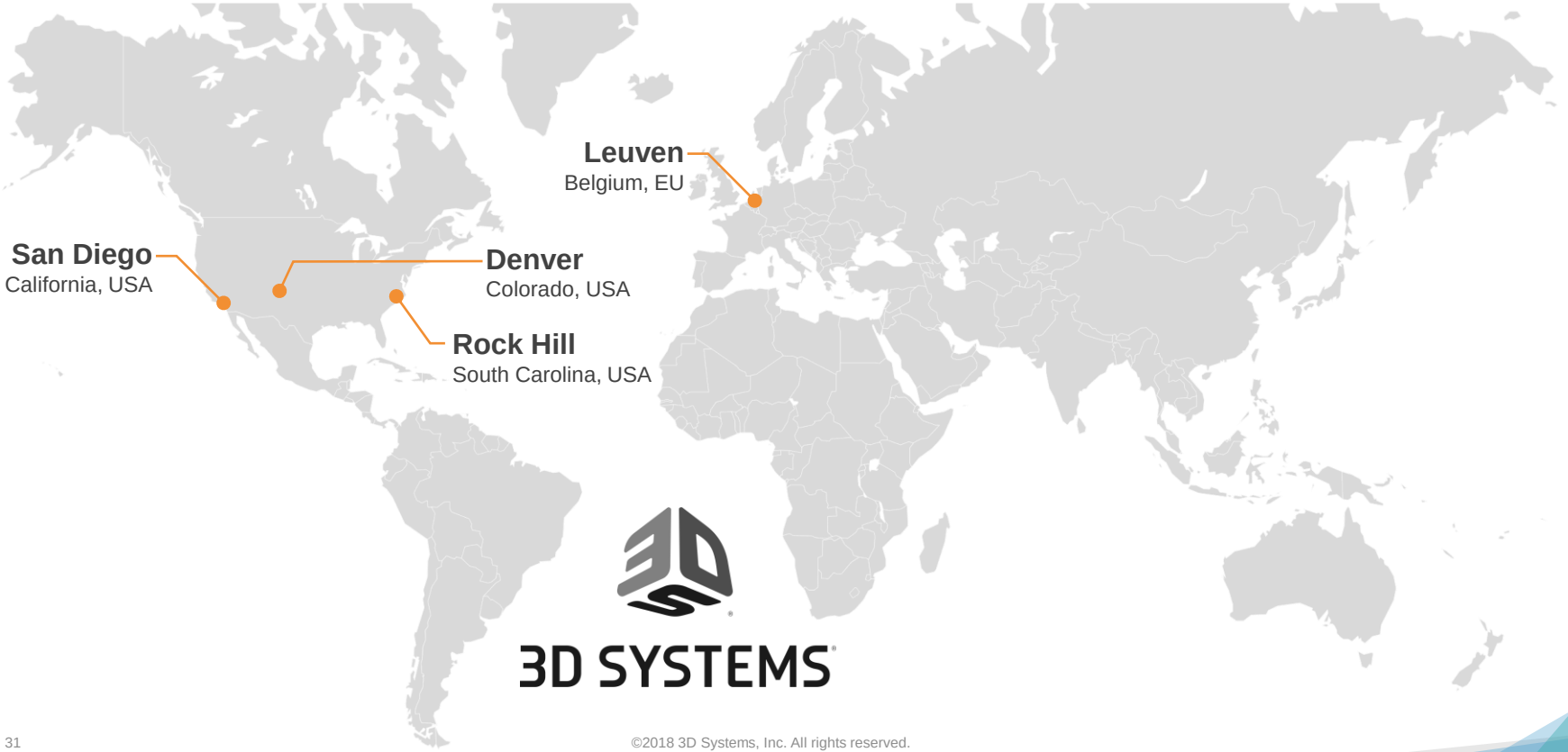
3 On average, every functional prototype is created with three different processes

100 Application Engineers With an average **10+** years of experience

25,000+ Functional prototypes manufactured to date

Appearance Models

Customer Innovation Center(CIC)



Standing on the Shoulder of Giants

3D SYSTEMS

3DXpert，All-In-One Software

From Design to Metal Additive Manufacturing

Production Workflow Software Portfolio

Dx Geomagic® Design X™ Cx Geomagic® Control X™ Sp 3D Sprint™ Gc GibbsCAM® Ci Cimatron® Xp 3DXpert™

3D Digitization Platform

Manufacturing Software Platform

Productivity • Ease of Use • ROI

End-to-End Digital Workflow

DIGITIZE

- Geomagic for SOLIDWORKS
- Geomagic Design X
- Geomagic Wrap

DESIGN & SIMULATE

- Geomagic Sculpt
- Geomagic Freeform
- Geomagic Freeform Plus
- 3DXpert for SOLIDWORKS
- Dicom to Print (D2P™)
- Cimatron
- GibbsCAM

MANUFACTURE

- Cimatron
- GibbsCAM
- 3D Sprint
- 3DXpert

INSPECT

- Geomagic Control X

MANAGE

- 3D Connect

Geomagic® Design X 2019

- The Fastest Path from Scan to CAD

- The only reverse engineering solution to combine feature-based CAD with 3D scanning!
- Design in days, not weeks
- Improved speed, quality and user experience in 2019

3D Sprint

- 3D print better parts without needing high-priced software
  - Increase efficiency with optimized management of data
  - Be more productive and reduce printer down time
  - Single, easy user interface streamlines time-to-print

3DXpert™

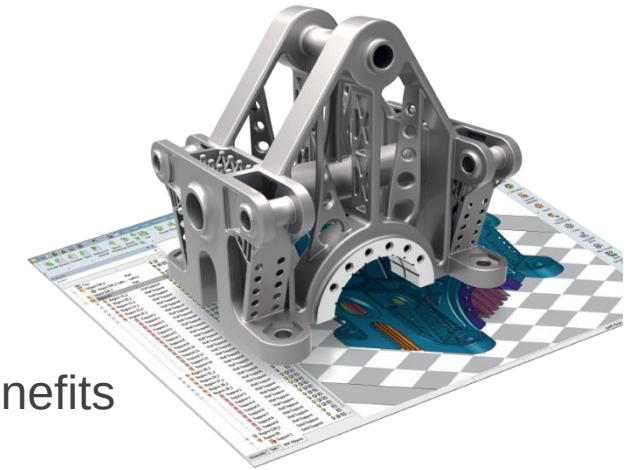
- The Only All-In-One Software Solution for Metal Additive Manufacturing

- The only vendor to offer a real complete workflow for design for AM!
- 3 winning pillars: Metal printers + 3DXpert + LaserForm® powders

- Dedicated solution for medical, aerospace & automotive industries

3DXpert Highlights

All-In-One Solution From Design to Post Processing

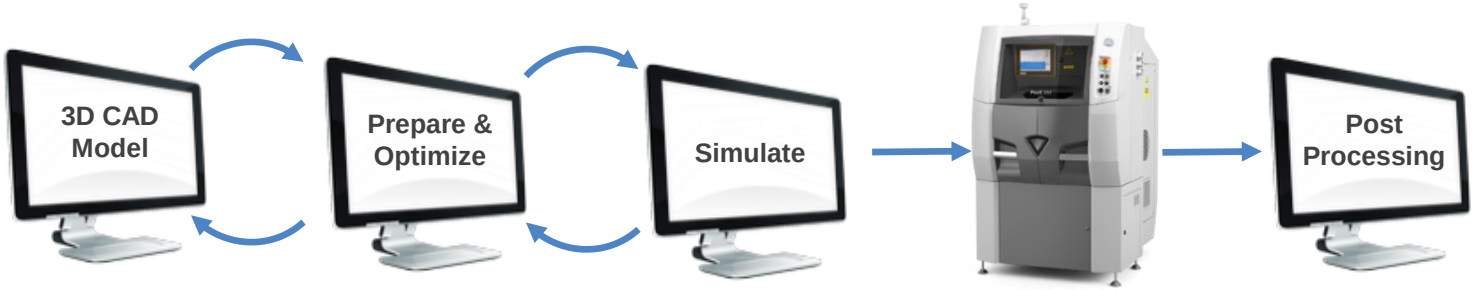


- **Hybrid native CAD** - maintain CAD integrity
- **Lattice structures** – minimize weight and material
- **Surface textures** – deliver functional or aesthetic benefits
- **Build simulation** – minimize build tryouts and cut production costs
- **3D zoning** – assign different print strategies to different zones

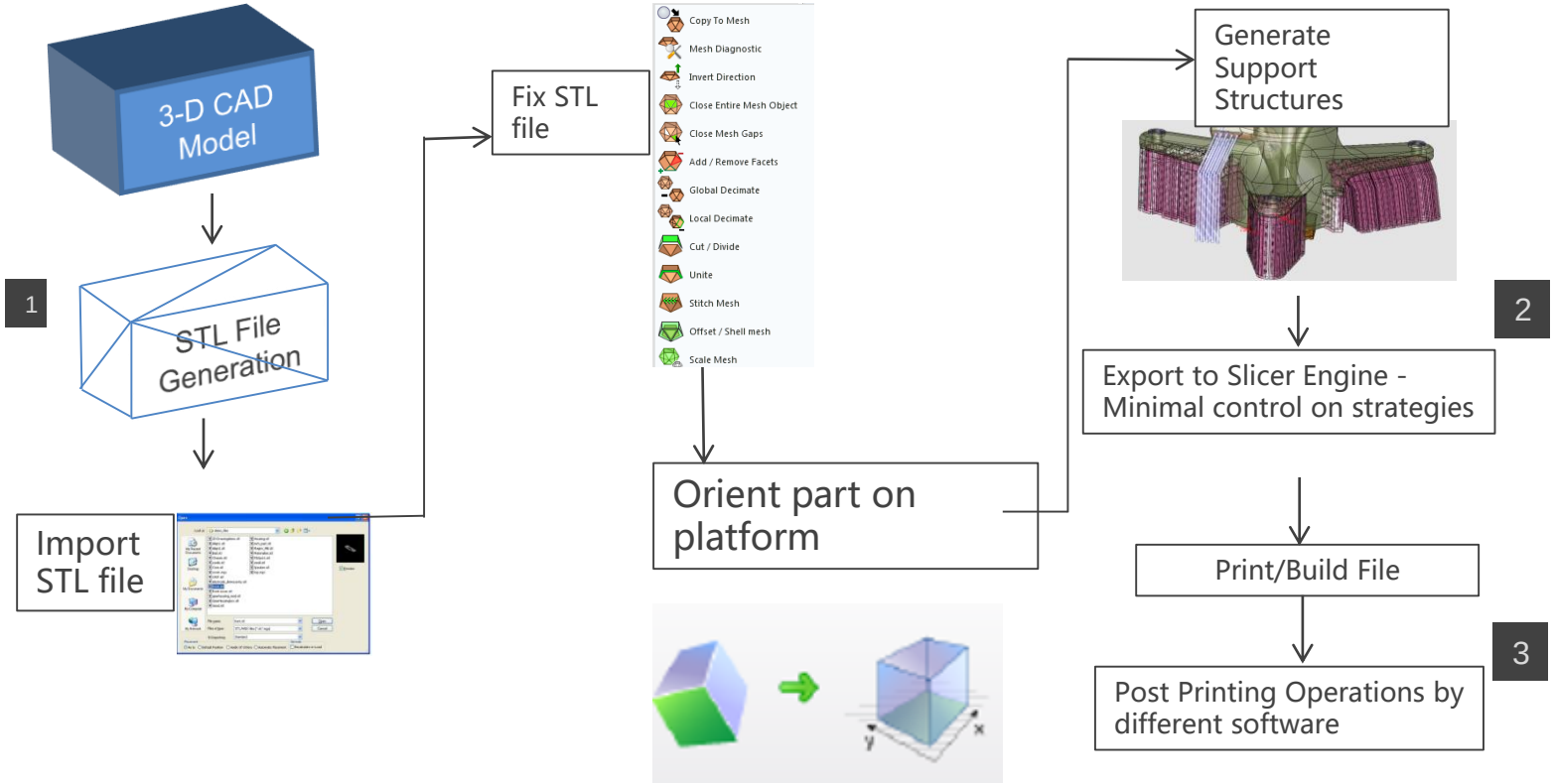
Additive Manufacturing Workflow Pain Points

Back and Forth Iterations Between Multiple Software Solutions

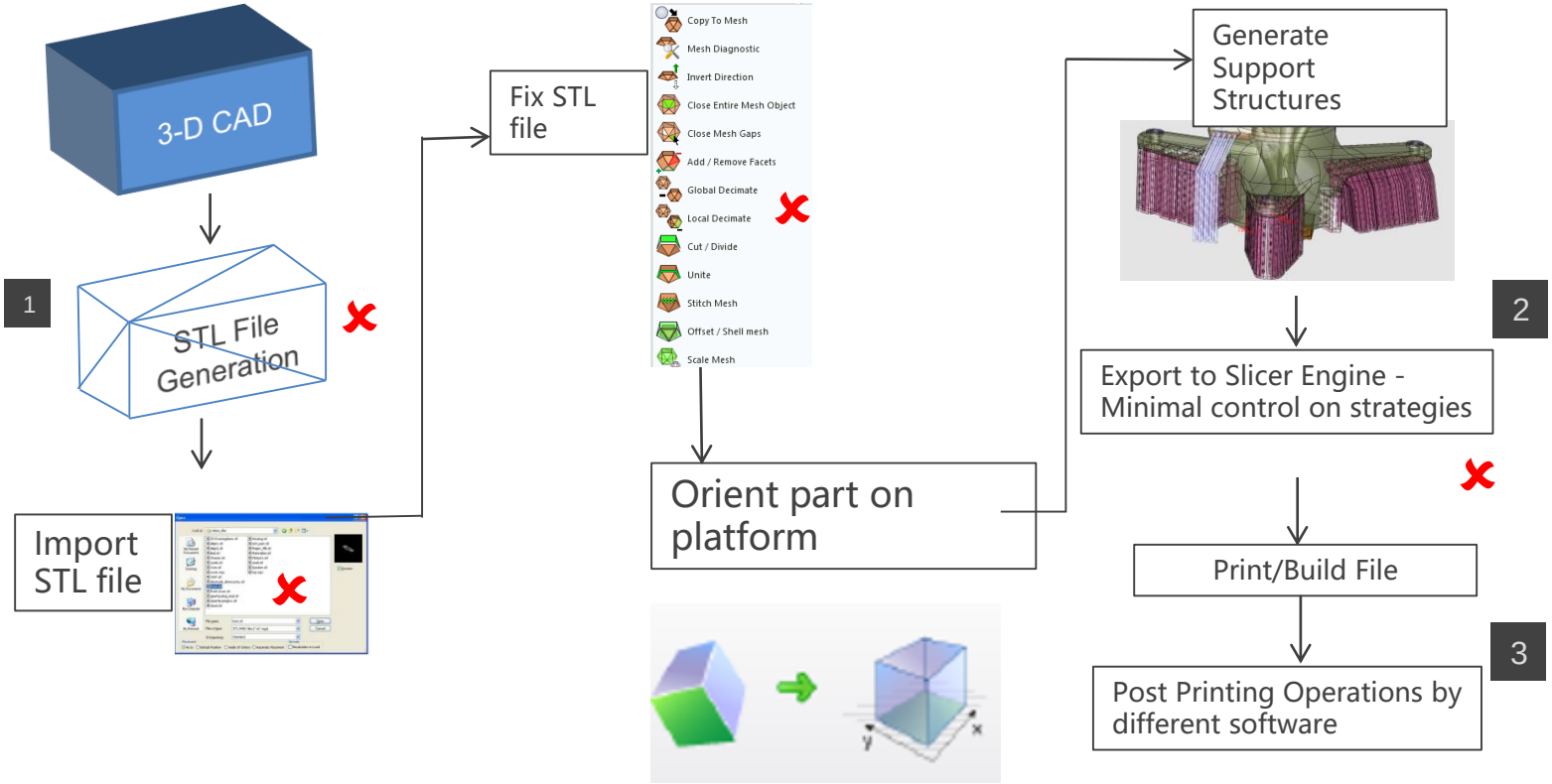
- **CAD integrity -** downgraded with conversion of B-rep to mesh
- **Design modifications –** slow and complex iterations
- **Structure optimization –** slow and complex lattice creation & editing
- **Build failures –** high number of build tryouts
- **Print strategies –** limited control over print strategies
- **Post processing operations –** not integral part of the workflow



A Typical Additive Manufacturing Data Stream



3DXpert Additive Manufacturing Data Stream

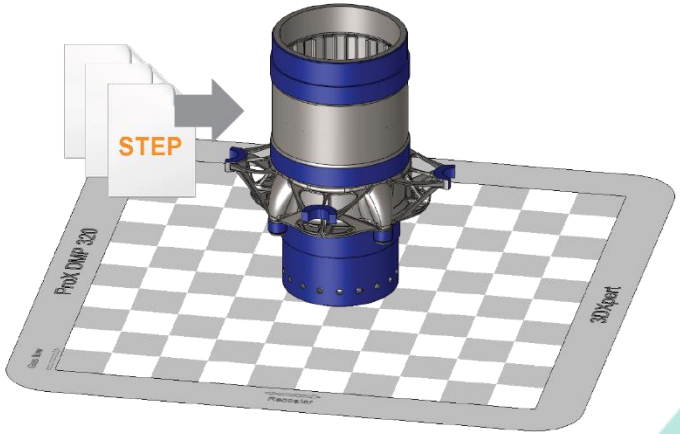


Native CAD Data

Maintain Data Integrity

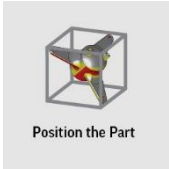
- Read original data CAD model without conversion
  - Avoids downgrade to MESH
  - Maintains data integrity

- Supports Hybrid CAD, both MESH & B-REP (solid & surfaces)
  - Standard CAD toolset
  - Automatic healing of both STL and B-rep geometry when required

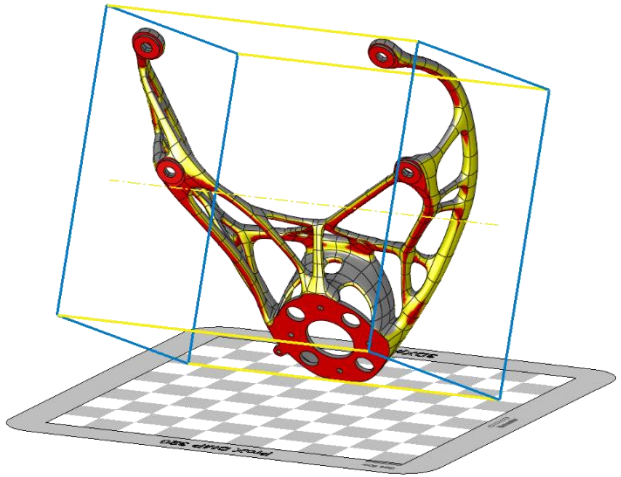


Position & Modify Geometry

Adapt for Print



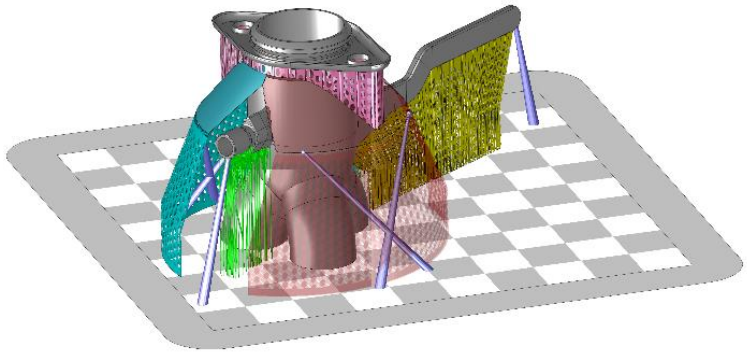
- Real-time analysis of supports and down facing areas
- Automated best fit positioning
  - Minimize: tray area, supports & print time
- Visualization
  - Print environment, gas flow and roller directions
- Printability checks - thin wall analysis, curvature Map etc.
- Modify & Edit
  - Direct modeling tools
  - Parametric & history-based hybrid CAD tools
  - Machining Offset



Smart Support Creation

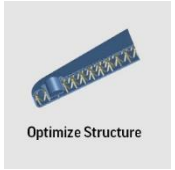
Prevent Part Distortion with Minimum Material & Simple Removal

- Automatic analysis
  - Automatically find regions that require supports
  - Geometrical-based residual stress analysis
  - Manually add or remove supports
- Easily create and edit
  - Any type - wall, lattice, solid, cone and skirt
  - Automatic best practice templates based or manual creation
  - Save and re-use templates
  - Manual adjustments - fragmentize, tilt, and offset
  - History based features

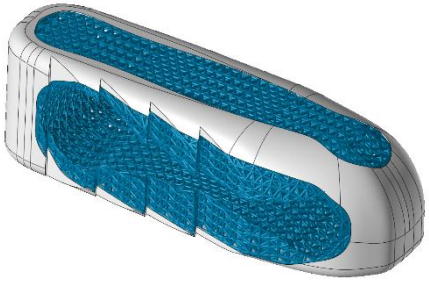


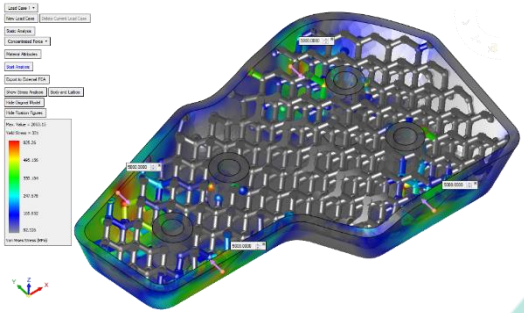
Structure Optimization

Minimize Weight and Material and Apply Surface Textures



- **Volumetric** - Lattices and infill structures to minimize weight and material usage while maintaining part strength
- **Surface texturing** - apply printable and conformal lattice based surface textures
- **Lightning fast** - creation, view and editing
- **Various types** – templates based, configurable thickness & density, user defined
- **Analyze and optimize** – iterative lattice optimization based on FEA linear-stress analysis
- **Automatic adjustment** - to shape change
- **Printable** - do not require supports
- **Slicing** - fast and accurate slicing





3DXpert – Design

OPTIMIZE STRUCTURE

- Create Micro Lattice structures with great ease

  轻松创建微晶格结构

- Lightning fast creation and viewing with V-REP

  用V-rep技术闪电般创建和可视化操作

  - Easy editing

  轻松编辑

- Combine with history based parametric features

  与基于历史的参数化特征无缝结合

- Printable

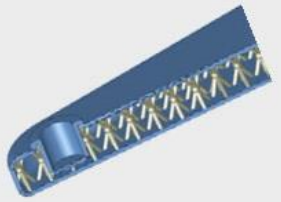
  打印可行性分析

- Fast and accurate slicing

  快速、精准分层

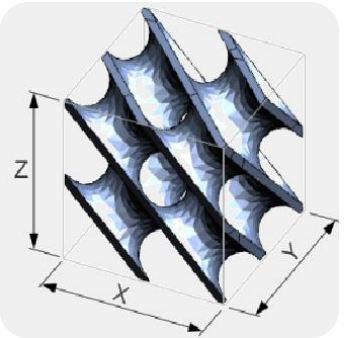
3DXpert – Design

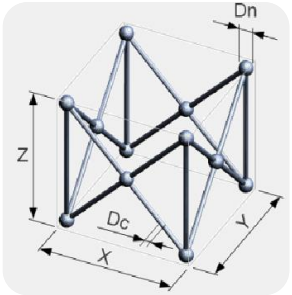
OPTIMIZE STRUCTURE

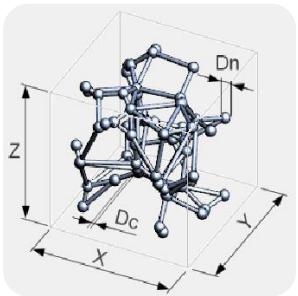


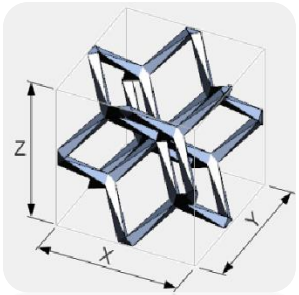
3 优化结构

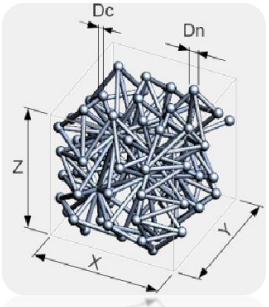
- A vast range of lattice types
  - Uniform
  - Radial
  - Medical (surface)
  - Variable Thickness (per node)
  - User Defined
  - Imported from analysis systems
- 种类多样的晶格类型
  - 匀称
  - 径向
  - 医疗（曲面）
  - 可变厚度（每个节点）
  - 用户自定义
  - 从分析系统导入

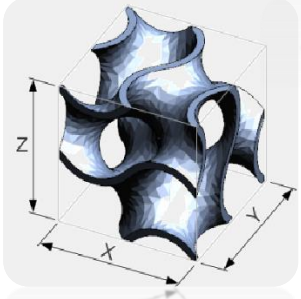


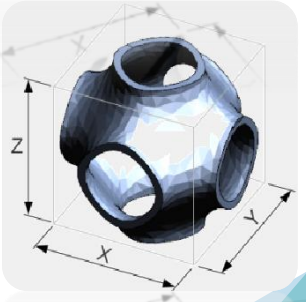






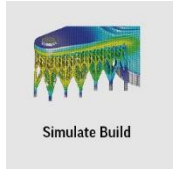






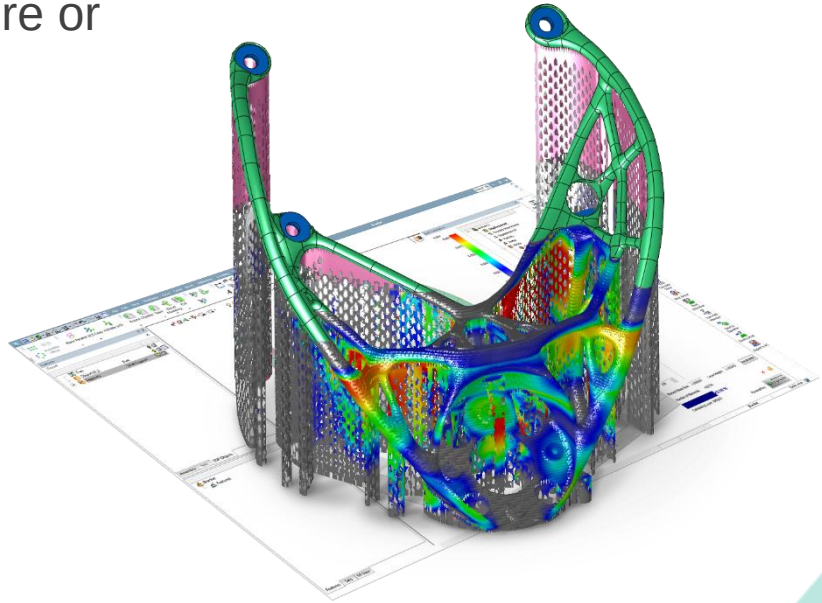
Build Simulation (1)

Cut Production Cost and Lead Time



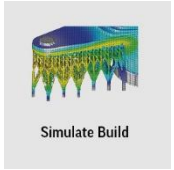
- Predict issues that might cause build failure or damage to the printer **before** printing

- Cut production cost and lead time
  - Reduce number of tryouts
  - Ensure repeatable process
  - Prevent optional printer damage

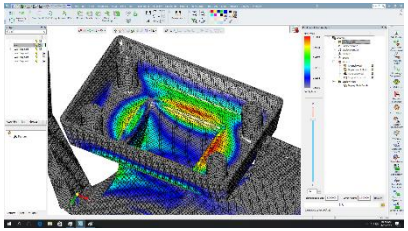


Build Simulation (2)

Integrated End-to-End Fault Prediction

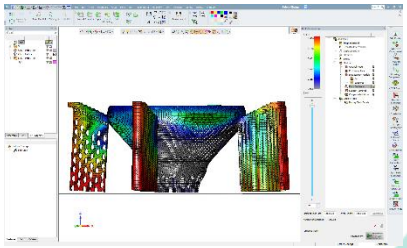


- Minimize Tryouts with End-to-End Fault Prediction
  - Design - verify proper part orientation and support design
  - Print - detect defects to the printed part or the printer itself
  - Post-processing - analyze the effects of taking the part off the build plate, removing supports, and heat treatment



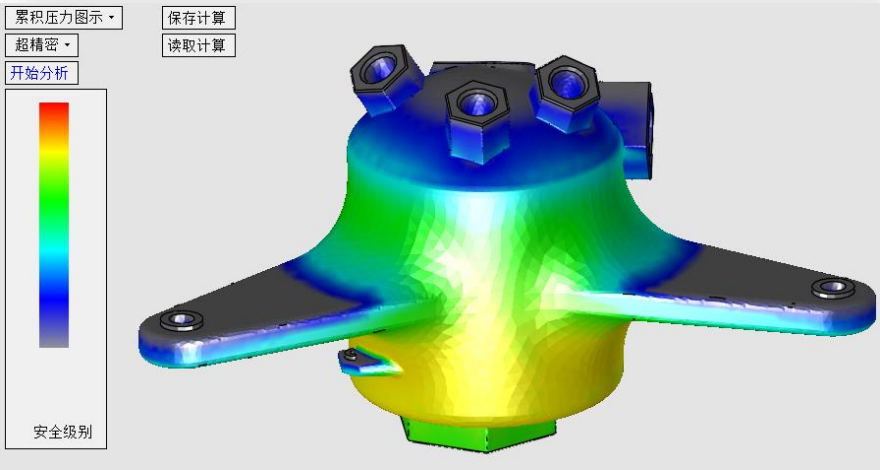
Displacement Analysis

- Shorten Time to Final Model
  - Integrated within the design environment
    - Work directly on the model for changes - no data transfer
    - Visually compare with original model
  - Offload simulation calculations to a central server for all design stations
  - Detect defects early - receive layer-by-layer simulation results
  - Suggested compensated model - reference to reach the final model.



Cutting Off Supports Analysis

Print ability analysis打印可行性分析

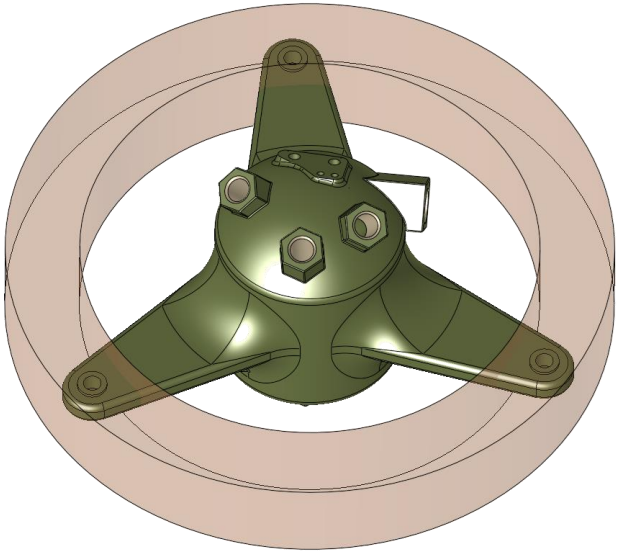


- Residual stress analysis 残余应力分析
  - Accumulated stress 累积压力
  - Boundary distortion stress 边界变形
  - Accumulated heat areas 累积温度
- Volume analysis 打印体积分析
- Interlock analysis 零件互连、互锁、互相干涉分析
- Geometric integrity analysis 几何完整性分析
- Void analysis 内空区域分析
- Build simulation analysis 成型模拟分析
- Slice area analysis 切片区域分析
- Thin wall analysis 薄壁分析

Optimize Printing Strategies

Accelerating Print Time While Maintaining Part Integrity

- **3D zoning (*)** - automatic and manual assignment of different print strategies to different areas
  - **Shorten printing time** - using faster printing strategies
  - **High surface quality** - using more accurate printing strategies
  - **Eliminate divisions** – no need to divide the part, eliminating weak points
  - **Control** - slice for multiple layer thicknesses

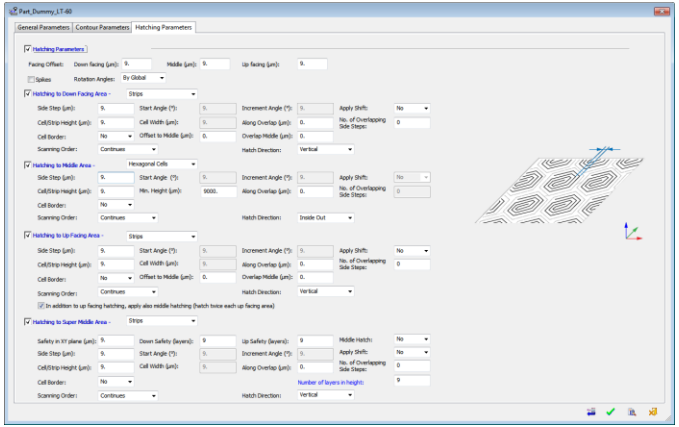


(*) Patent pending

Calculate Scan-Path

Flexible Scan-Path Control

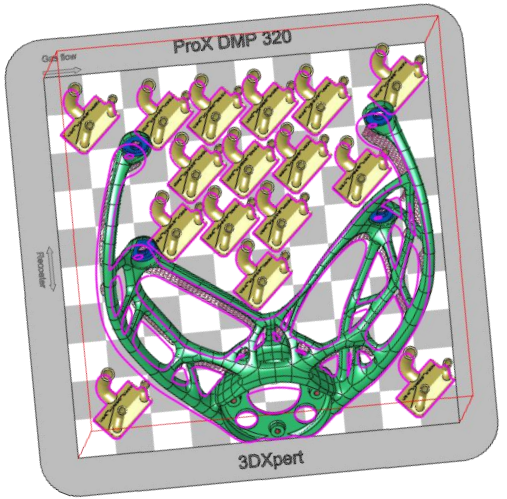
- **Automatic or fully Controlled**
  - Best practice validated parameter sets
  - Control every aspect of your scan path
- **Intelligent scan-path**
  - Fuses zones and geometry into one merged part
  - Multiple exposure option for reducing required supports
- **Validate print process –** preview actual scan path of any layer before full calculation for entire part



Arrange Build Platform for Printing

Optimize Build Platform

- Position and nest – automatic tray setup for best utilization of build plate footprint and for minimal printing time
- View & Inspect - view your slicing results to ensure correct definitions
- Estimate - on screen real-time material and print time estimation, including custom based 3D PDF reports
- Automated labelling tool
- Export - send optimal combined scan path to any printer

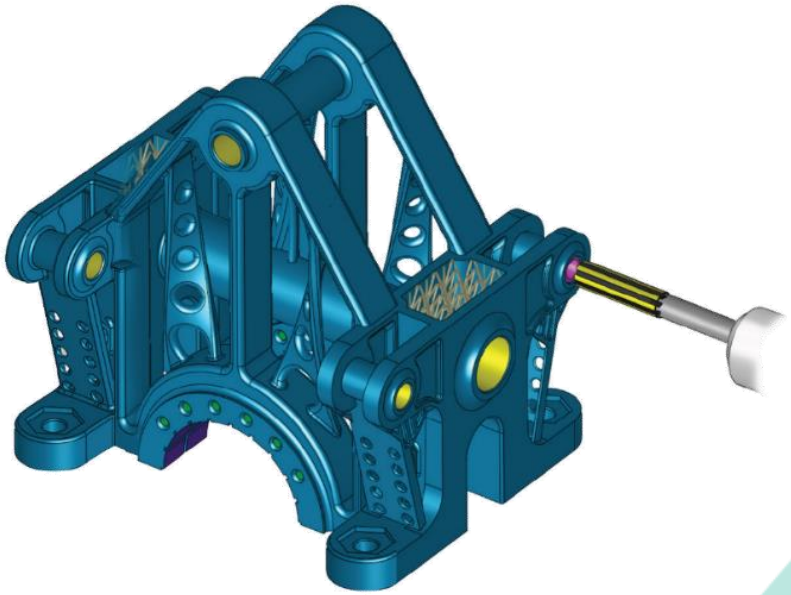


Post Printing Operations

Finalize Part Manufacturing Within the Same System

- Use robust machining and drilling programing tools
  - Automated support removal
  - Drill, tap, ream holes
  - Machine high-quality surface areas

- Integrated documentation tools
  - Drafting
  - PMI
  - PLM connectivity



Subtractive Manufacturing

- Emerging market of Hybrid Manufacturing
- Uniquely position to offer both solutions
- Compliments additive solution.
  - Post print machining
  - Printed jigs and fixtures
  - CAM for hybrid machines
- Traditional Manufacturing
  - Large part of global manufacturing market

Use Case 1: Tooling

THE NEED

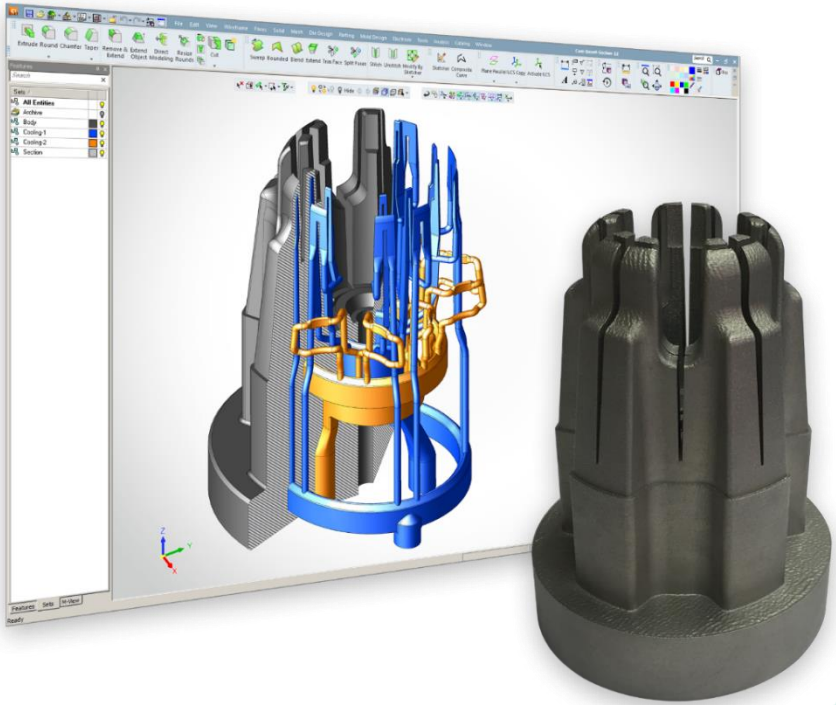
- Reduce the manufacturing cost per part
- Reduce overall injection cycle time
- Avoid warpage

THE SOLUTION

- Design & print a conformal cooling insert with 3DXpert
- Utilize full integration with Cimatron Mold Design application

THE RESULTS

- Reduced design time by up to 80%
- Decreased cost of mold by 18%
- Reduced need for EDM and CNC
- Reduced cycle time by more than 22%



Use Case 2: Medical

THE NEED

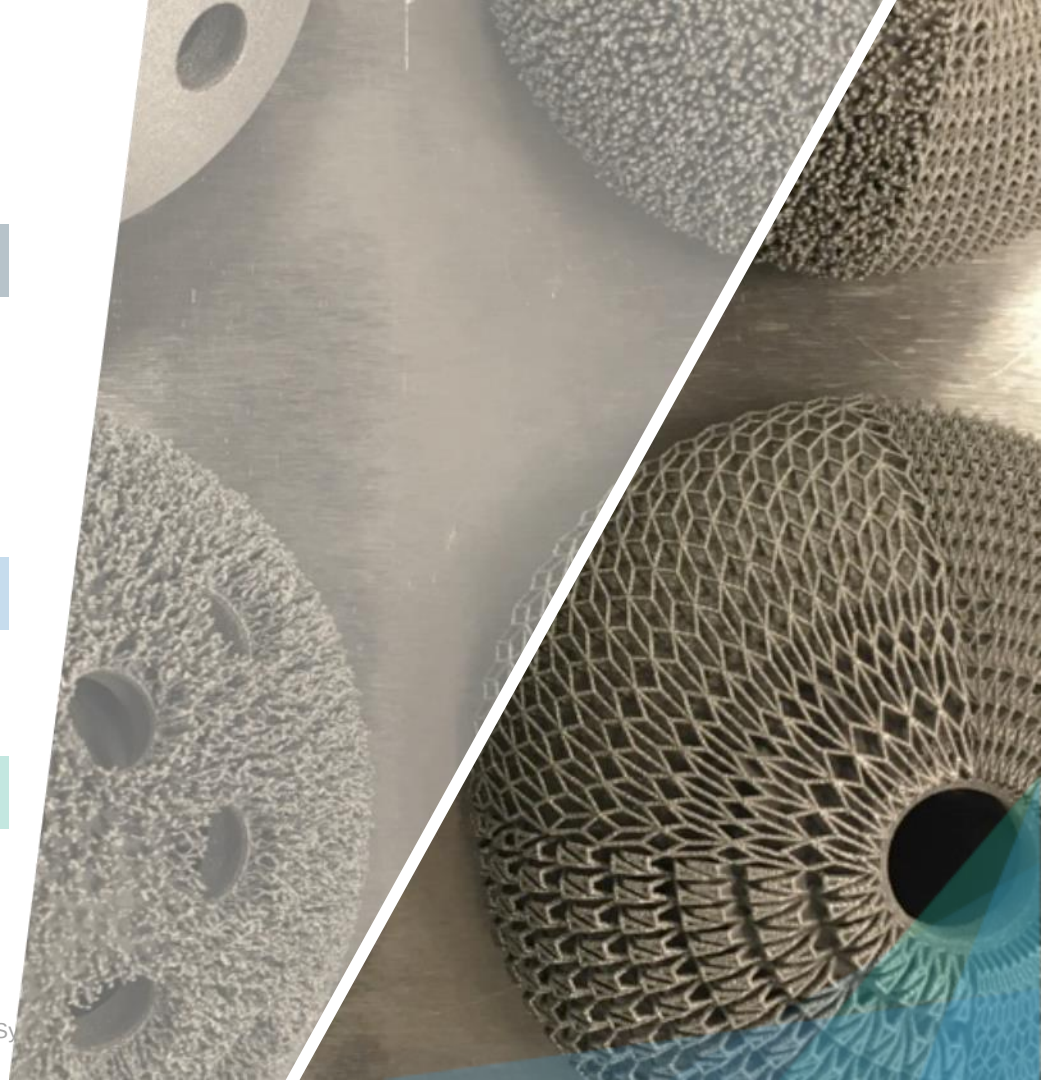
- Promote bone ingrowth
- Promote tissue ingrowth
- Control the roughness of every part surface
- Create trabecular structures
- Reduce part weight

THE SOLUTION

- Design and print parts with surface lattice with dedicated slicer and printing strategies

THE RESULTS

- Less material usage
- Shorter printing time
- No data loss
- Reduced lead time



Use Case 3: Aerospace

THE NEED

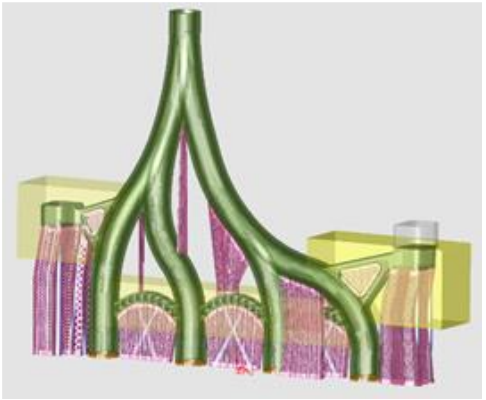
- Assembly simplification
- Lightweight part
- Flexible printing strategies

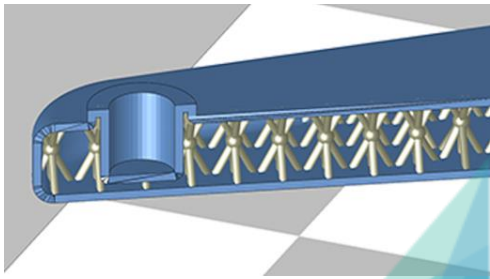
THE SOLUTION

- Micro structure lattice for topology optimization
- 3D-Zoning technology
- Easy control on defining the process print parameters

THE RESULTS

- Enable high-end parts design
- Shorten design time by up to 80%
- Reduce material and machining time
- High quality parts





With our technology, expertise and know-how, we are

MAKING 3D PRODUCTION REAL

Thank you !

Q&A