

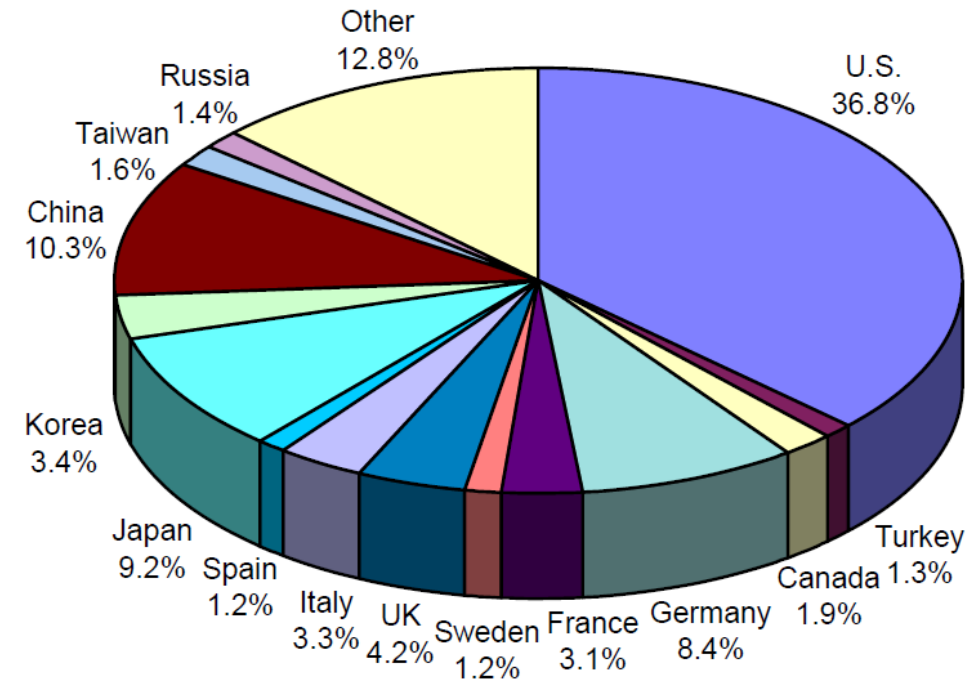
Industrialize Additive Manufacturing

Beppe Grimaldi, Siemens PLM Software

3D Printing Market (Industrial AM)

- **Total industrial AM market of \$6bn with CAGR of 17.4% in 2016**
 - Thereof products: \$2.7bn
 - Thereof services: \$3.4bn
- **13,000 industrial systems sold in 2016, total cum. installed basis of > 100.000 industrial AM printers worldwide**
- **Average price per machine approx. \$100k**

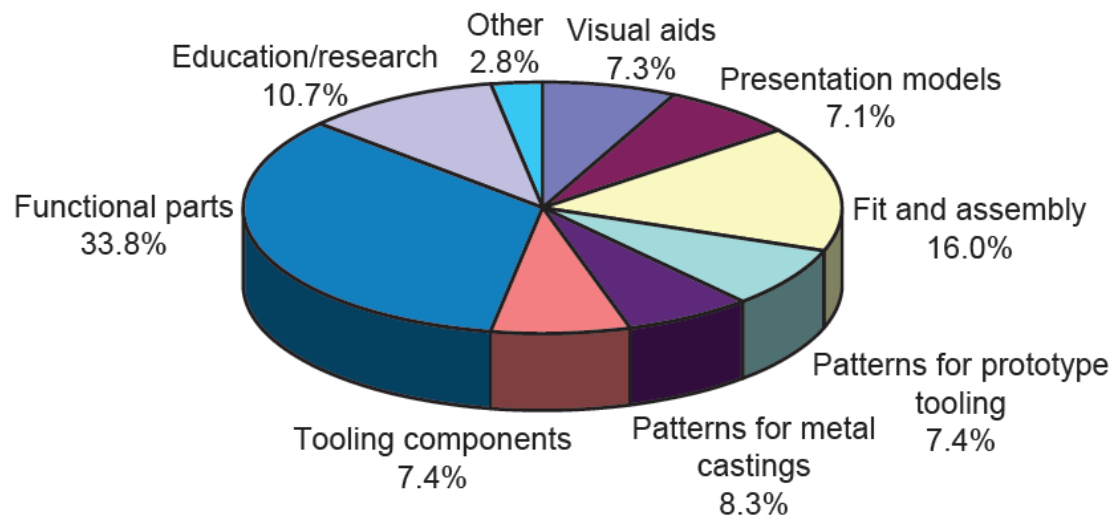
Industrial Additive Manufacturing Machines installed per Region and Country in 2017



Source: Wohlers Associates, Inc.

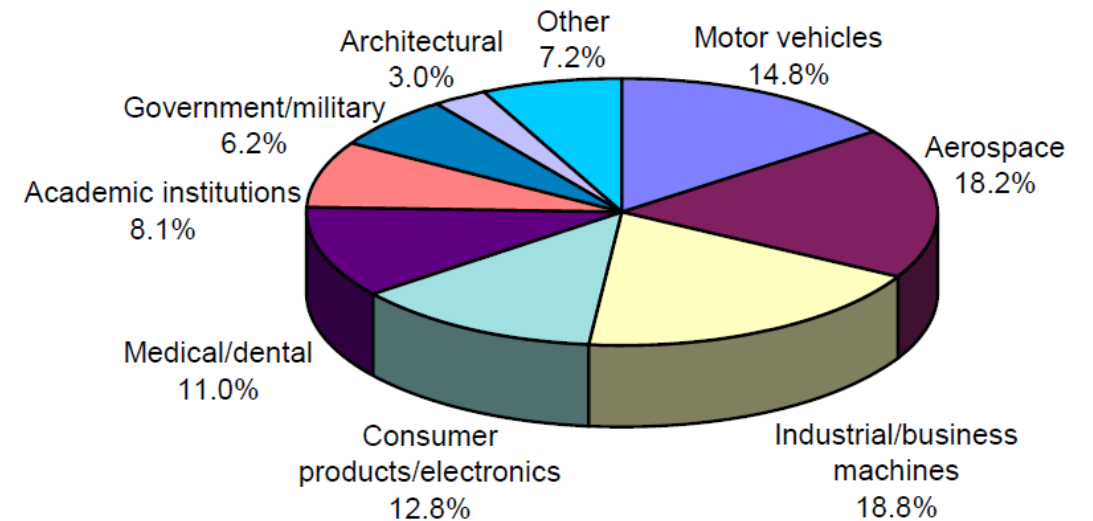
3D Printing Market Overview

Industrial AM and its Applications (2017)



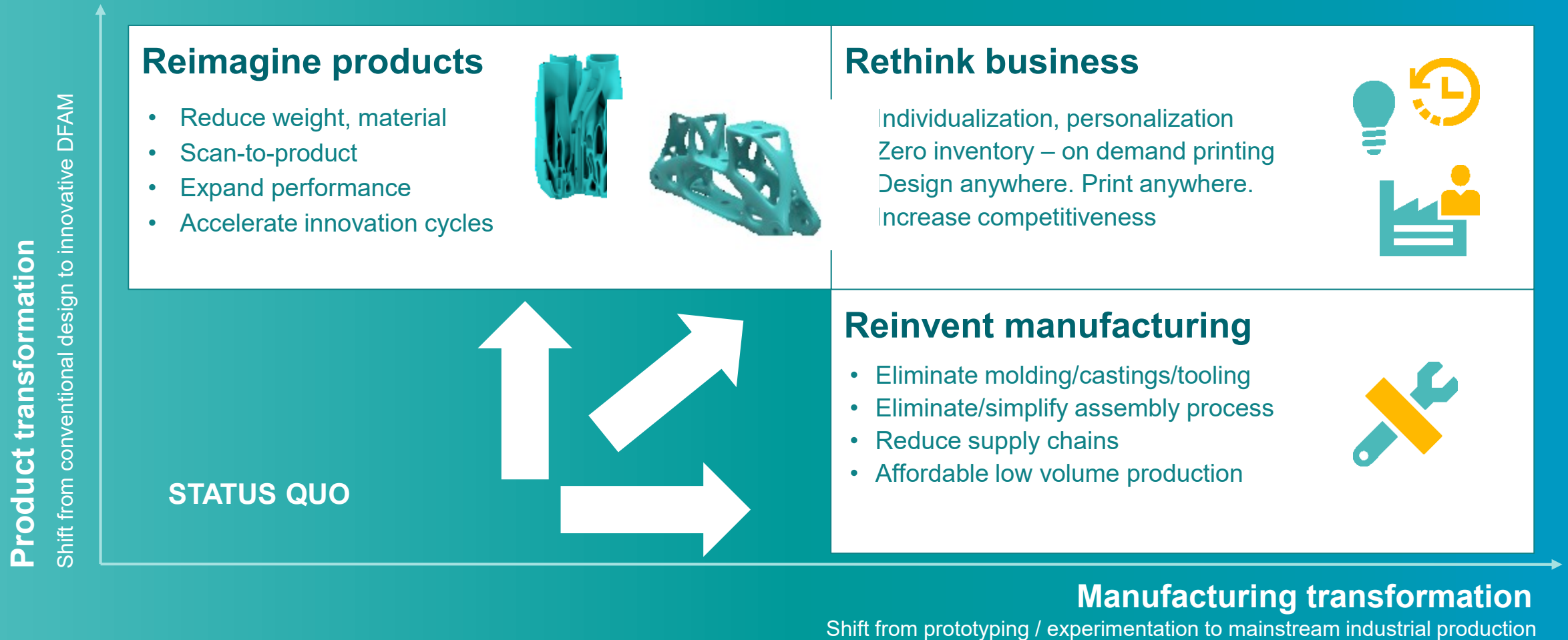
Source: Wohlers Associates, Inc.

Distribution by Industry in 2017 (based on service provider revenue split)



Source: Wohlers Associates, Inc.

Additive Manufacturing is driving Innovation and help overcome current barriers by...



Additive Manufacturing

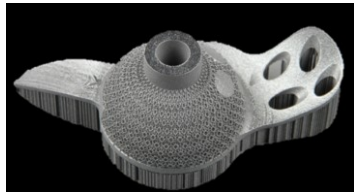
Industries & Use Cases

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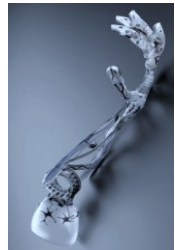
Medical



Individualization



Functional materials



Braces

Automotive



Functional prototypes



Engine/transmission
subsystems



Automotive Fixtures

Energy



System to Part



Product performance



Multi Materials

Aerospace



Weight reduction

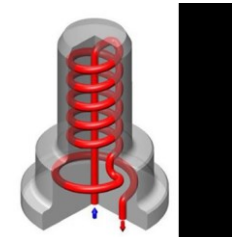


Titanium performance parts



Ducts & Tubing

Machinery



Conformal Cooling



valves



Spare parts

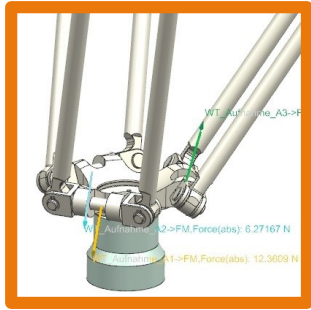
Additive Manufacturing, Ordinary Process

From requirement driven Generative Design to 3D Printing

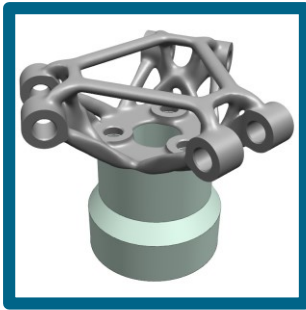
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1 - Product Design

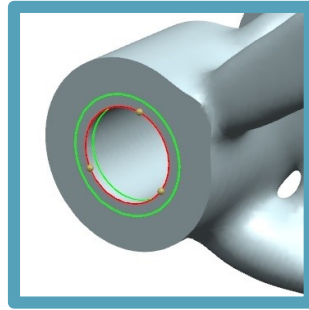
2 – Production planning



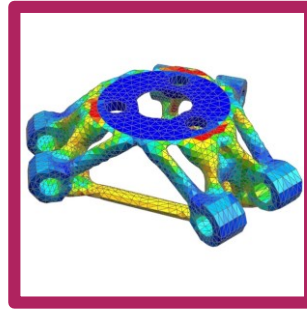
Requirements



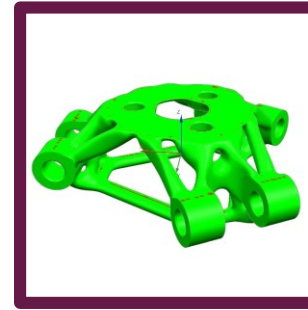
Generative
Design



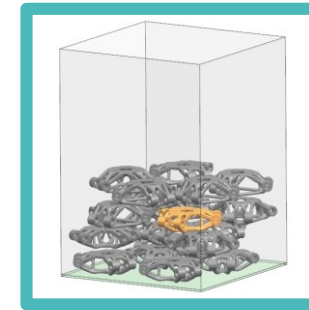
Adaption



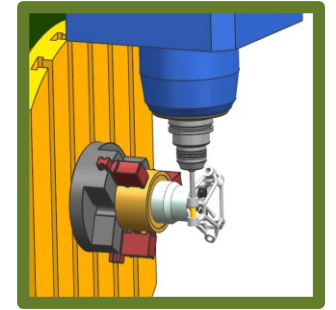
Performance
Validation



Manufacturing
Validation



Pre-Processing
& 3D Printing



Part Finishing &
Quality

STEP
IGES

STL

FEM

STL

STL

STL

CAD
SOFTWARE

SIMULATIONS
SOFTWARE

PRINT PREPARATION
SOFTWARE

BUILDPROCESSOR

CAM & Coordinate
Measuring Machine
SOFTWARE

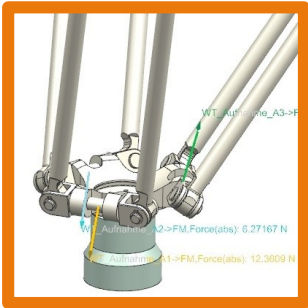
NX – One integrated Additive Manufacturing Solution

From requirement driven Generative Design to 3D Printing

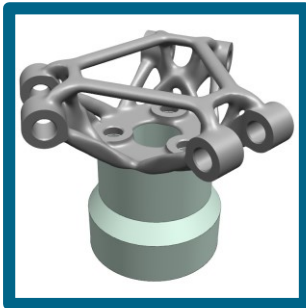
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1 - Product Design

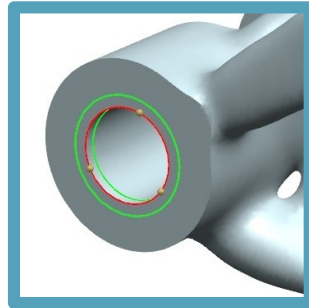
2 – Production planning



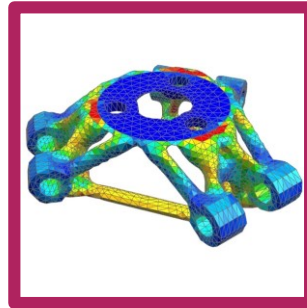
Requirements



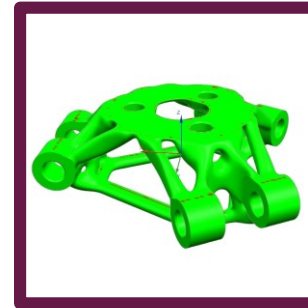
Generative Design



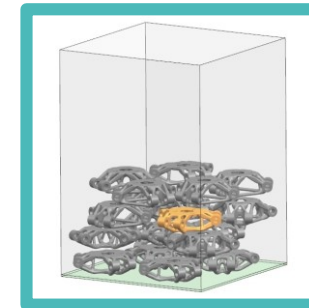
Adaption



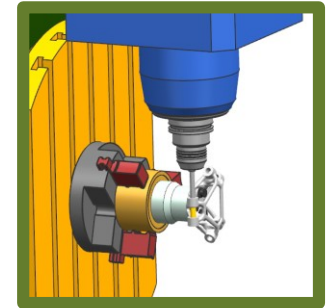
Performance Validation



Manufacturing Validation



Pre-Processing & 3D Printing



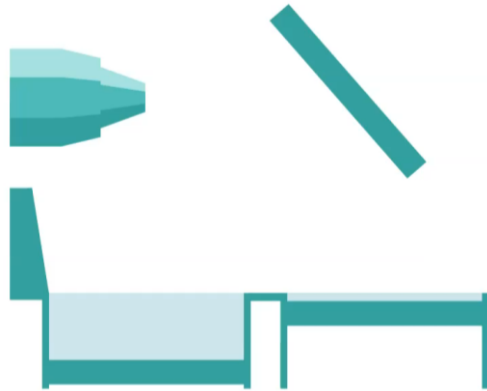
Part Finishing & Quality

Data and Process Management

Industrialize Additive Manufacturing

Supported Print Technologies

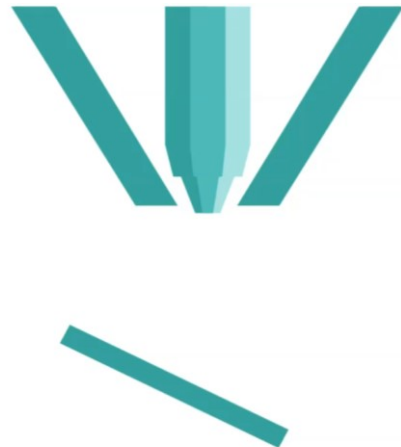
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Powder Bed
Fusion



Jetting



Directed Energy
Deposition

DMG MORI



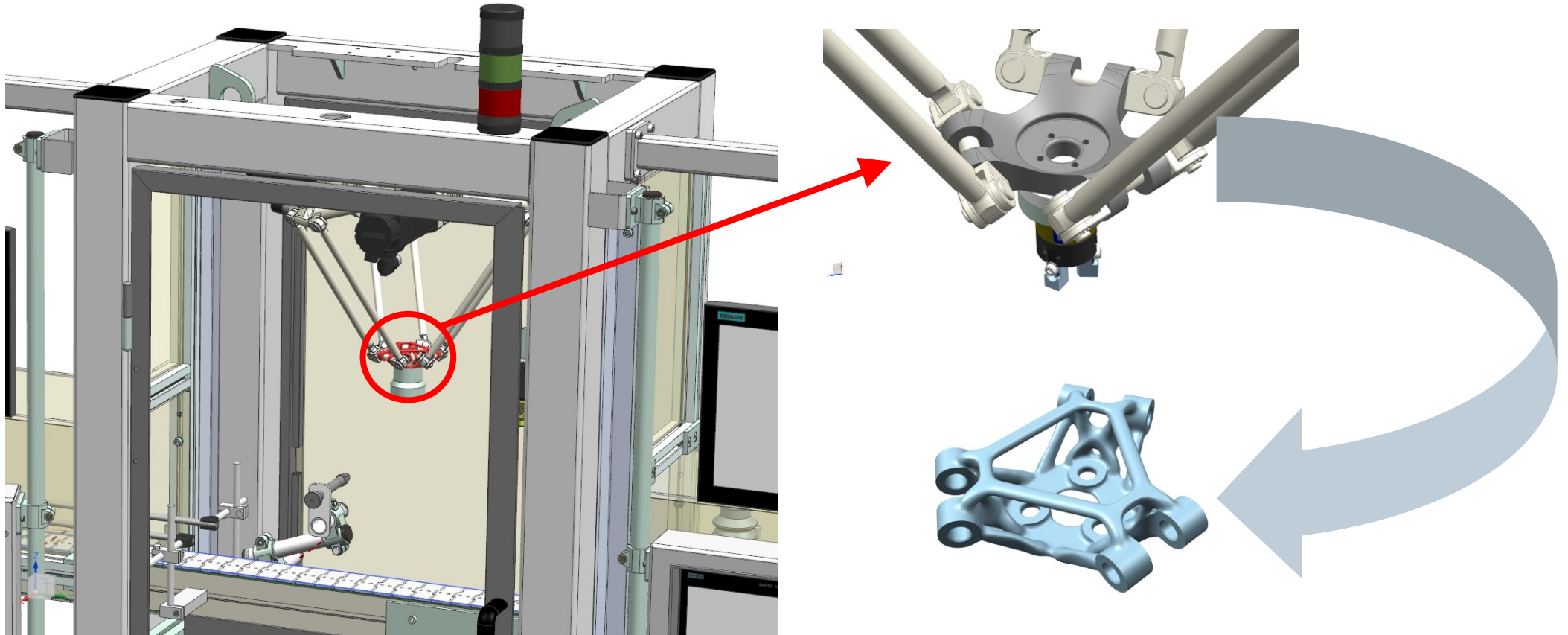
Fused
Deposition
Modeling



Use Case: Generative Design

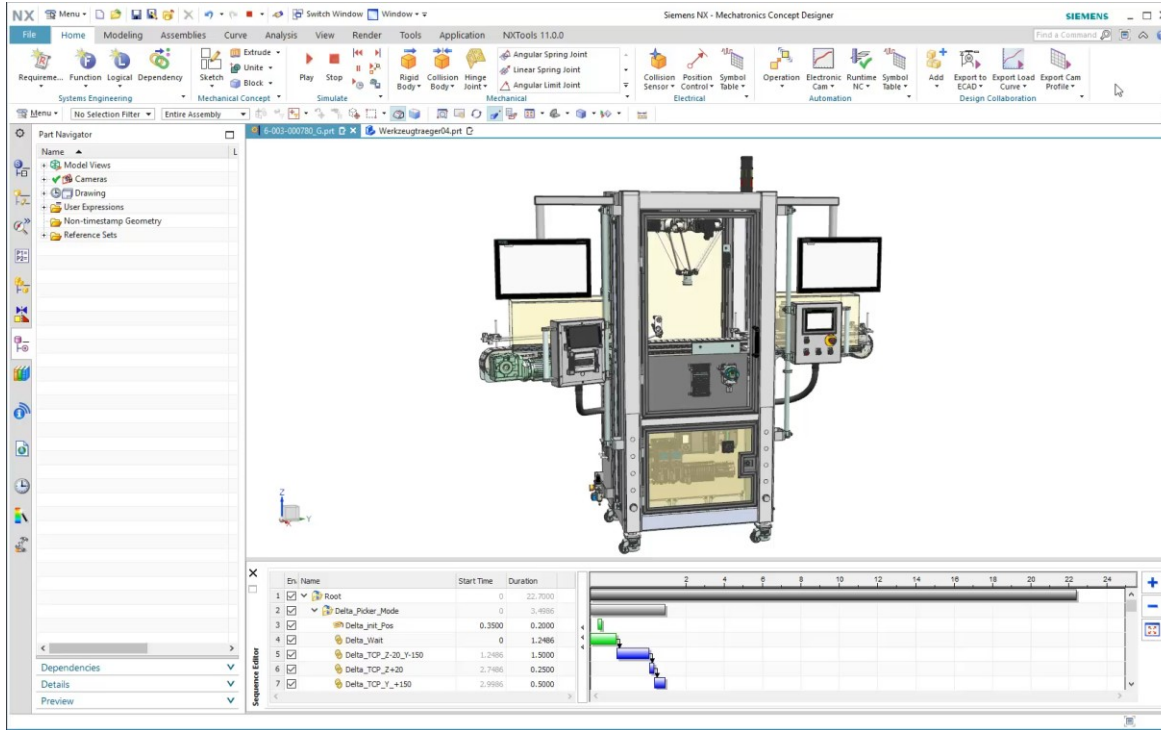
Tool carrier of Delta robot

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NX – One integrated Additive Manufacturing Solution

Capture requirements



Overview

- Capture all Requirements that are relevant for the Subsystem or component design
 - System Loads and Constraints
 - Design Space
 - Mounting Points of Components
 - Materials
 - Costs
 - ...
- Use Simcenter 3D and 1D Solutions to execute full System Simulation

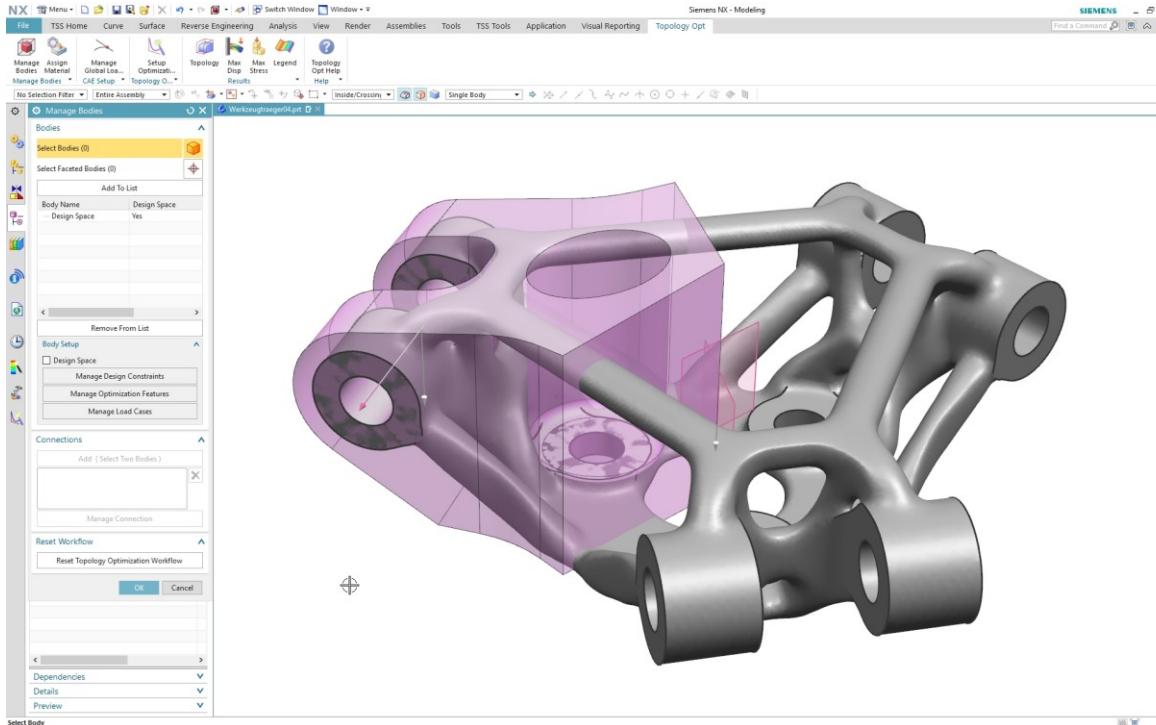
Benefit:

- Use NX and Simcenter capabilities in a seamless integrated way to capture requirements
- Rapid, associative changes possible



NX – One integrated Additive Manufacturing Solution

Generative Design



Overview:

- Topology Optimization generated design Proposals under consideration of the main requirements
- Intuitive Integration into the Design Environment.
- Fast generation of smooth design proposals that may be used in the engineering process.
- Topology optimization for the designer:
- Simple workflow in the design environment
- Performance-optimized solver

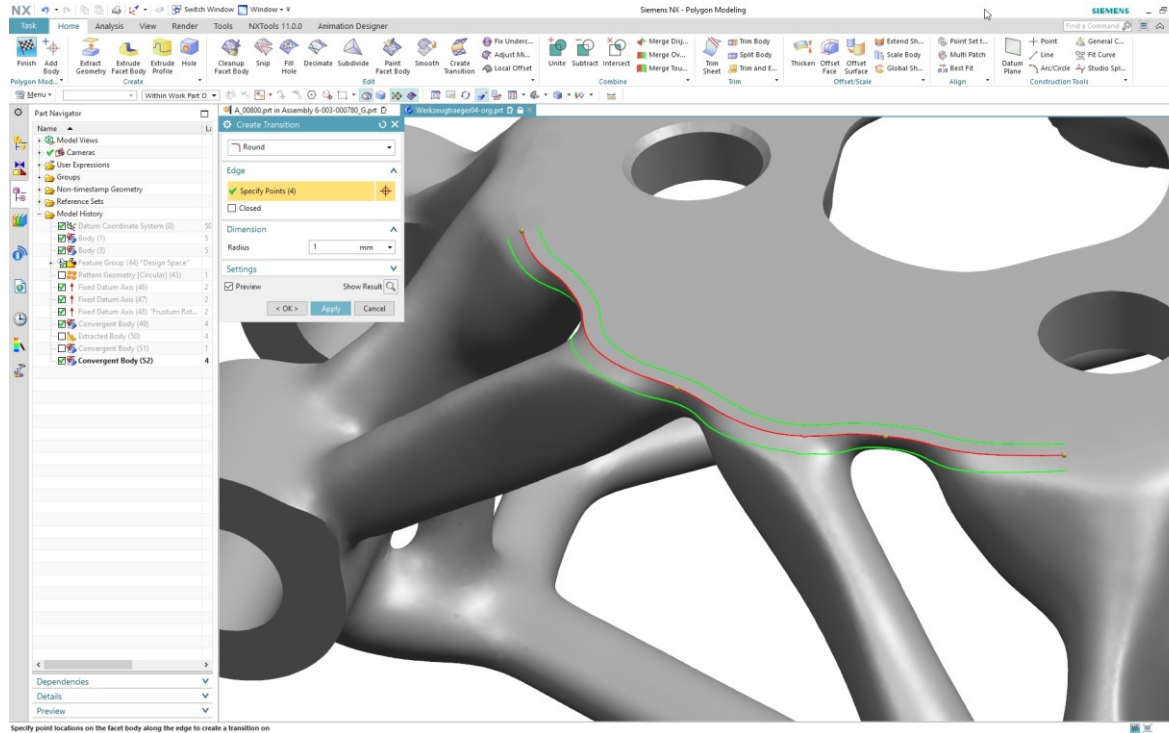
Benefit:

- Easy handling. The user remains in its design environment
- Competitive advantage with light and stable components with Bionic shaping



NX – One integrated Additive Manufacturing Solution Adaption

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Overview:

- Easy processing of faceted geometry with conventional feature commands by Convergent Modeling
- Fast re-approximation of facet geometry with subdivision modeling and Realize Shape
- Reverse engineering for easy creation of freeform surfaces and prismatic geometries

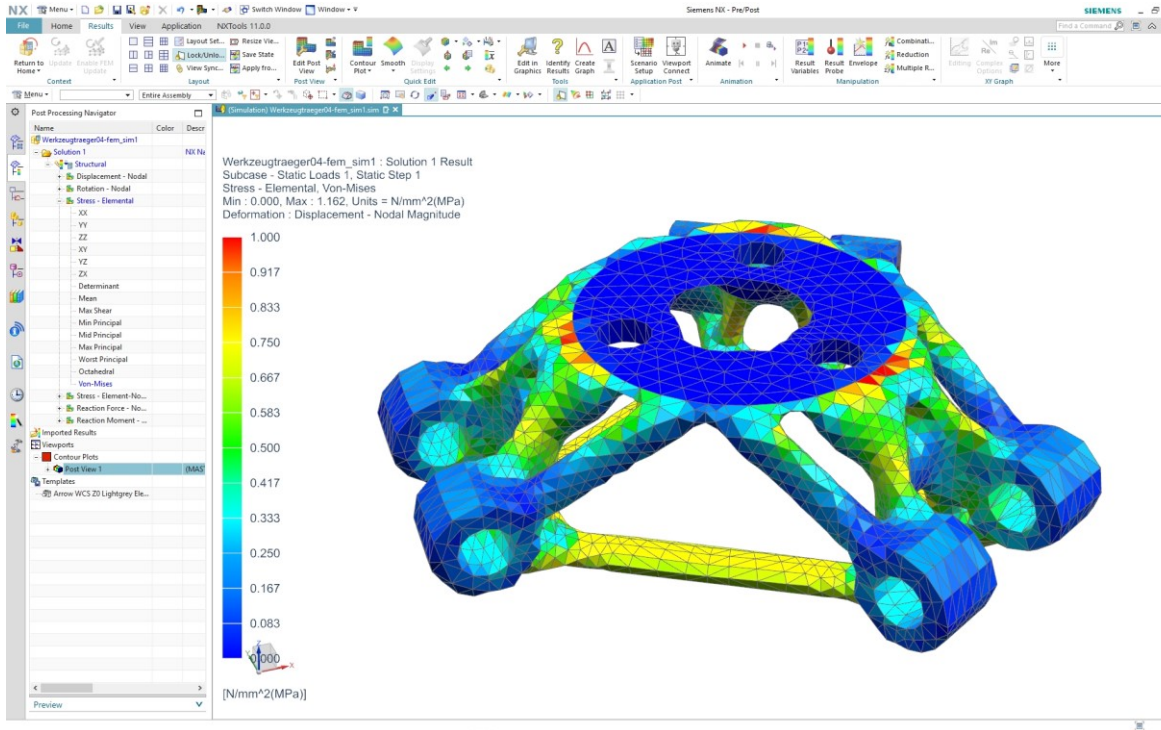
Benefit:

- Time savings by directly re-using the facet geometries from the topology optimization
- Suitable functions for surface rebuilding for different post processes



NX – One integrated Additive Manufacturing Solution

Product Validation

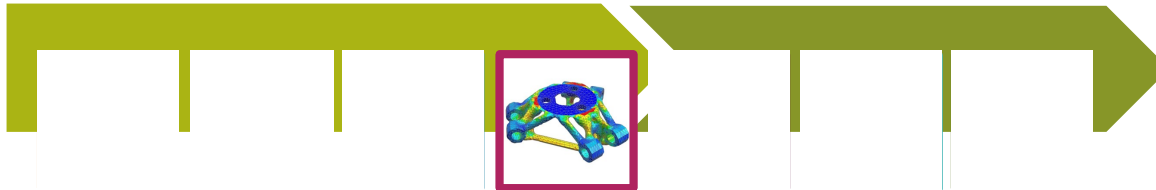


Overview:

- Multidisciplinary functional validation of the final design by simulation with NX Nastran. Structural mechanics, thermal, motion, acoustics, etc.
- Rework and analysis of results within NX
- Direct connection to other simulation tools

Benefit:

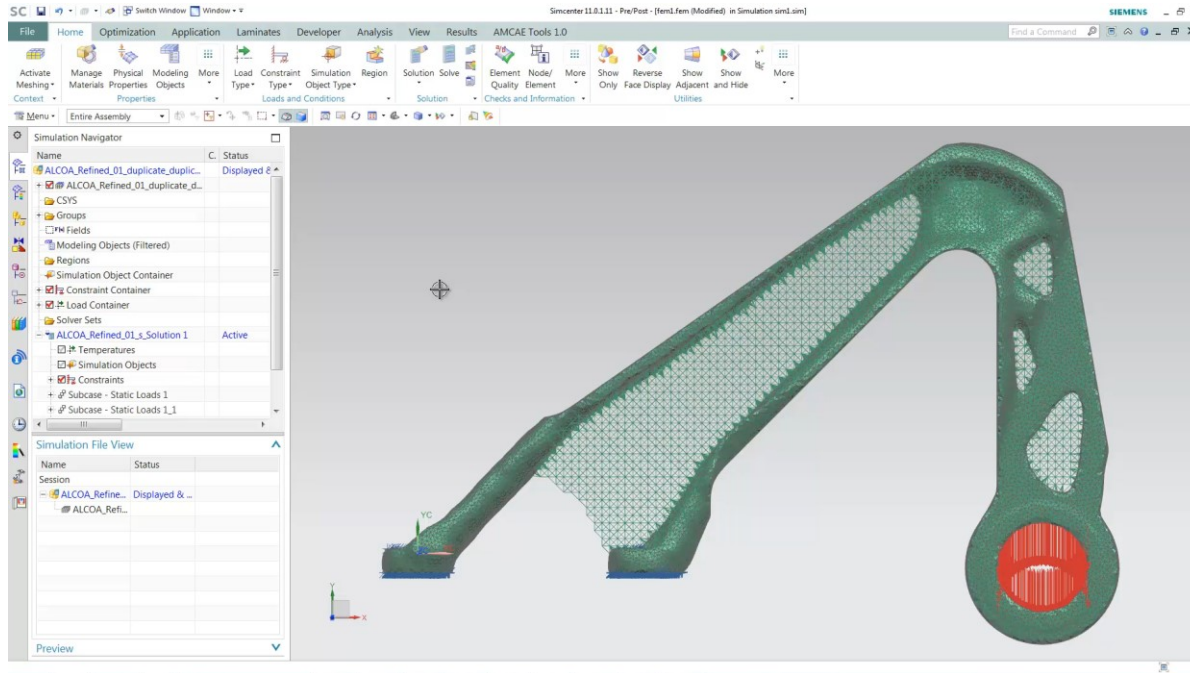
- Check the design intensively without physical prototypes.
- Virtual tests of load cavities which are very difficult to put into reality
- Same User Interface as in Modeling and Manufacturing



NX – One integrated Additive Manufacturing Solution

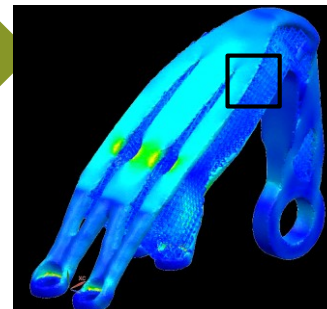
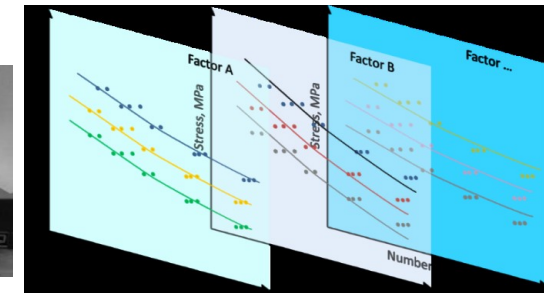
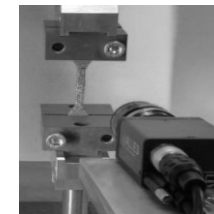
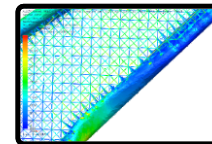
Product Validation

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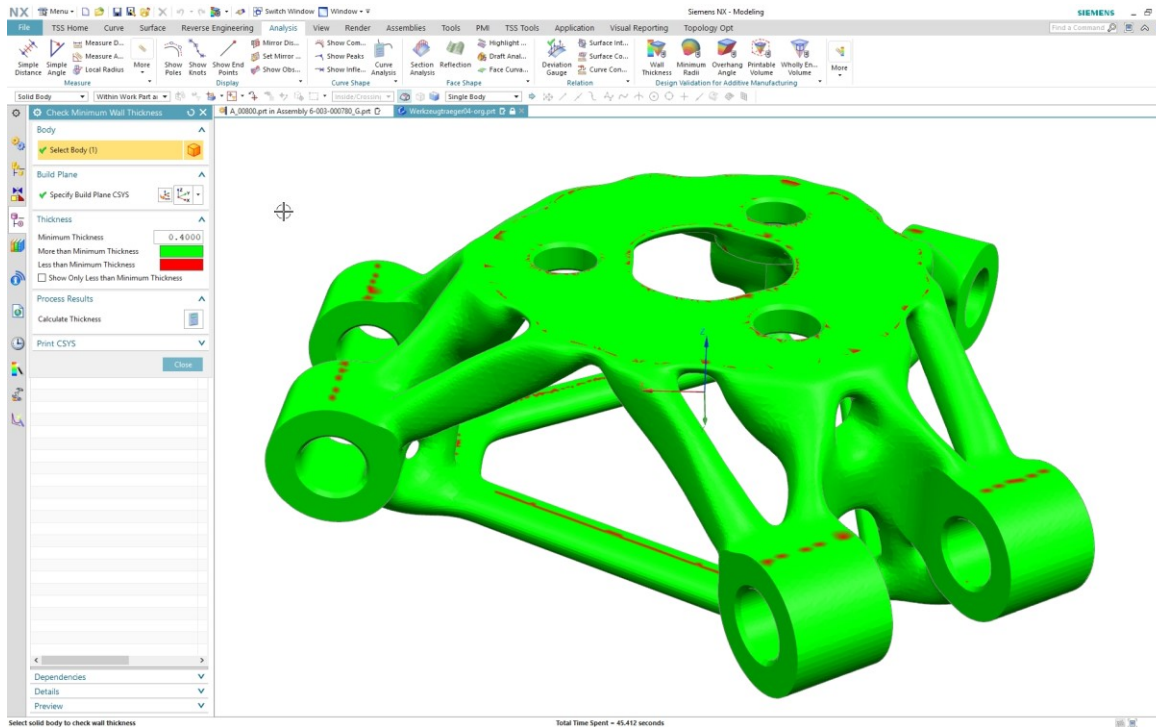
Full Simcenter CAE multi-attribute capabilities to accelerate the adoption of AM components

- **Virtual Material Characterization** enables the usage of lattice structure to achieve optimal performance
- **Novel lattice simulation** technique to achieve accurate results in a short computational time
- **Fatigue Life Prediction** for AM: “Smart” inter/extrapolation of SN-curves based on multi-scale modeling



NX – One integrated Additive Manufacturing Solution

Manufacturing Validation



Overview:

- Integrated analysis for production-appropriate modeling of the components:
- Representation of the area overhang angle for support geometry in additive production
- Check for material inclusions
- Verification of a minimum wall thickness
- Layout definition for the building tray

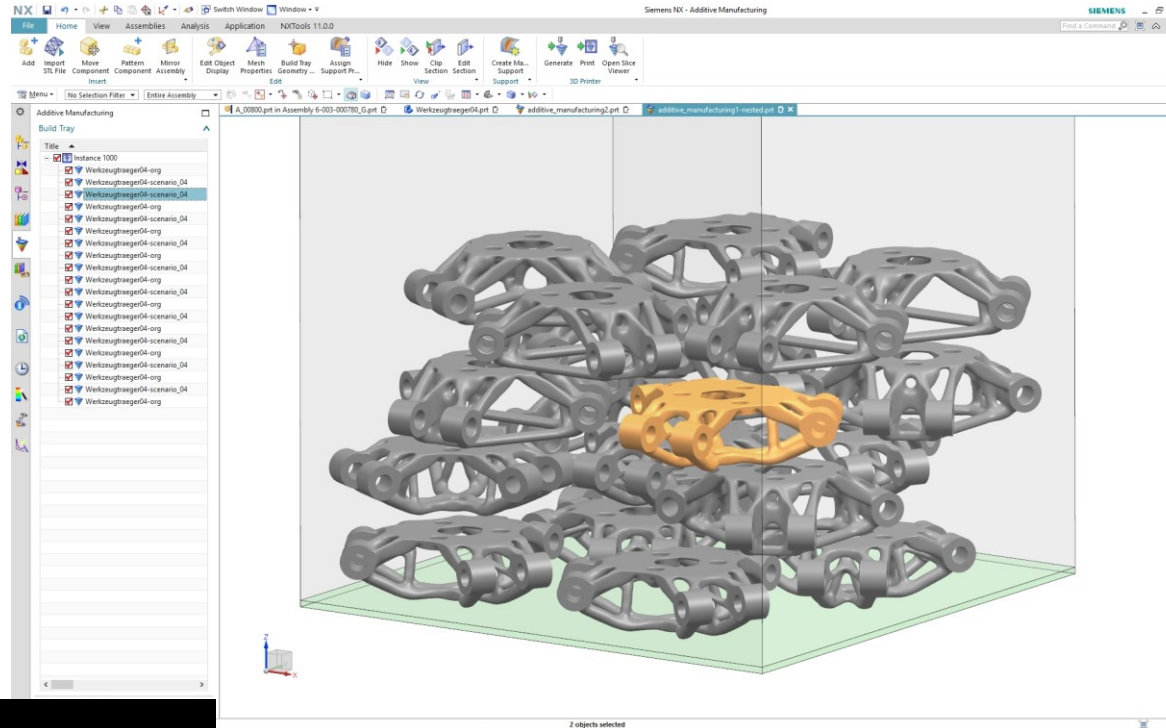
Benefit:

- Fault avoidance through early production validation
- One system with a uniform user interface for various applications



NX – One integrated Additive Manufacturing Solution

Pre-Processing & 3D Printing



Overview:

- Print job setup by selecting the printer and the build tray
- Parts positioning and nesting
- Creating the associative support structures for metal parts using powder bed fusion methods
- The different build processors generate the output to drive the selected 3D printer with the right parameters for the material and print strategy

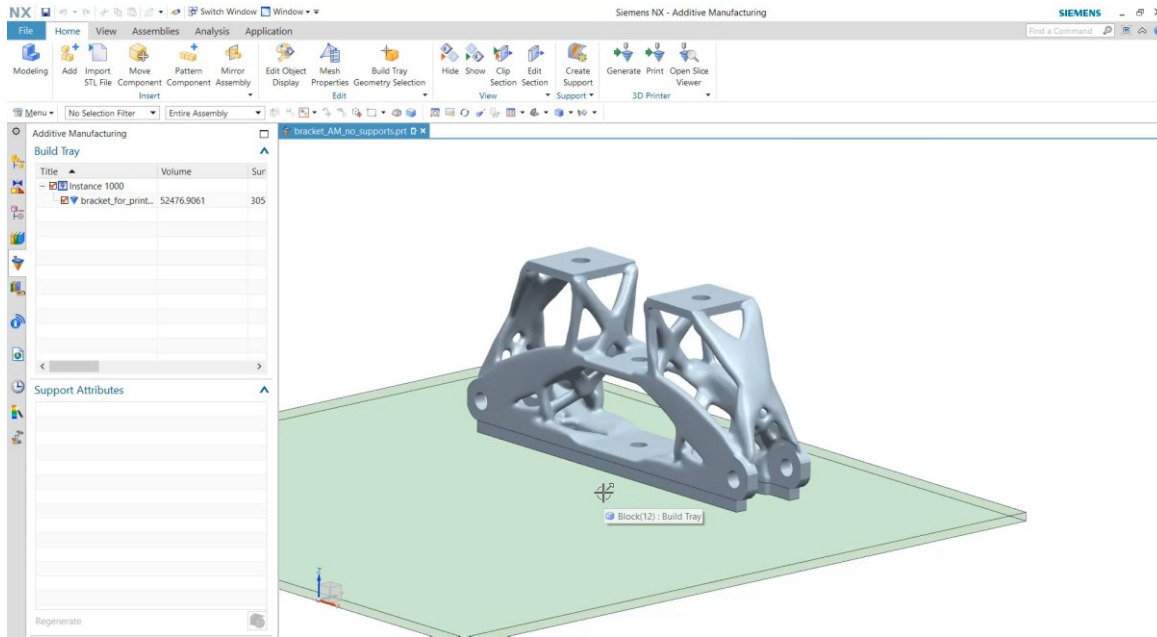
Benefit:

- Only one data format without any conversion
- Users could work in one User-Interface
- Completely associative
- Work preparation (pre-process) completely in the CAX environment



NX – One integrated Additive Manufacturing Solution

Pre-Processing & 3D Printing



Automatic support generation

Automatically generates support structures for the selected parts on the build tray, based on the predefined parameters.

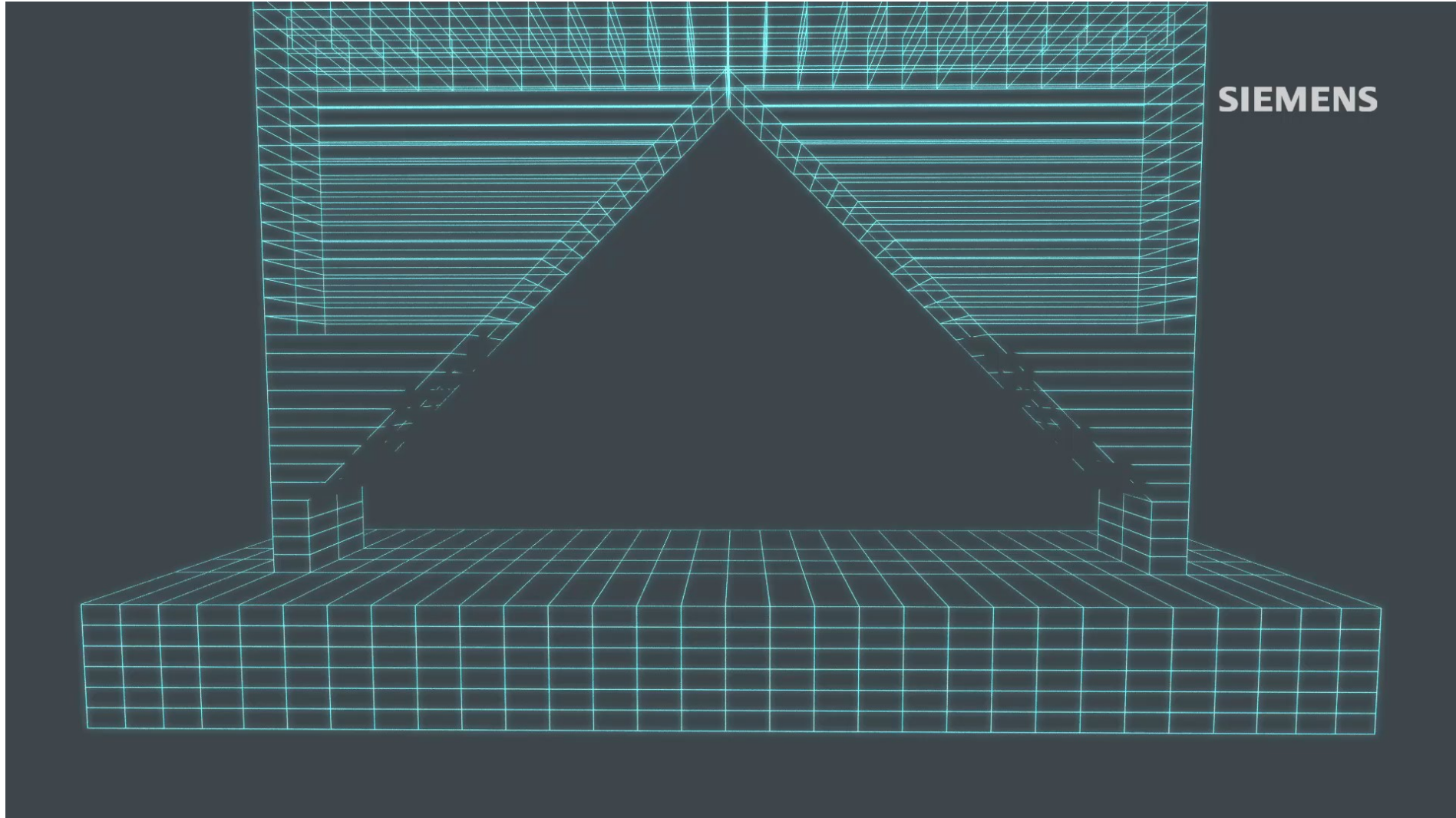
- Allow wide variety of complex and detailed parts to be printed

Capabilities

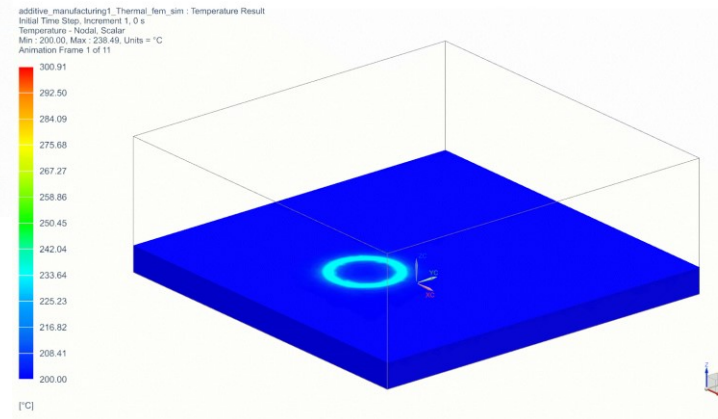
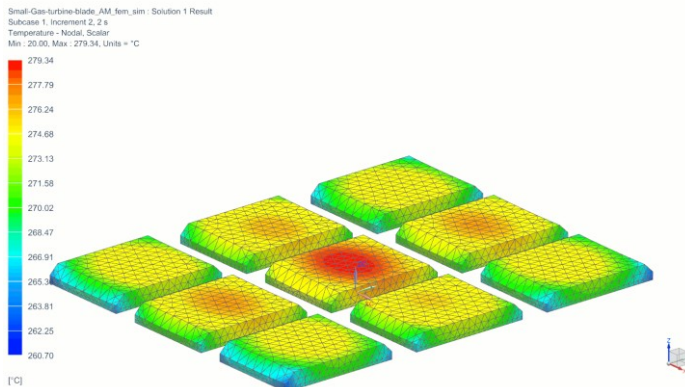
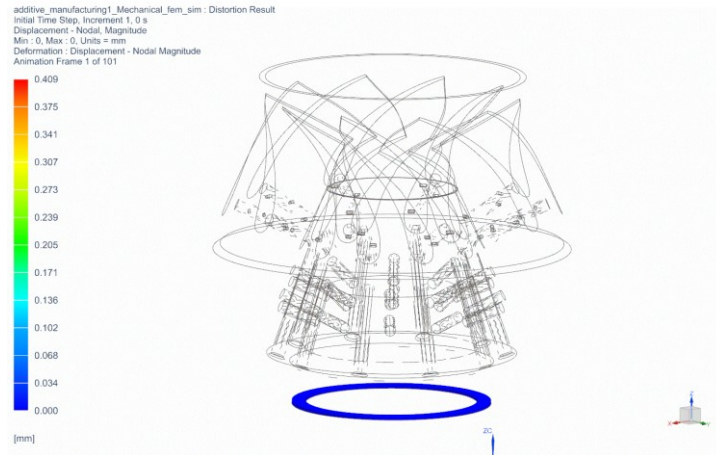
- Automatically identify critical areas that requires support according to the surface angle
- Support different Support Structure's type : Block, Line, Point
- Customize support structure using different support parameters (e.g. teeth, thickness, etc...)



Local Over-heating



Analyst functionalities

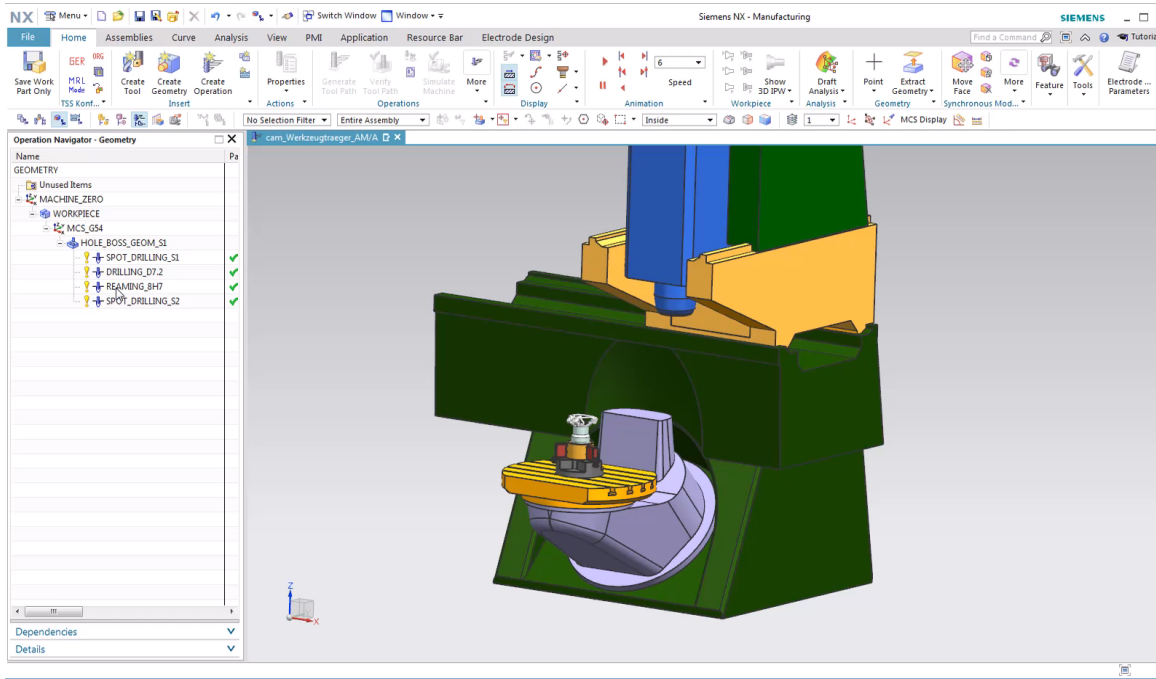


Overview:

- Capabilities to predict distortions
- Prediction of residual stresses
- Assessment of the temperature of the build with/without powder, one of multiple lasers

NX – One integrated Additive Manufacturing Solution

Part Finishing & Quality

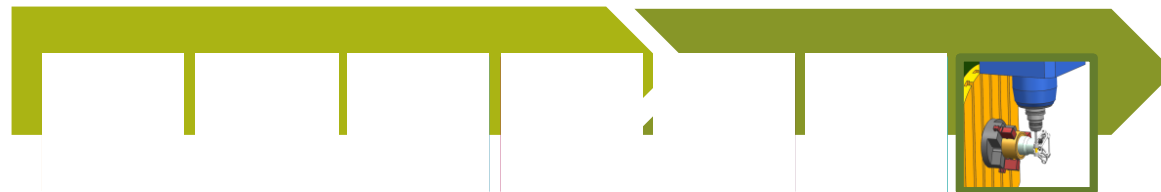


Overview:

- 3D printed parts could directly be finalized to get the needed precise functional areas (e.g. holes etc.)
- Additional different machining disciplines (2,5 – 5 axis operations) are available
- NX CAM also provides advanced CNC programming capabilities to efficiently machine printed parts of any complexity
- The accuracy of the finished parts can be inspected with NX CMM to create inspection programs

Benefit:

- Complete integrated CAM tool chain for the 3D printed part finishing process
- Enables complete 3D printed part finishing process



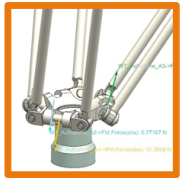
NX – One integrated Additive Manufacturing Solution

From requirement driven Generative Design to 3D Printing

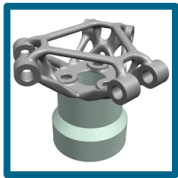


1 - Product Design

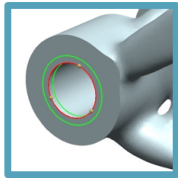
2 – Production planning



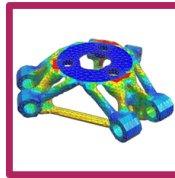
Requirements



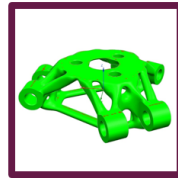
Generative Design



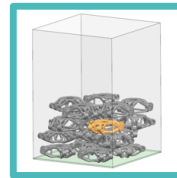
Adaption



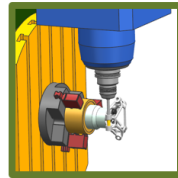
Performance Validation



Manufacturing Validation



Pre-Processing & 3D Printing



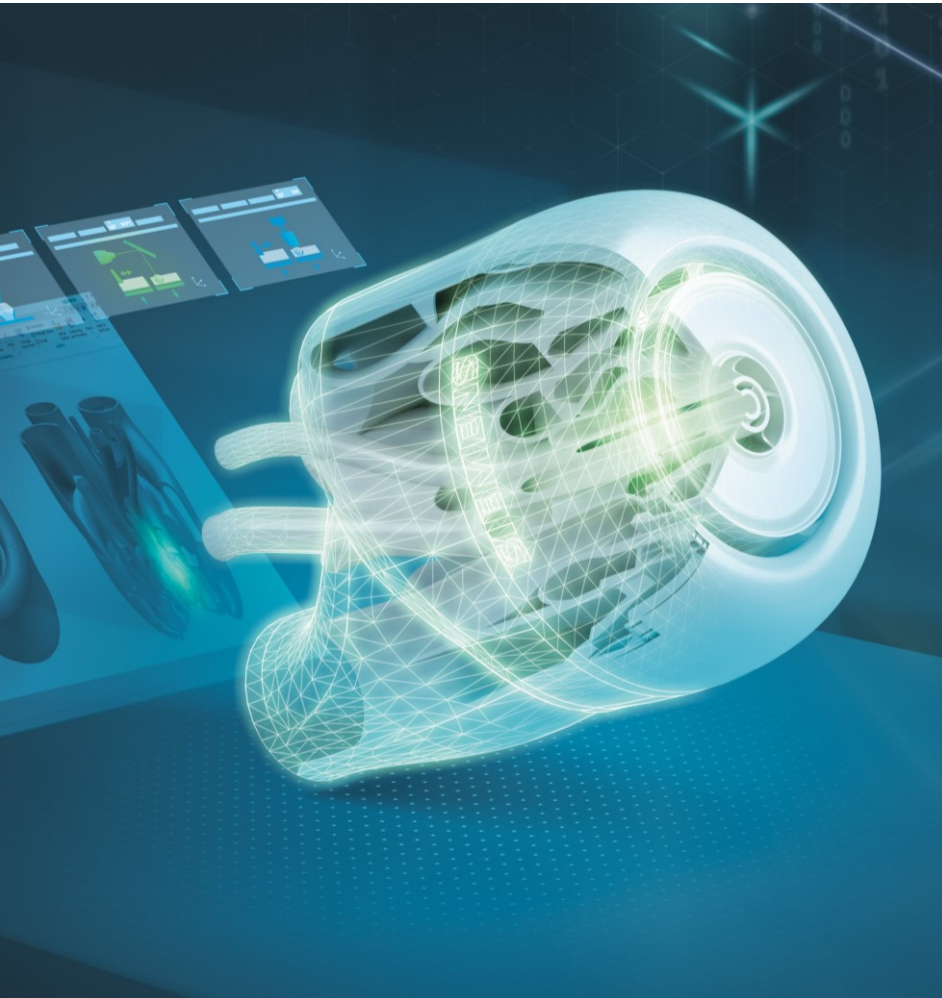
Part Finishing & Quality

Data and Process Management

Summary:

- Supports full AM Process-Thread
- ONE Data-Format for CAD/CAE/CAM – ONE User-Interface
- Fast & Stable Process and Full PLM Integration
- Reproducible
- Associative Design-Changes

Contact



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