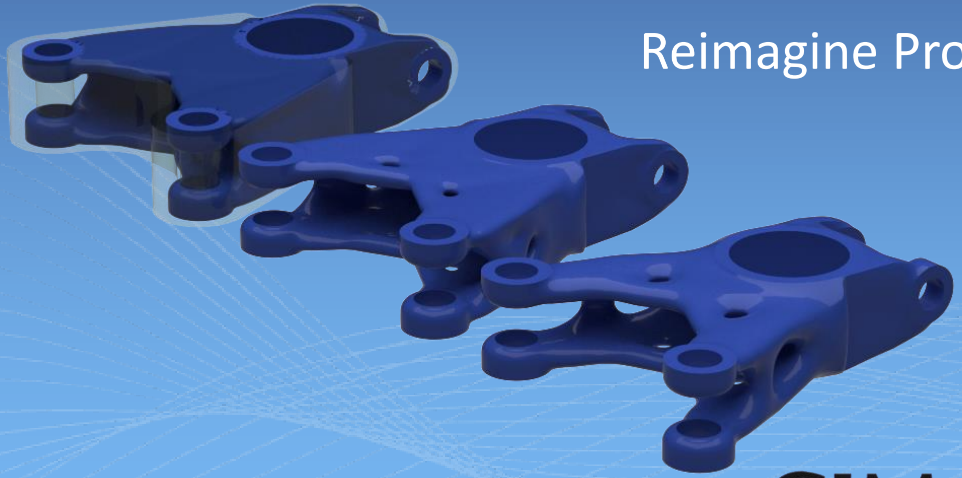
CIMdata eBook

Sponsored by Siemens PLM Software

Siemens PLM Software Advances Generative Design Technology in NX

Reimagine Products



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Takeaways

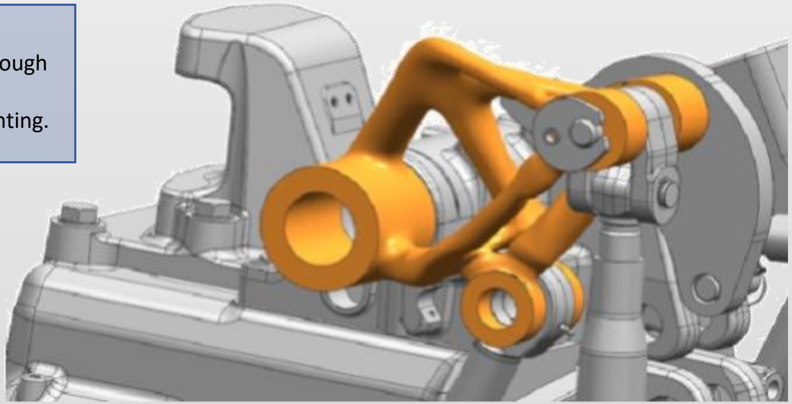
What you need to know

Takeaway #1
Generative design technology uses algorithmic methods to transform requirements into product geometry and design.

Takeaway #2
Generative design is a set of tools and techniques to create optimized product designs from requirements and constraints, rather than by creating the geometry first and then validating. It gives engineers and product designers the means to explore more options in less time to find the best design. NX provides an integrated set of tools such as topology optimization, facet/mesh modeling, rule-based CAD, and advanced freeform shape creation to enable a generative design workflow for designers and engineers to create designs that meet requirements more efficiently.

Takeaway #3
Generative design requires a workflow approach from initial design through to manufacturing. Siemens PLM Software's **Convergent Modeling** technology underlies the full workflow from design modeling to 3D printing.

Takeaway #4
Today's implementation of Generative design is the first step toward a vision of automatic creation of model geometry that fully meets design requirements.



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Introduction

Enabling innovation to reimagine products

New Design Methods

Recent advances in design technology are driving new levels of innovation across product development and a call to "Reimagine Products" in shape and form unprecedented in the past. These new methods are called Generative Design.

Generative Design

Generative Design turns the traditional design paradigm on its head. Whereas conventional methods rely on a "model then analyze" iterative cycle, with Generative Design the product designer first identifies the necessary design space (or bounding volume) and design goals (such as minimizing weight). Geometric constraints are identified together with additional values for non-geometric parameters such as material and cost constraints. Software algorithms then do the job of automatically cycling through numerous geometric model permutations seeking an optimum solution based on all of the defined constraints.

The Iterative Cycle

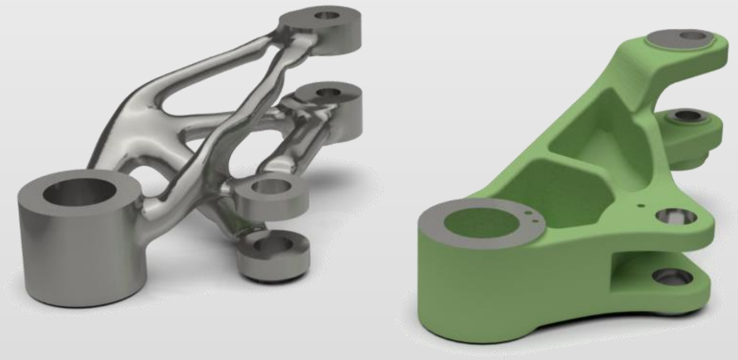
At each step in the cycle the optimization algorithm learns from the previous results whether the design is improving toward its target goals and makes the appropriate model adjustment for the next iteration, running until its specified goals have been met.

Examples of Generative Design

Some Generative Design methods include topology optimization, shape optimization, manufacturing optimization, and even rules-driven parametric CAD techniques.

These optimal designs, sometimes termed "organic" because they can mimic nature, cannot be derived through traditional design methods, nor can they be manufactured using traditional, subtractive manufacturing methods. The companies who produce such designs will potentially disrupt and displace the companies who don't.

Generative design approaches offer product developers the opportunity to explore many more design alternatives than when using traditional methods. However, it can be a challenge for today's CAD solutions to accept the output geometry from generative design including topology optimization methods since it is in the form of a faceted model. Most CAD systems cannot modify faceted geometry.



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Generative Design

Simulation-driven design

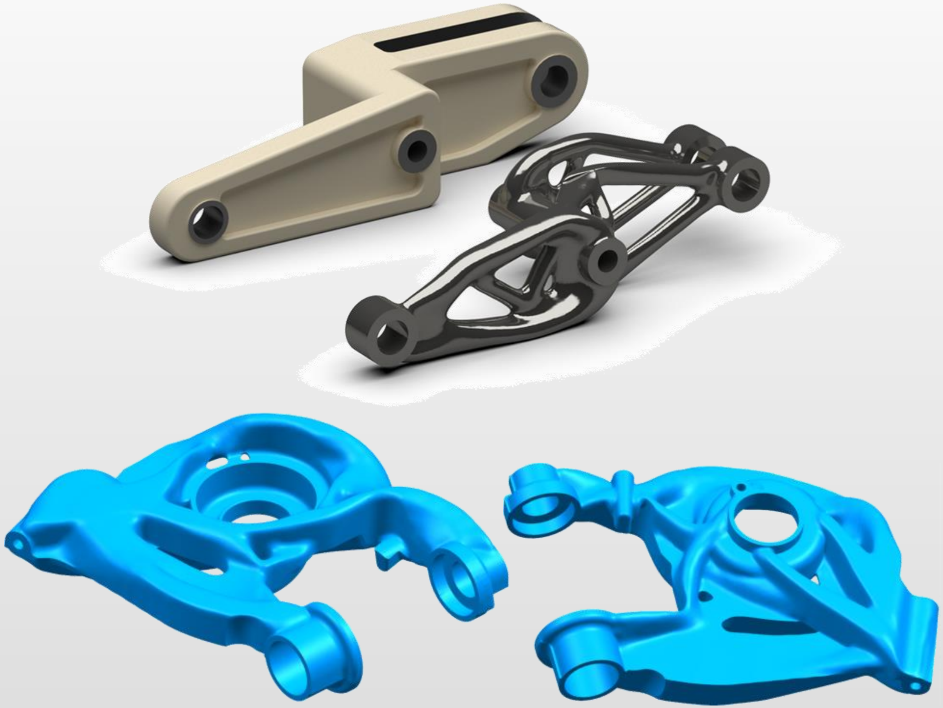
Defining Generative Design

It is difficult to obtain a succinct characterization of Generative Design because software solution providers all promote slightly different definitions. CIMdata defines Generative Design as a process or set of tools wherein the shape and composition of a product are determined by using physics-based simulation and other analysis methods that consider performance requirements and optimize to objectives such as minimum cost and weight.

Versus Traditional Design

Generative Design differs from traditional methods in that the algorithmic process evaluates and changes the product model for the next analysis iteration. No human operator is involved once the optimization process begins.

The origins of Generative Design are in mechanical design but the technique can be extended to other disciplines such as electrical or electronic design.



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Topology Optimization

Lighter and stronger

Defining Topology Optimization

The most recognized generative design process is topology optimization. It optimizes material layout within given design spaces for a given set of functional requirements including loads, boundary conditions, and constraints.

Typically the goal of the optimization is to both meet the structural strength of the model while minimizing its mass, thereby reducing its weight and saving on material.

Generating Benefits

Generative design methods facilitate faster decision-making. Once initialized, generative design processes run without human intervention. With a given set of conditions, designers are able to conduct more experiments in much less time than is possible with traditional design methods. Input parameters can be varied to experiment with the design using Siemens PLM Software's HEEDS to facilitate the process.

Topology optimization reduces material use. The approach creates models that require only the amount of material needed to meet product requirements which reduces material waste and cost.

Transforming Production

When combined with additive manufacturing, topology optimization gives manufacturers the capability to produce complex shapes that are impossible to build using traditional methods. This pairing speeds production of both prototypes and finished parts.

Further, the topology optimization / additive manufacturing combination can reduce costs by using less material and by eliminating the need for expensive equipment and tooling.

Images courtesy of Siemens PLM Software

Workflow and Design Space

Bounding the problem

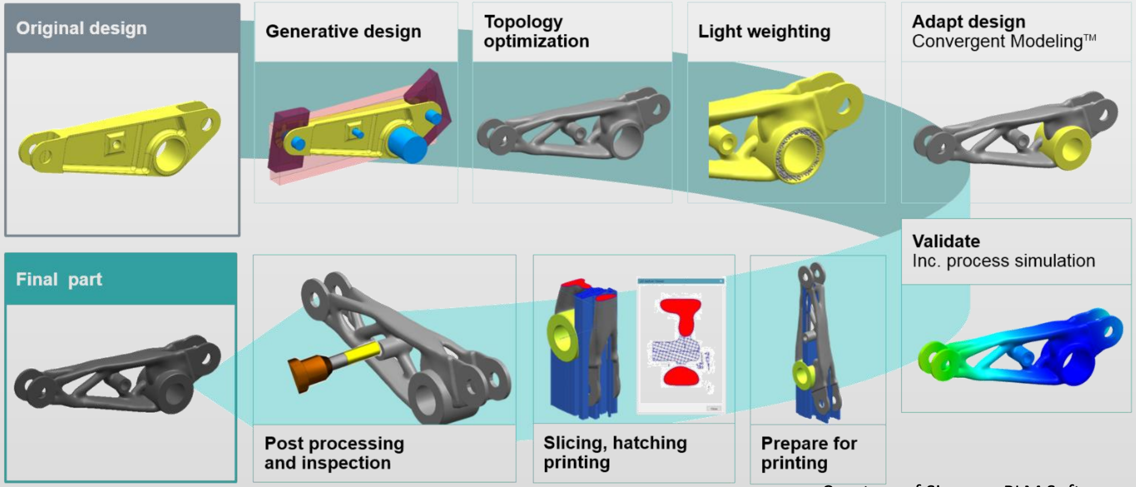
Workflow

The workflow starts with identifying a target part for optimization. The designer initializes the generative design process by setting up loads, constraints, and target goals. The topology optimization is run and the designer finalizes the part model with precise geometry edits where needed, adding light weighting lattice structures, performing a final analysis validation, setting up support structures for 3D printing, and executing the final 3D print.

Design Space

One important step happens early in the workflow. The seeding of the topology optimization algorithm by bounding the design space for the component part or assembly. The designer specifies the volume of space within which the resultant optimized geometry should be constrained. In addition, the designer adds specific keep out areas, loads, and other related information such as material type.

Design and Manufacturing Topology Optimization Workflow



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Convergent Modeling

A blend of faceted and precise

CAD Geometry

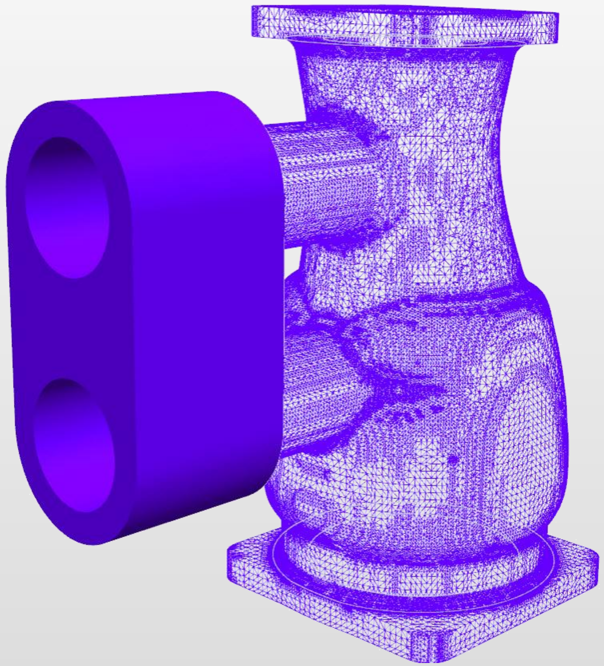
Conventional CAD solutions have foundations that are built upon precise geometry. Product development in all industry verticals has long relied on concise shape definition with attention to tight tolerances for quality control. The vast majority of CAD solutions in the market cannot handle the faceted geometry data that is the output of topology optimization algorithms, leaving product designers in a quandary.

Convergent Modeling

Siemens PLM Software delivers generative design by leveraging an extension within their Parasolid geometry kernel that underlies their flagship NX CAD solution. Parasolid now supports a mix of precise geometry using non-uniform, rational B-splines (NURBS), exact analytic functions and mesh/planar faceted geometry. Siemens calls the pairing Convergent Modeling™. Therefore, generative design algorithms produce mesh geometry that can now be modified within NX and enables designers to do topology optimization without the need of an analyst.

Siemens PLM Software is proactively updating all the numerous downstream design functions to operate on faceted geometry.

Combining Precise and Faceted Geometry



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Adapting the Design

Model edits and lightweighting

Model Edits

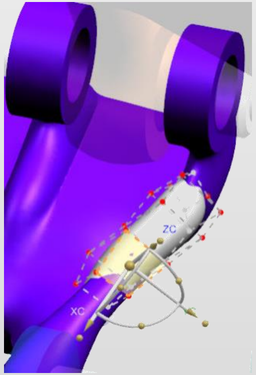
The practical benefit of Convergent Modeling is that faceted geometry ranks equally with precise geometry in the NX solution allowing the use of editing capabilities that are familiar to designers. Product designers can easily add fillets, drill holes, and do other edits to help finalize the product model.

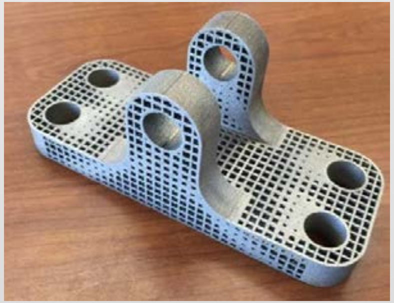
Design for Additive Manufacturing (DfAM)

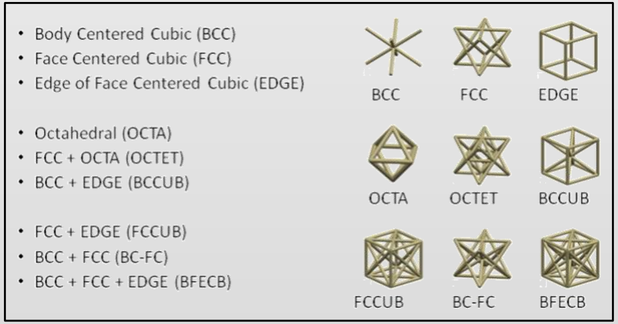
"Lightweighting" or the reduction of product mass describes any process used to reduce weight. The use of lattices defined by facet geometry is one such method and has grown in popularity due to the increased use of 3D printing. The ability to manufacture products with sophisticated lattice structures is virtually impossible using traditional manufacturing techniques. 3D printing makes the addition of lattices possible. They are intricate geometrical structures used to reduce weight and material consumption and at the same time strengthen components.

The user uses selection tools to specify the area within which they wish to generate the lattice and then specify the lattice's appearance and density. They may select from many different lattice cell types and indicate the cell edge length and rod diameter, as well as the placement and orientation of the lattice. Lattices are produced by additive manufacturing processes and provide structural integrity to product designs while reducing the amount of material used, and hence the weight, in the finished product.

Validating designs for 3D printing is a key step in the process that can eliminate costly re-design of parts for additive manufacturing. These integrated capabilities in NX help designers know if a design can be printed long before it is released to manufacturing, saving time and improving efficiency. Some of the checks include: Is my part too big for the printer? What faces might need additional support? Check the wall thickness and identify voids with a part.







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Validate

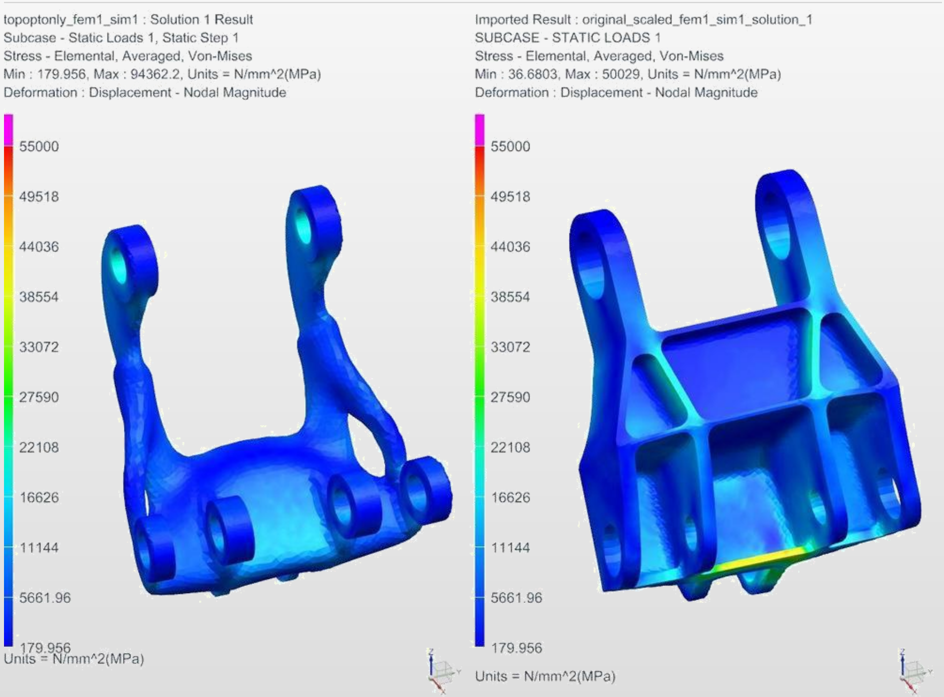
Simulate the result

A Bow to the Traditional Design Process

Once the designer has obtained their topology optimized model and made any necessary edits, a final analysis of the part is performed to assess its adherence to the part's upfront design requirements.

In that the goal of topology optimization is to meet, for instance, specified structural strength objectives of the model while minimizing its mass, final results should be evaluated and recorded.

This final simulation is especially important if the designer has made geometry edits to the topology optimized result and if a more refined look at physics for stiffness and durability is necessary. Siemens PLM Software reports that this can be done with a single analysis input data set.



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Prepare for Printing

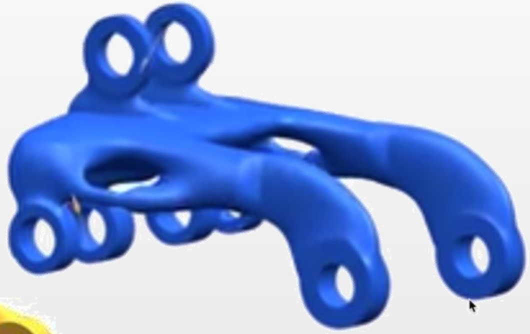
Expedite manufacturing setup

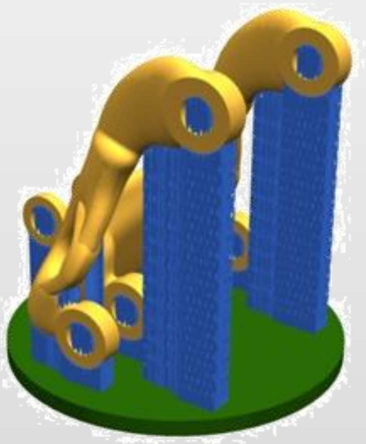
Print Using a Wide Range of Hardware

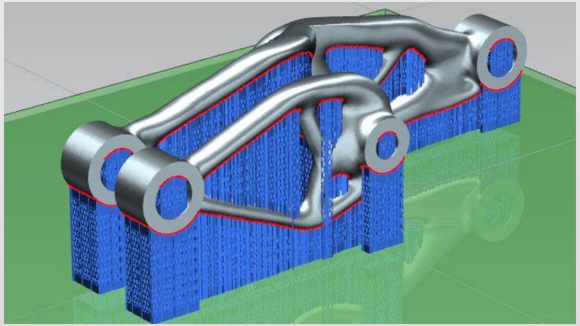
Because 3D printed parts are built layer upon layer, each new layer requires a layer upon which to build. Depending upon the specific 3D printing technology being used and the overall complexity of the part model, support structures may be required. Placement of these supports and their choice of material can be critical decisions for a positive 3D printing outcome.

Siemens' NX software offers all the necessary pre-print setup operations in their integrated print preparation software. Once the 3D printer is selected, NX offers templates for supported printer types providing build volume and settings to control the print process.

The tools offer part positioning, orientation, and nesting capabilities. In addition, designers can create support structures (powered by Materialise, a Siemens PLM Software partner) to maintain model integrity during the printing process.







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3D Printing

Supporting additive manufacturing

Range of Hardware

Siemens PLM Software's NX solution supports a wide range of additive manufacturing hardware platforms. Siemens has been developing partnerships with the premier hardware companies across the industry to support their products. CIMdata recognizes the extensive relationships that Siemens has developed.

NX understands the 3MF (3D Manufacturing Format) and STL (STereoLithography) data standards used for interfacing with various types of 3D printers.

In addition to supporting Powder Bed Fusion technology printers commonly used for metal printing, Siemens has partnered with HP to support their Multi Jet Fusion devices.

NX also supports hybrid manufacturing machines. These machines use a DMD (Direct Metal Deposition) process for 3D printing of metal parts and allow normal subtractive operations all within the same device. Their multi-axis nature means that the deposition paths used are 3D rather than planar.

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Conclusion

CIMdata's final thoughts

Partnering for the Future of Design

The emerging technology of Generative Design, especially Topology Optimization, is gaining interest in product development communities. While most implementations are in prototype study or for one-off parts, the future is sure to bring more examples staged in a production environment. That future is uncertain concerning changes in direction it will take over the next few years. However, CIMdata believes Siemens PLM Software has set the stage at a fundamental level within their NX solution to support their customers who will go on the Generative Design journey no matter which directions that journey will take.

The implementation of Convergent Modeling within NX will surely reap numerous benefits for its users.

While the current process workflow for generative design has aspects of manual intervention, Siemens PLM Software is working on future improvements.

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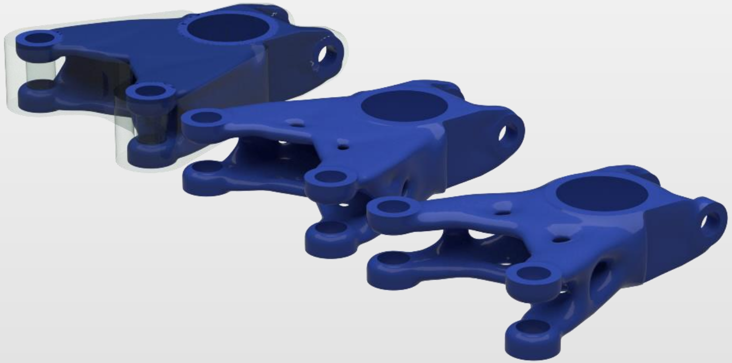

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