MFG500646

Basics Generative Design in Fusion 360

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Autodesk

Learning Objectives

- Change the way you design using Generative Design
- Define, generate, and explore a generative design study
- Build knowledge of what generative design is and how it could change the way we think of design
- Learn how to increase product performance on components

Description

Generative design is changing the way we design, engineer, and manufacture the products of tomorrow. By capitalizing on cloud technology, hundreds or thousands of higher-performing design options can be generated based on objectives, enabling users to make tradeoffs for different materials, performance, and production options. The benefits of generative design are also not restricted to just the world of additive manufacturing, but can also be capitalized on with subtractive manufacturing, and even as design inspiration for traditional techniques. In this presentation we will learn how to use Generative Design to create multiple models that meet production, performance and cost requirements and choose which ones to produce.

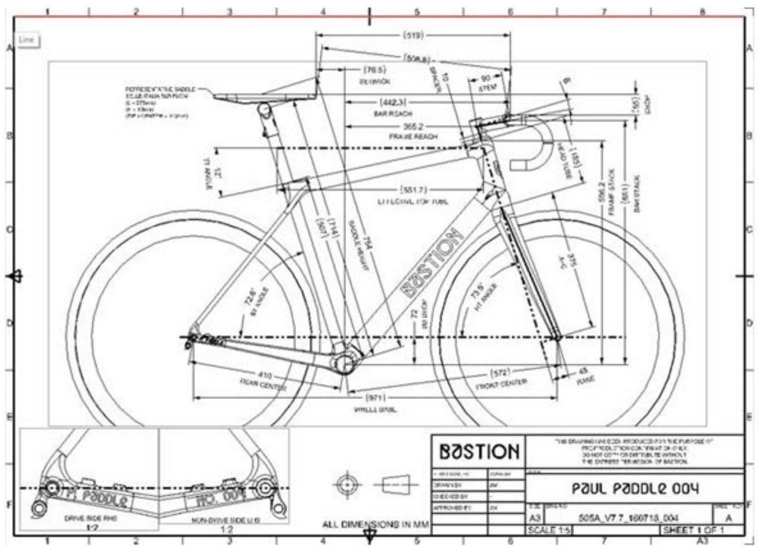
Speaker(s)

Alessandro Gasso is currently employed as Fusion 360 / Generative Design Adoption Specialist within the Customer Success Organization at Autodesk, Inc. Over the past 21 years with Autodesk, Ale has worked in various roles including product support specialist for Inventor, the lead for the EMEA Inventor Product Support Team, EMEA technical lead of Inventor software, premium support specialist leading the PSS Manufacturing Team, manufacturing industry technical lead, and Enterprise Solutions leads manager. Ale was the co-author of the Being Inventive Inventor blog, and he has spoken at Autodesk University from 2012 to 2020. Before Autodesk, Ale worked for 7 years as a mechanical designer for a company in the defense industry. Ale is a native of Italy who speaks English, Italian, French, Spanish, and Portuguese, and he holds a master's degree in electromechanical engineering from the University of Naples (Napoli).

Generative Design

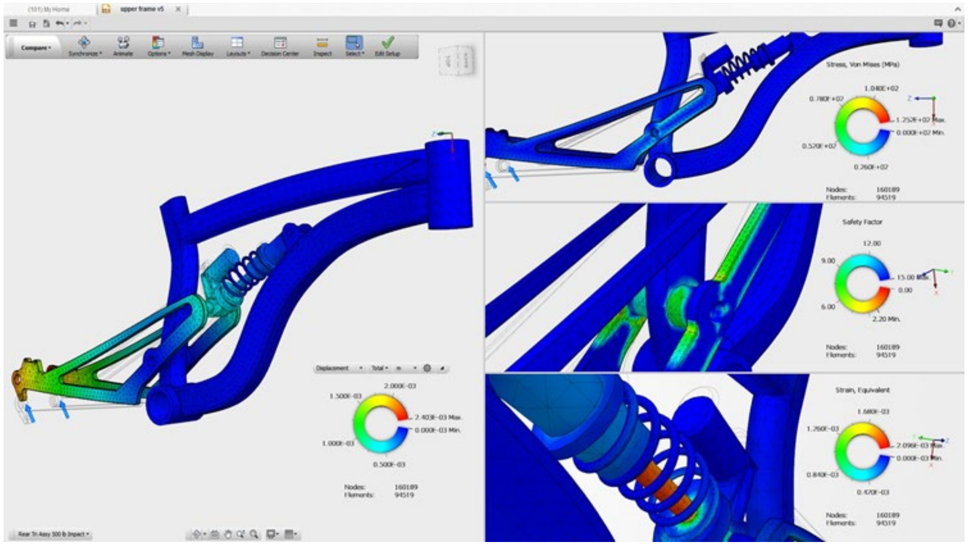
To power this technology requires a step change in software to drive not a function of the system, but the entire process.

So far in the history of engineering software, we have seen 3 waves of disruption, but thanks to these new trends, we're about to witness a 4th.



In the first wave of disruption, we saw 2D CAD revolutionize design through the ability to reuse and edit content.

In the second wave of disruption, we saw 3D parametric deliver massive leaps in productivity through its ability to control change.



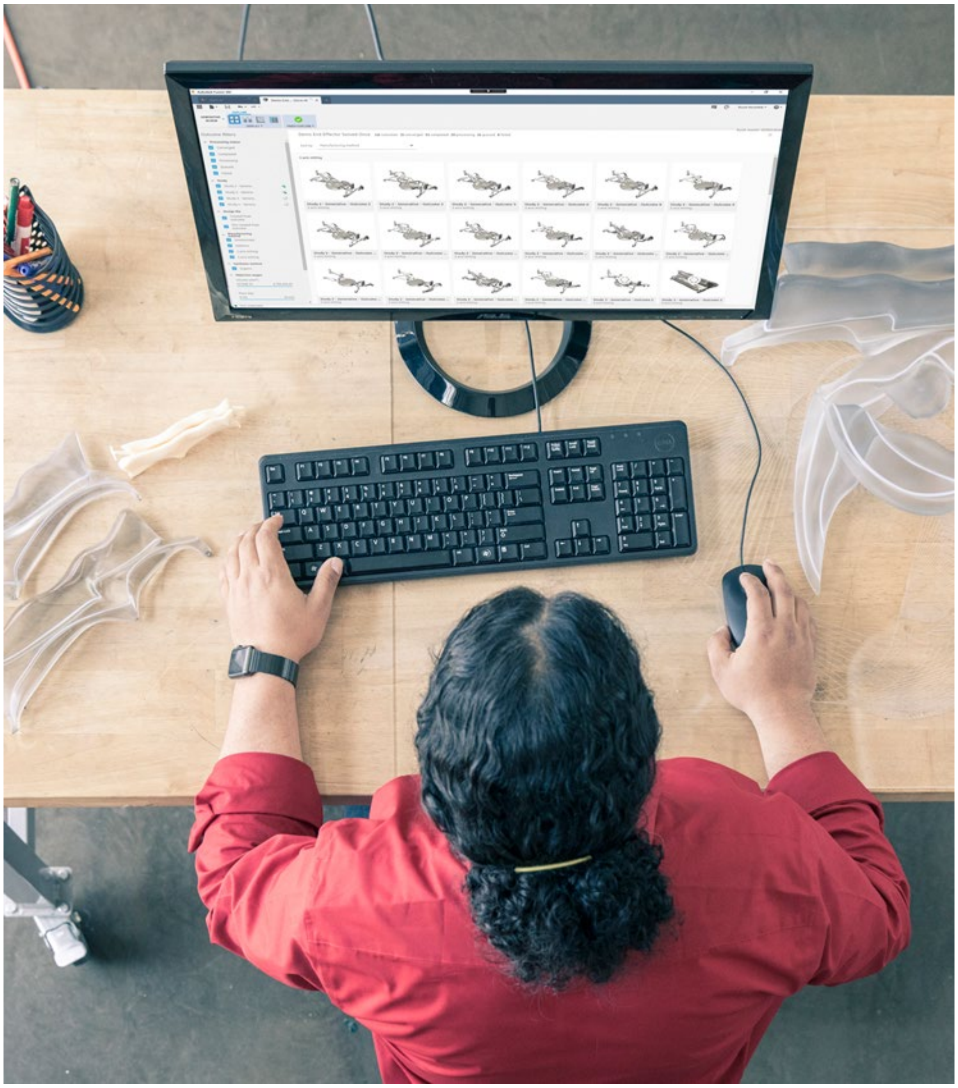
In the 3rd wave of disruption, we saw model-based design equip engineers with the technology necessary to simulate behavioral characteristics of designs in order to improve product performance and quality.

But in this next, 4th wave of disruption, we will witness the advent of a new technology that empowers engineers to automate the process of generating huge volumes of design and manufacturing instructions, optimized to the precise requirements of the customer and the manufacturing process being utilized, so that organizations can deliver not just one great product, but hundreds of thousands of uniquely optimized solutions, at scale, for an infinitely variable market demand.

This is what we call generative design and manufacture.

What is Generative Design

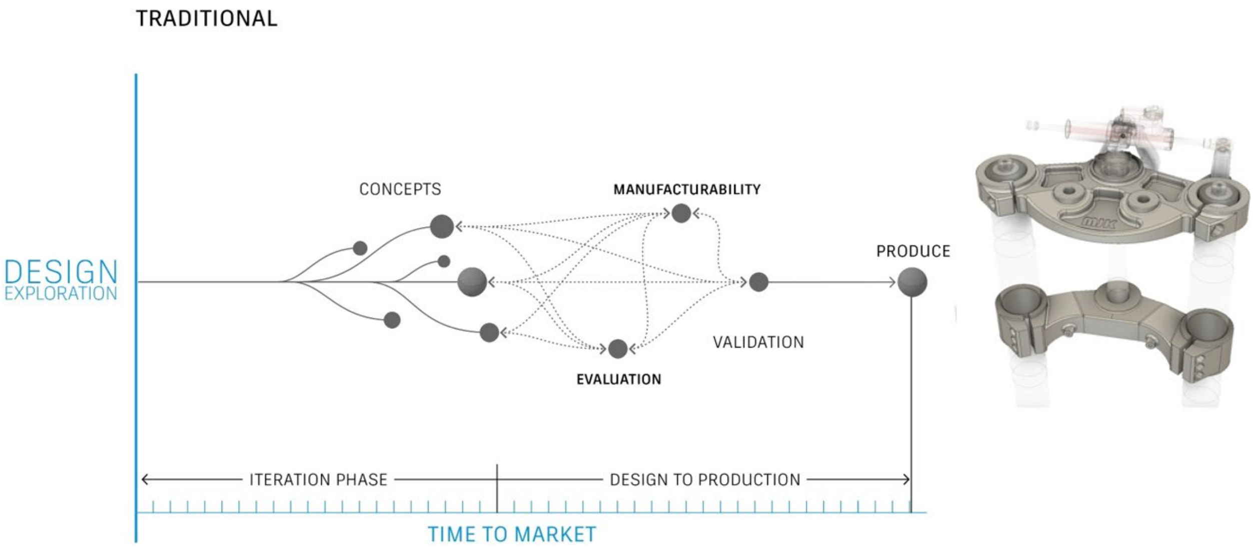
Generative Design is a design exploration technology.
Simultaneously generate multiple CAD-ready solutions based on real-word manufacturing constraints and product performance requirements.



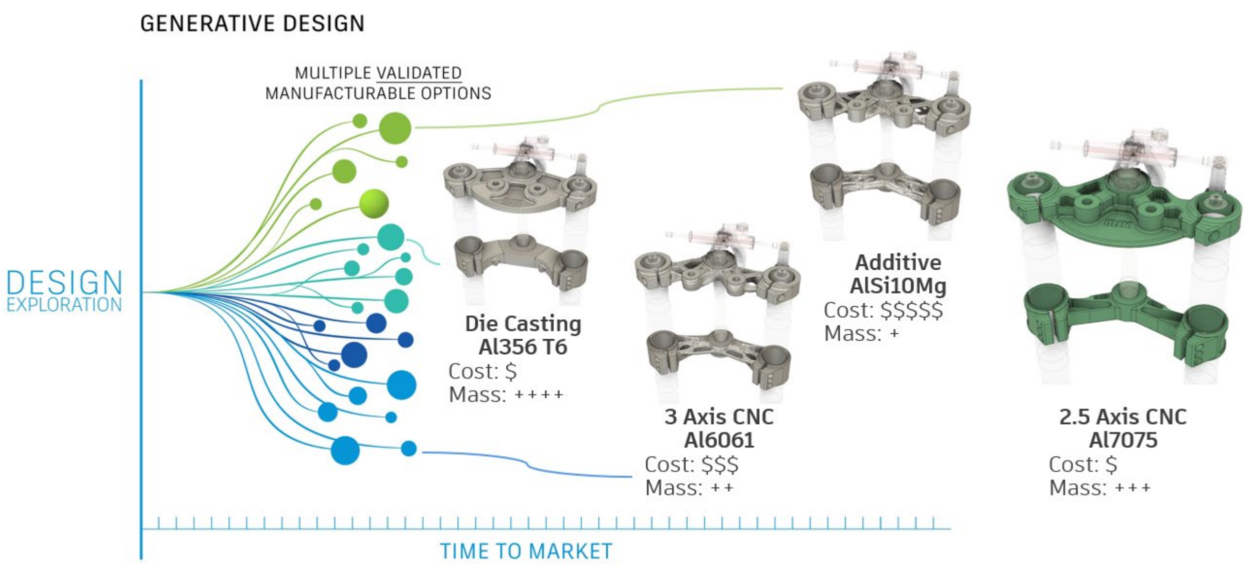
Designers or engineers input design parameters (such as materials, size, weight, strength, manufacturing methods, and cost constraints) into generative design software and the software explores all the possible combinations of a solution, quickly generating hundreds or even thousands of design options. From there, the designers or engineers can filter and select the outcomes to best meet their needs.

How Generative Design helps the product development process

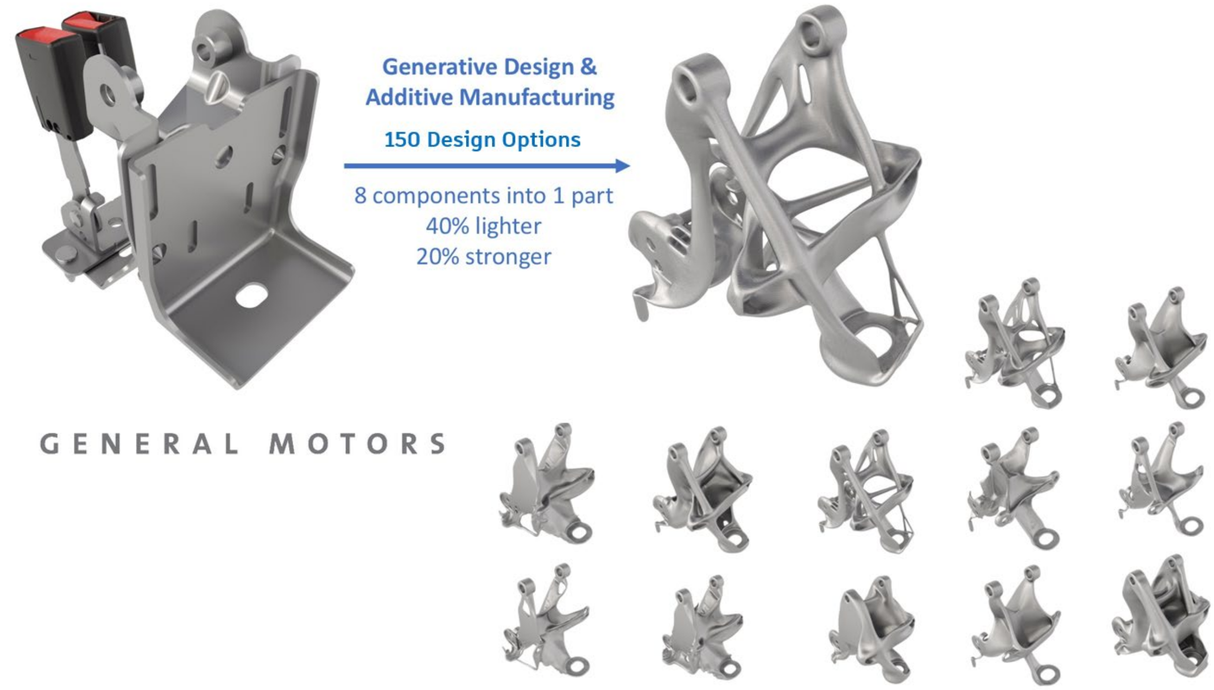
In the traditional approach, we must evaluate and validate the manufacturability of few concepts before sending one of them to production.



This can lead to numerous iterations, feedback cycles and restarts, which elongates the time to manufacture.



Generative Design generates a wide range of designs that meet the requirements.
The result is complex, high-performance structures that human designers would never have conceived.
Unlike topological optimization, the software explores all possible permutations of a solution, considering even today's production capabilities and technologies, quickly generating design alternatives.
What makes the design exploration unique is its ability to analyze all the possible variants of a solution and present the list of possible choices to the designer, who will be able to make an educated decision on tradeoffs for a given design challenge and produce it, reducing the time to go from the design to production and therefore, increasing the productivity and amplifying ability to innovate.
Another big advantage that Generative Design offers is the is the parts consolidation.
The example below is a component of the seat belt of an electric car.



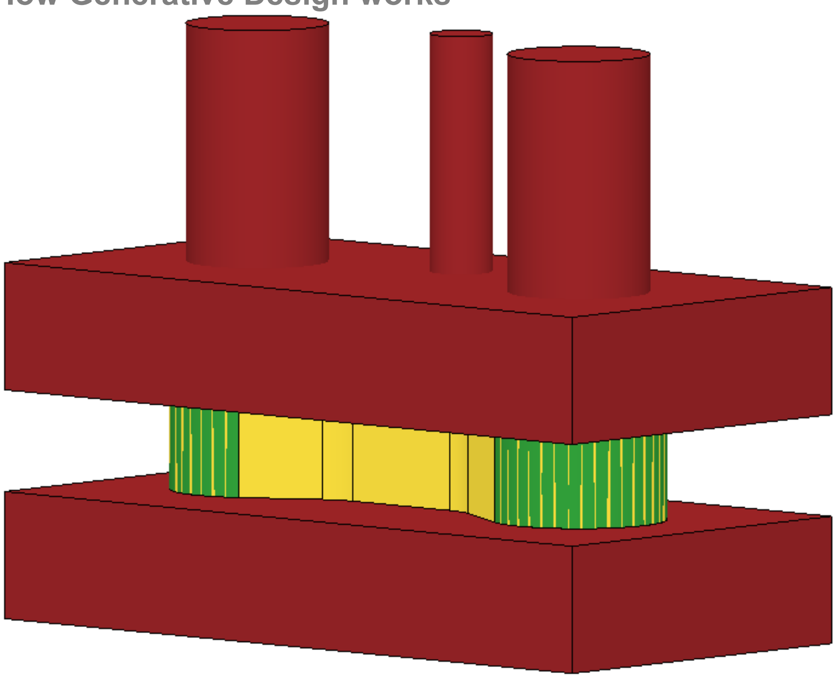
Generative Design allowed to replace the 8 components of the original design with one that resulted 40% lighter and 20% stronger than the original design.
By the way, the real advantage was that the General Motors could pick the part that then they have produced looking at the 150 design options for the same problem.
The generated outcomes were for an additive production, but Generative Design in NOT exclusive to Additive Manufacturing.

Generative Design is also for more “traditional” manufacturing production technology.
Thanks to the collaboration of a company called aPriori, for most of the material that we use for generating the outcomes we can also estimate the cost for producing the part and this is going to help even further for doing the tradeoff and select the outcome(s) we want to produce.

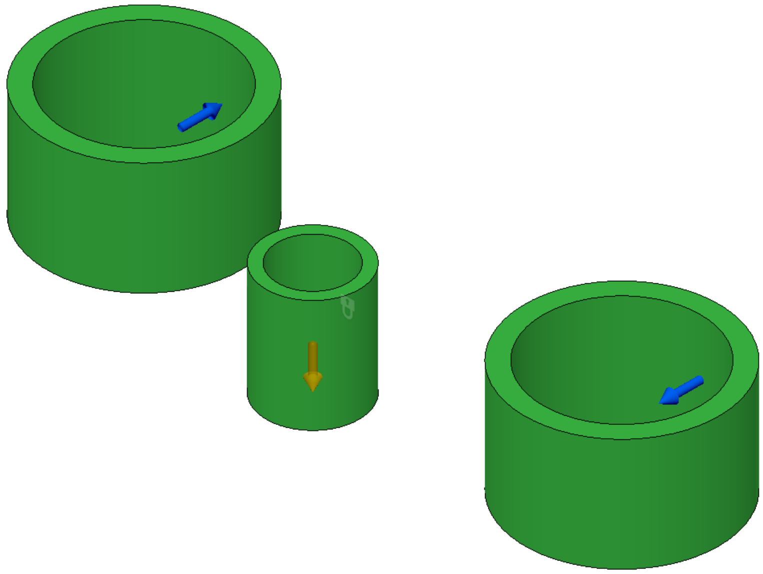
Why Generative Design?

Today, the design teams have less time to come up with new ideas and to conceptualize and there are challenges with tribal knowledge where just one or two people have all the ideas in their heads.
Downstream manufacturing processes are not considered during the design phase and late-stage changes are costly.
So Why Generative Design?
For the first time, the computers are helping us, instead of us having to feed it every sketch, extrusion and stay on top on what can be manufactured.
Generative Design provides cost and manufacturing options in the beginning, not in the end when 100’s of hours has been spent in the design process.
Generative Design offers more options to choose from. So, the design engineers can do what they are good at, what is problem solving and using their skills to pick the best design for the task.

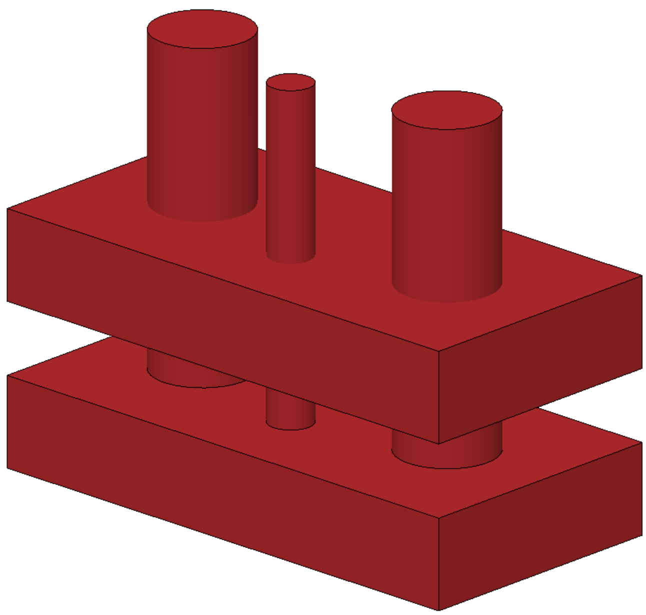
How Generative Design works



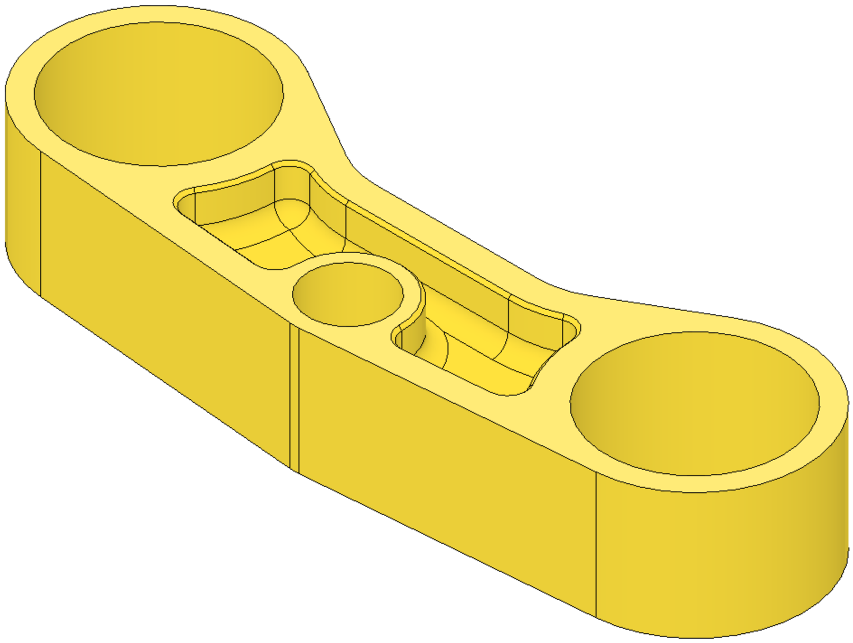
The first step for setting up a Generative Design study consists in creating the geometries of the Design Space. That is, the **Preserve Geometry**, the **Obstacle Geometry** and the **Starting Shape** (optional)



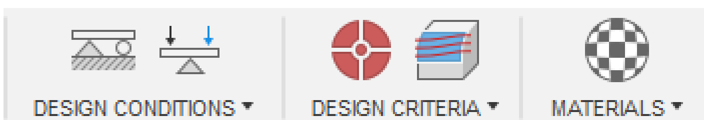
The **Preserve Geometry** typically includes the connection points to attach the design to other objects or interact with them or you interact with, such as handles. This is the geometry where you apply the loads and constraints for the study. This geometry is incorporated into the final design.



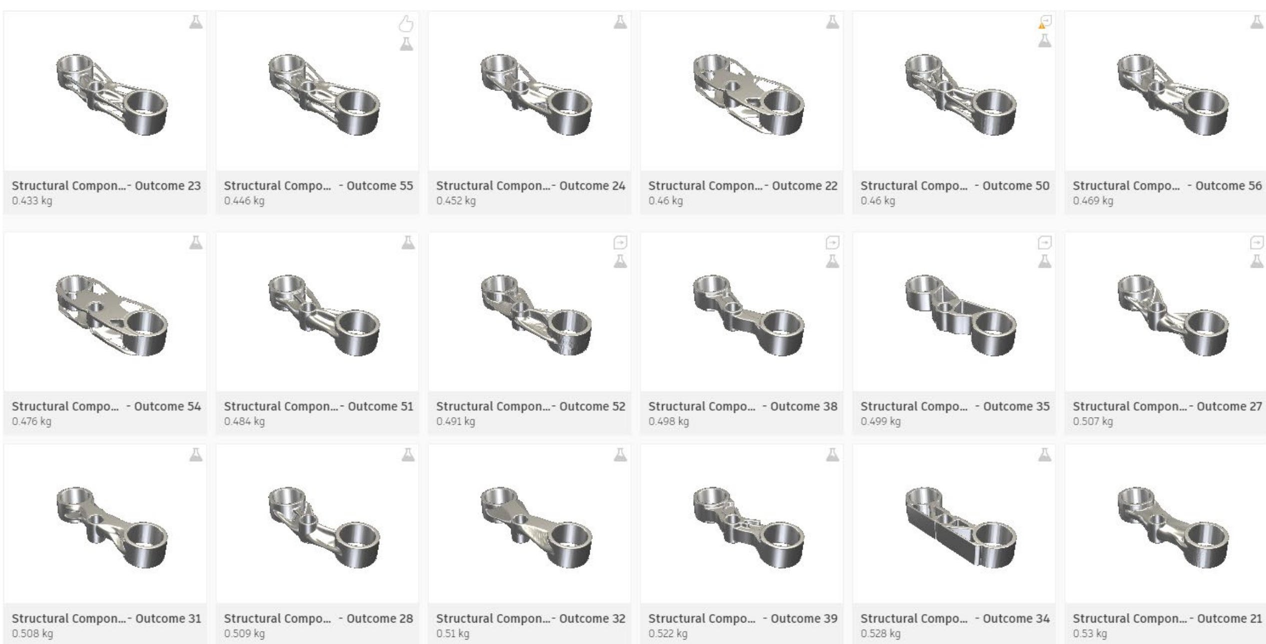
The **Obstacle Geometry** represents areas we want to avoid, because we need clearances for things like fastener and tool access, other components of the assembly, possibly the motion of some of them, etc. The solver does not add any material to these spaces.



The **Starting Shape** is the initial shape from which the solver generates the outcome. The starting shape is optional.



For completing the setup, the Design Conditions (Loads and Constraints), the Design Criteria (Optimization objectives and Manufacturing constraints) and the materials must be defined.

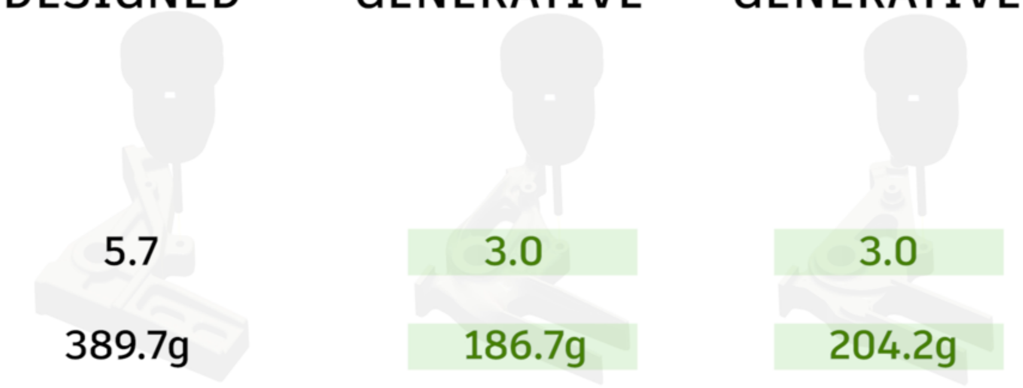


Based on that, Generative Design generates the outcomes, from where it is possible to select the one(s) to be produced.

The model to be produced can be exported as a "CAD-ready" solid model, that can be still edited and validate in Fusion 360 or any other CAD software, for be prepared for the production.

Trade-off

At the end of the outcome generation, it's up to us to decide the part we want to produce, based on our experience, our needs, the budget,etc.
But we can take this decision watching all the possible solution for the problem we want to solve.



	HUMAN DESIGNED	3-AXIS GENERATIVE	2.5-AXIS GENERATIVE
FOS	5.7	3.0	3.0
Mass	389.7g	186.7g	204.2g
Cycle Time	51 min	123min	35min

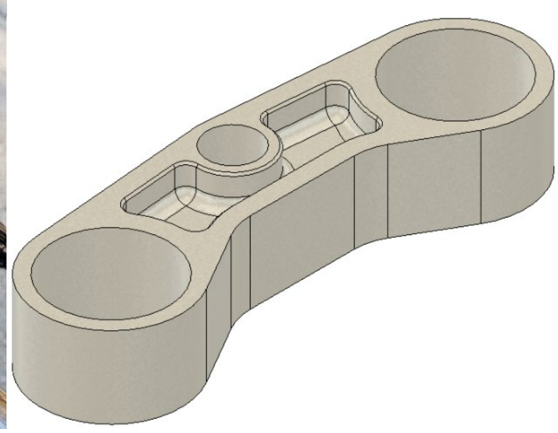
In this example one part has been designed in a traditional way, while the other two are two outcomes created with Generative Design, one for 3-axis milling production the other one for 2.5-axis milling production.
For the same material, the part designed in a traditional way looks overengineered, with values for the Factor of Safety and the Mass too high.
The outcomes created with Generative Design, respect the value of the Factor of Safety that has been set as target for the study and are much lighter of the human designed solution.
The one for 3-axis milling production is lighter than the one for 2.5-axis, but the Cost Estimation tells us that is more expensive to produce (longer Cycle Time).
Based on this information, we can decide to produce the lighter but more expensive part, because, for instance it is meant for the aerospace industry, where the higher production cost will be compensated by the fuel saving.
Otherwise, we can decide to produce the 2.5-axis milling part that it is cheaper and good enough for our needs.

Another advantage that Generative Design offers, besides the possibility to make an educated decision about the part we want to produce is that is that the solver generated 100 versions in 20 minutes for each manufacturing type, as opposed to the human designed equivalent that took 3 and a half hours to fully validate 3 alternatives as part of the manual process.

	HUMAN DESIGNED	3-AXIS GENERATIVE	2.5-AXIS GENERATIVE
Design Time	**3.5 Hours**	**20 Minutes**	**20 Minutes**
Options	**3**	**100**	**100**

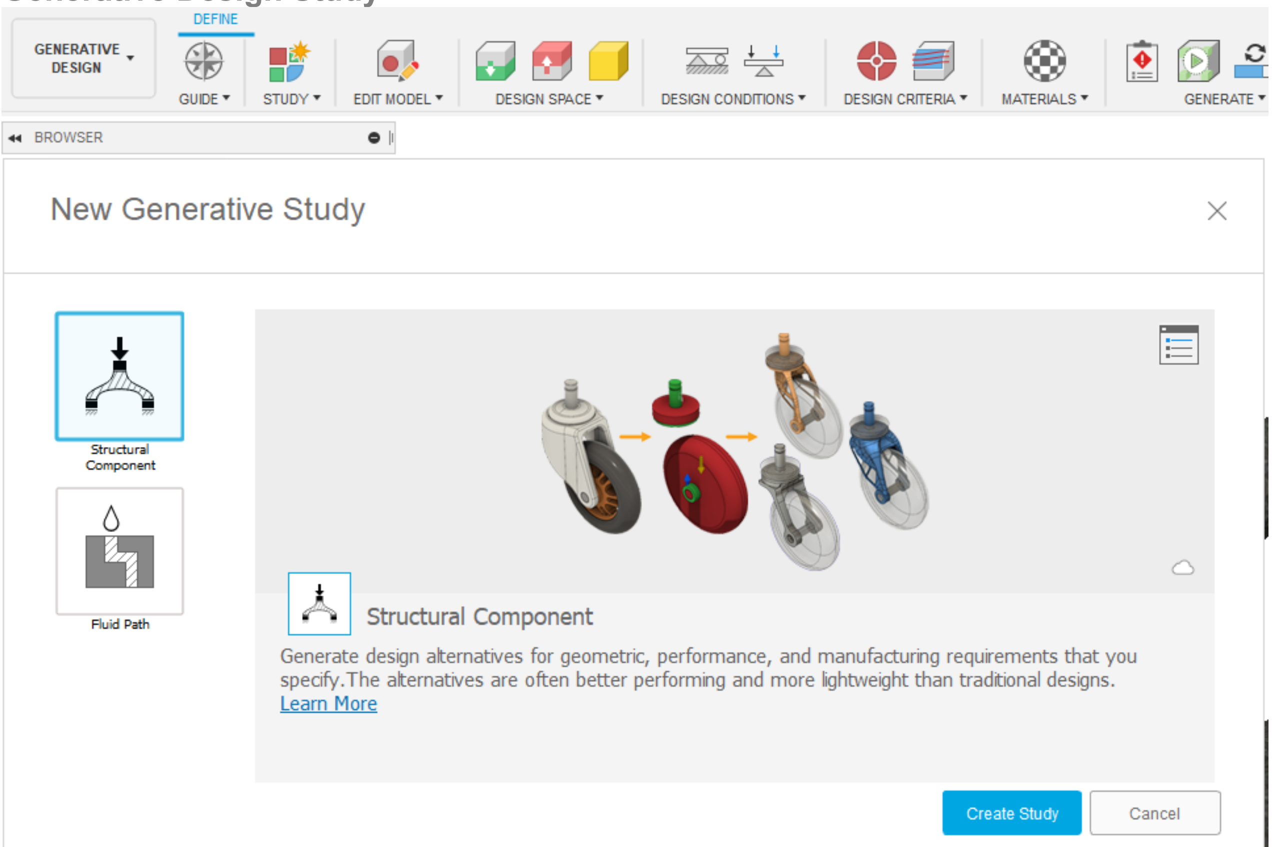
End-to-End workflow

We are going to use Generative Design for redesign a triple clamp of a motorcycle that has been designed with a traditional approach.

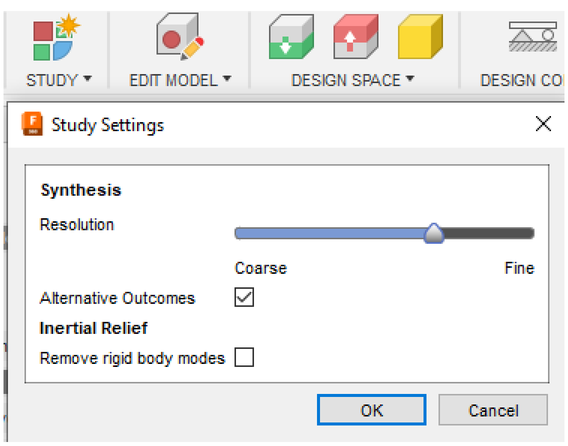



The objective is to redesign a lighter a better performing component exploring more innovative solutions that can be produced also with traditional manufacturing methods, like milling and 2-axis cutting.

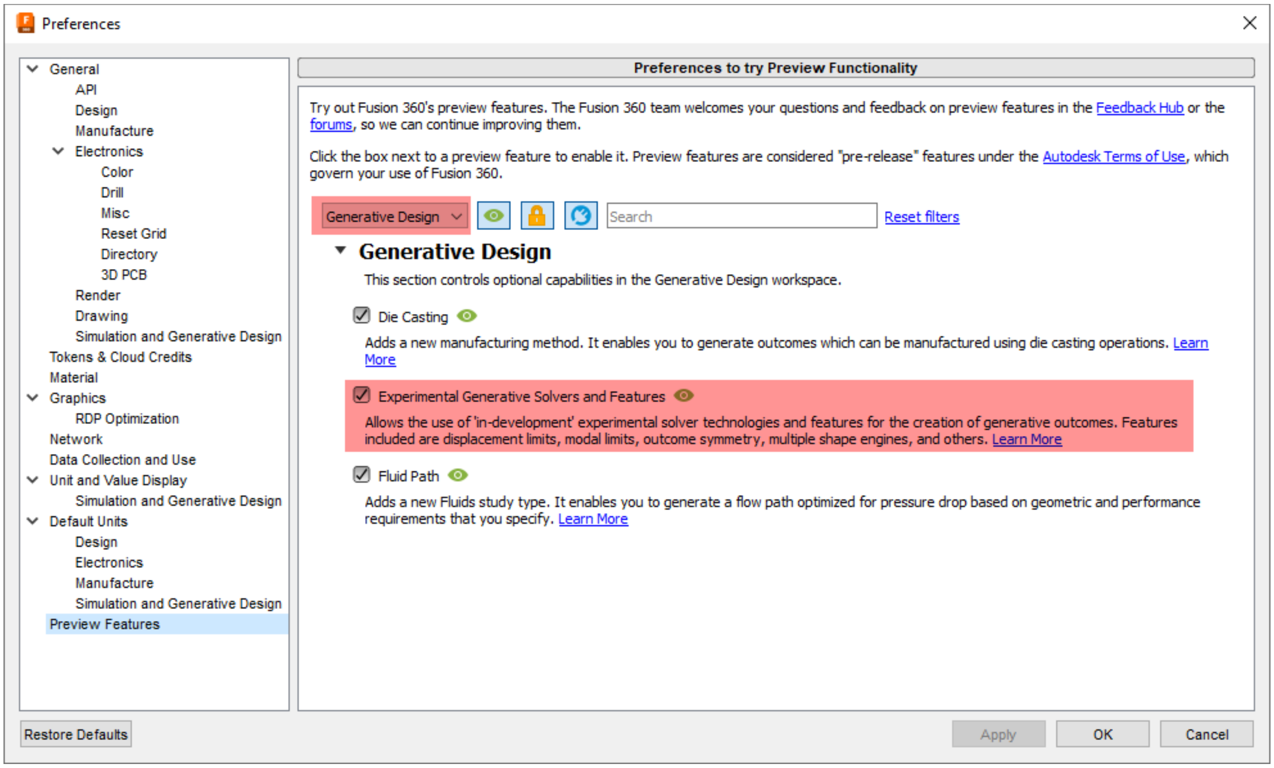
Generative Design Study



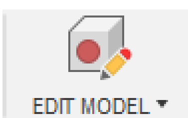
We open the file and switch to the Generative Design workspace and create a Structural Component study.



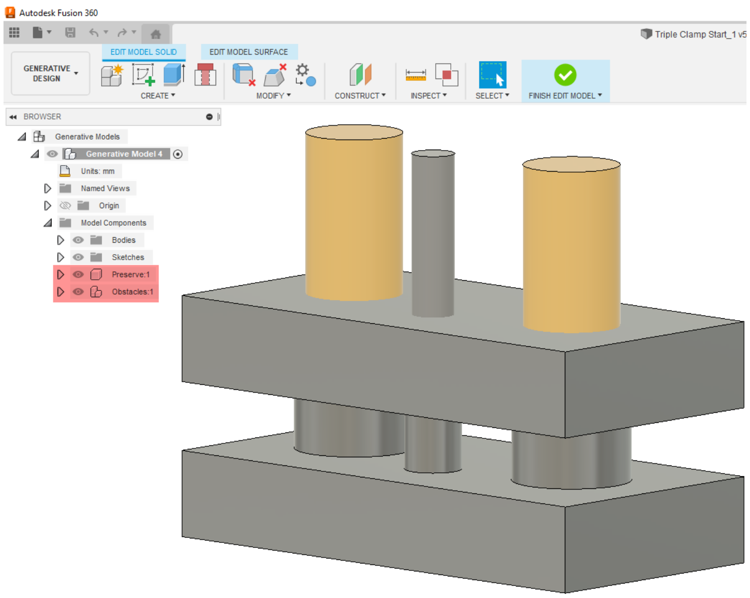
For the study settings we use a medium/fine Synthesis Resolution and select the “Alternative Outcomes” checkbox.
This option is available if the “Experimental Generative Solver and Features” checkbox is selected in Preferences > Preview Features and allows the use of “in-development” experimental solver technologies for the creation of generative outcomes, so that we can get more outcomes for the same material and manufacturing type.



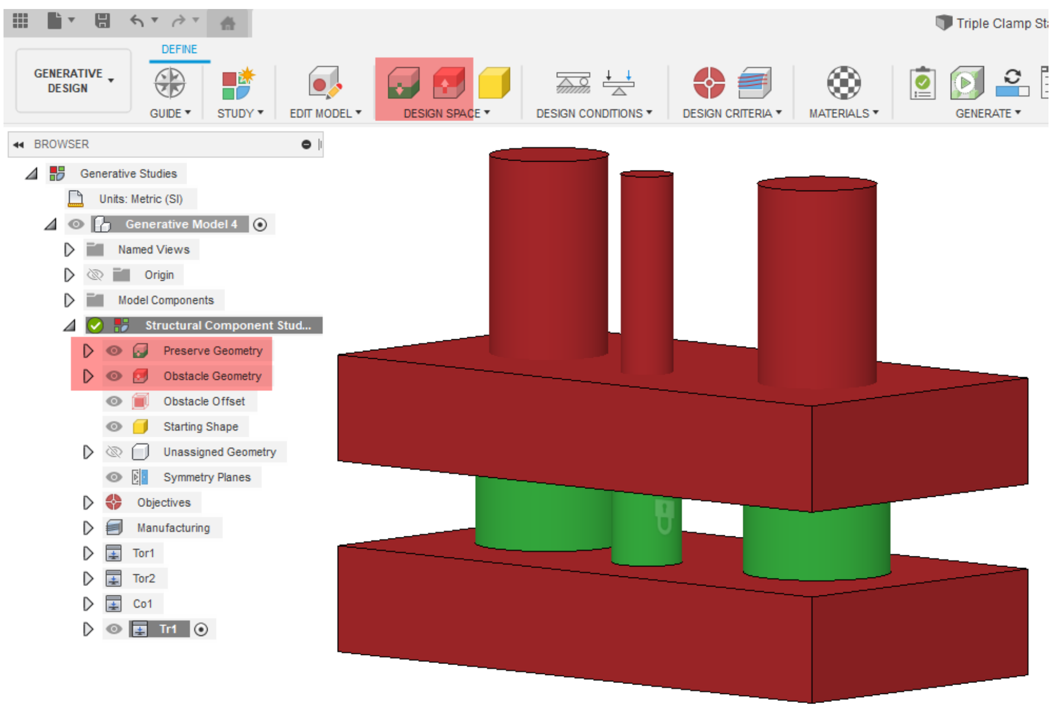
Design Space



We edit the model using the Edit Model workspace inside the Generative Design one for creating the objects we need for setting up the Generative Design study. That is, the **Preserve Geometry** and the **Obstacle Geometry**.



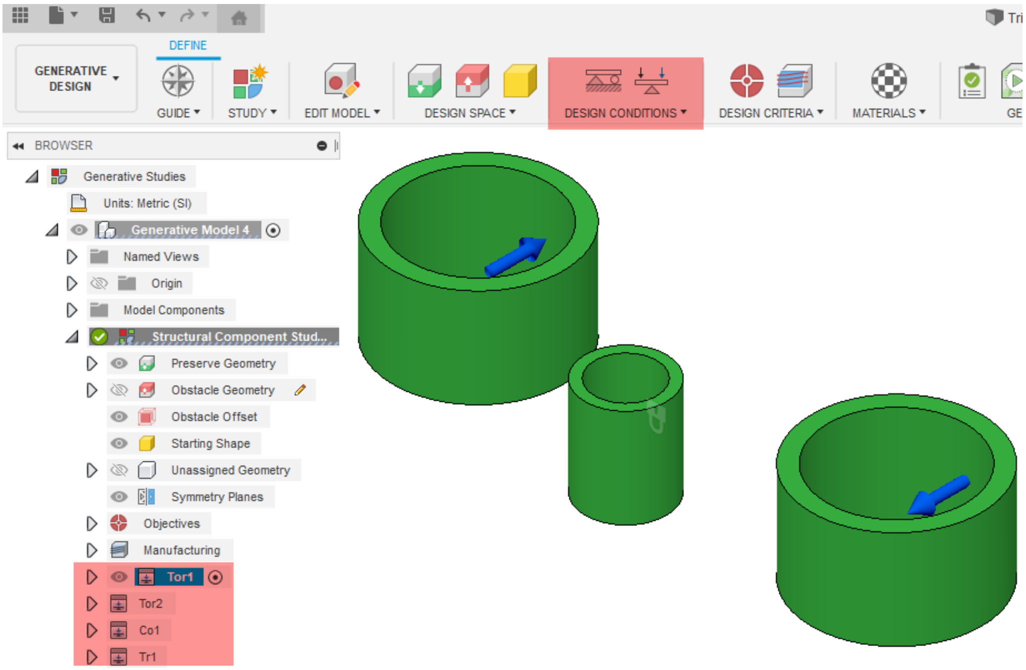
All the modifications we do in the Edit Model workspace, do not impact the original design.



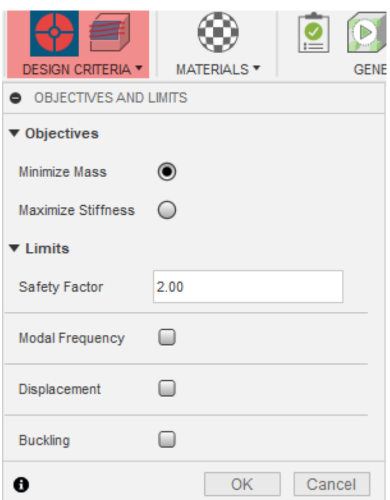
We finish the Edit Model and, back to the Generative Design workspace, we specify the Preserve and the Obstacle geometries.

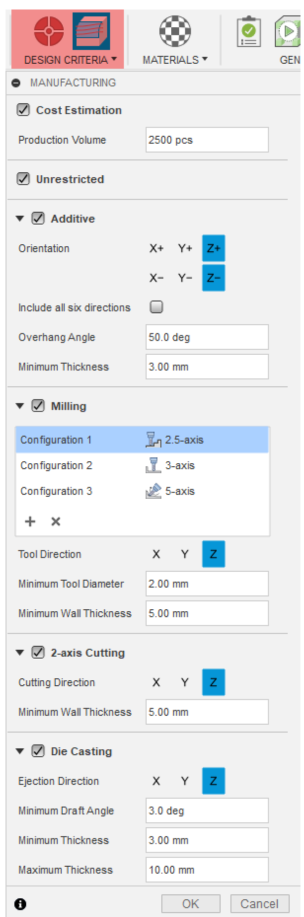
Design Conditions

Next, we define the Load Cases applying loads and constraints to the Preserve Geometry to simulate to simulate the stresses that the component receives while using the motorcycle.



Design Criteria

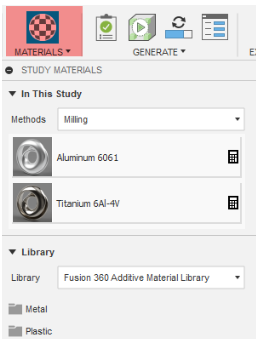




We define the Objectives of the study.
The additional options that allow to set the targets for Modal Frequency, Displacement and Buckling are also related Experimental Generative Solver preview, if this is enabled in the Preferences. By the way, not all the manufacturing types support yet these options and if we use them we get less outcomes.

We then select the Manufacturing processes we may use for producing the part.

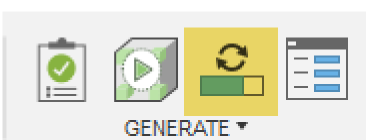
Materials



Finally, we select the materials we want the solver is going to explore in combination with the manufacturing types
We can select up to seven materials in a single study.

Generate

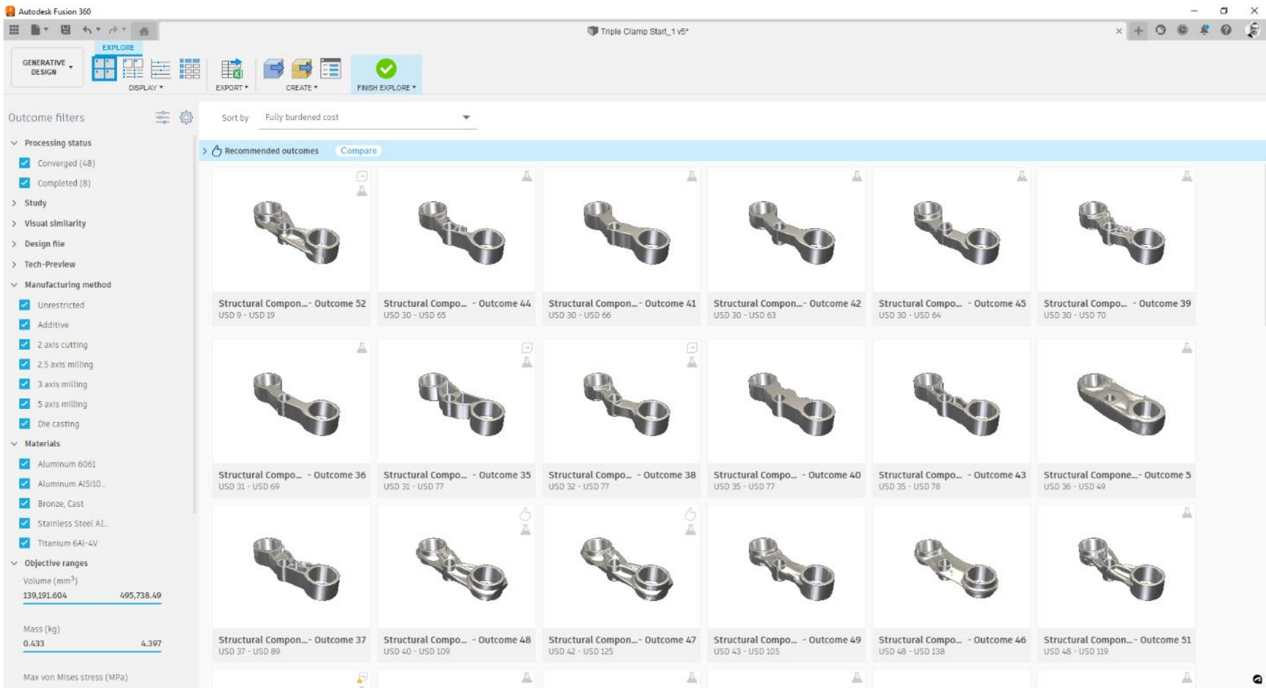
After that, we are ready to generate the outcomes.



The Generative Design solver explores and provides results for un-restricted, the additive process, standard milling up to 5 Axis and for metal casting, for each material selected.

Explore

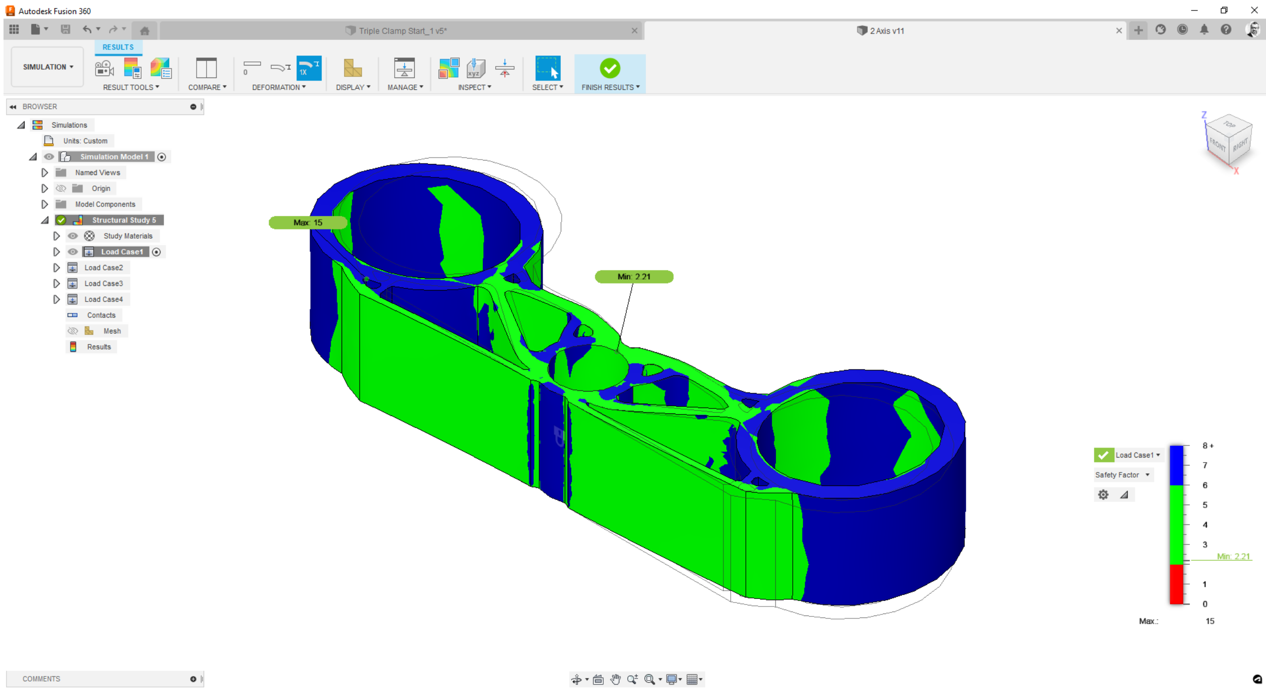
Within the explorer window, we can filter and validate different results and compare them against a min and max cost estimate based on material, production volume, manufacturing methods and shape complexity.
The results are saved in the cloud, and we can pick and choose from multiple pre-validated concept models.



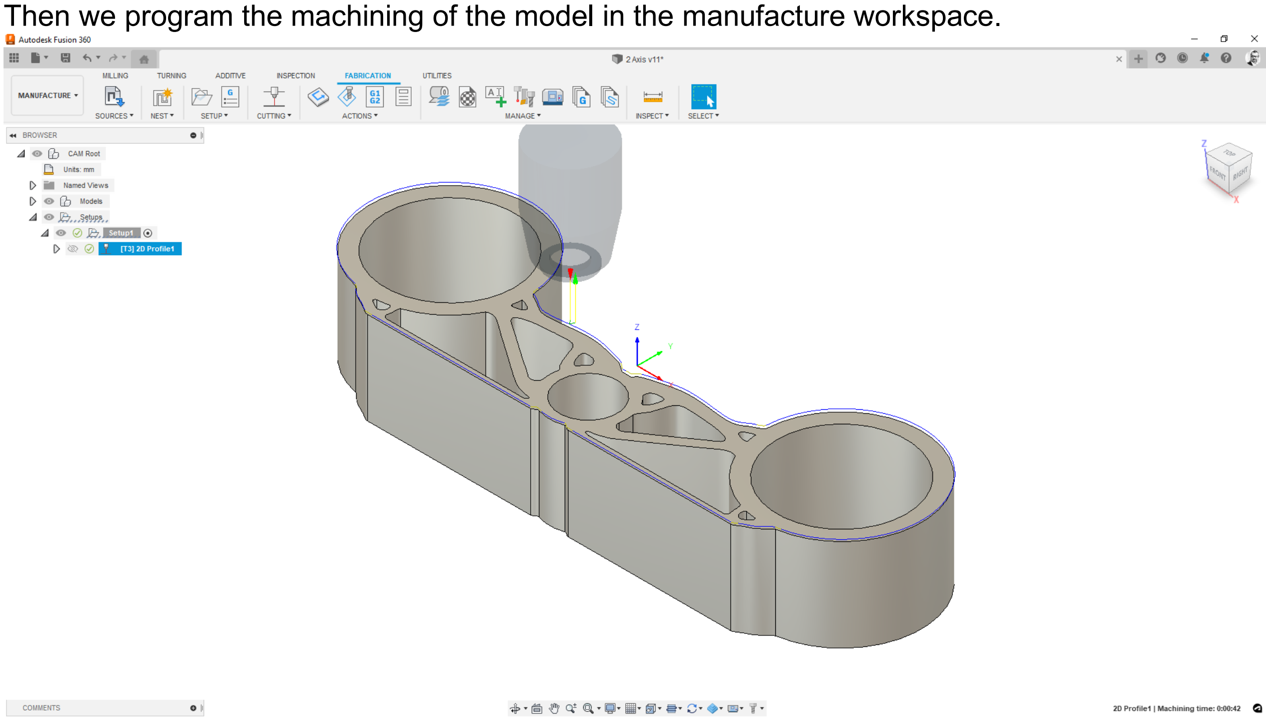
In this case we have download three possible design alternatives for the same material. 2 Axis Cutting, 2.5 and 5 Axis Milling.

Validate

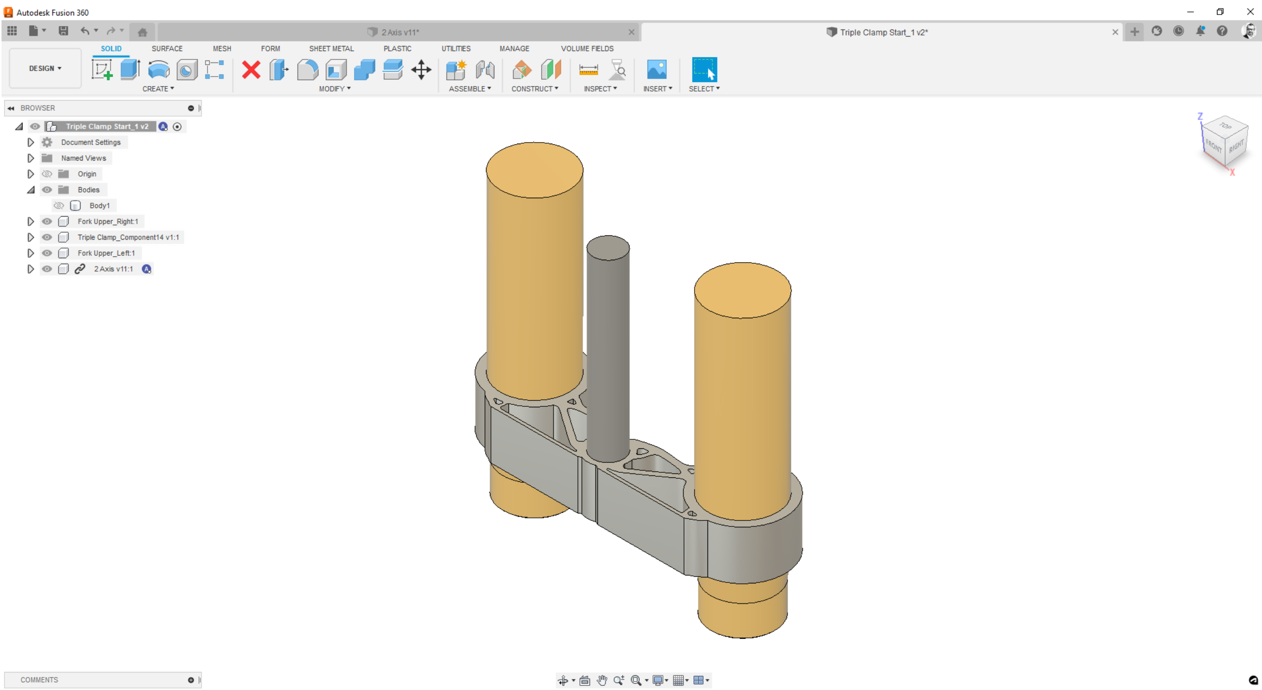
The outcomes from Generative Design are fully editable. We can modify the end results and make the tweaks we would like. As a validation point, we run a stress analysis simulation in Fusion 360 using the same loads and constraints inherited from the Generative Design Study, for verifying the component does not break and that the factor of safety respects the Generative Design setting.



Then we program the machining of the model in the manufacture workspace.



Finally, we can replace the original design with one of the Generative Design outcomes. In this case, we have used the one for the traditional 2 Axis Cutting production, that according to the cost estimation is also the cheapest, that we have verified with the stress analysis that is going to resist to the stresses that the component receives while using the motorcycle and is also going to be 37% lighter than the original design.



Conclusions

In this example, we have redesigned a triple clamp of a motorcycle with Generative Design.
The original design was created with a traditional approach.
Setting up the Generative Design study, we could explore more design options, with a better fit to each manufacturing process, spending less time getting a more competitive solution.

Learning resources

- Beginners
  - https://help.autodesk.com/view/fusion360/ENU/courses/#generative-design
- Advanced
  - https://www.autodesk.com/certification/learn/course/fusion360-generative-design-manufacturing-applications-expert
  - https://www.autodesk.com/certification/learn/course/fusion360-generative-design-intro-expert