Landing Gear Design Optimization Using Generative Design

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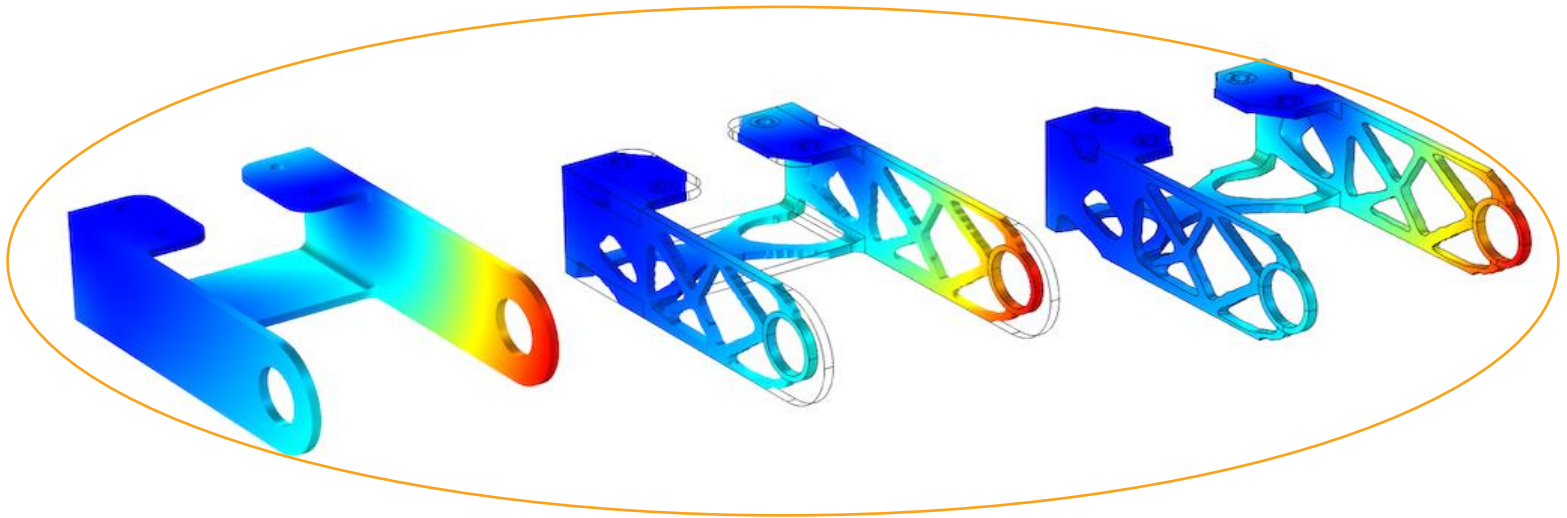
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Case study selection

Introduction about the project
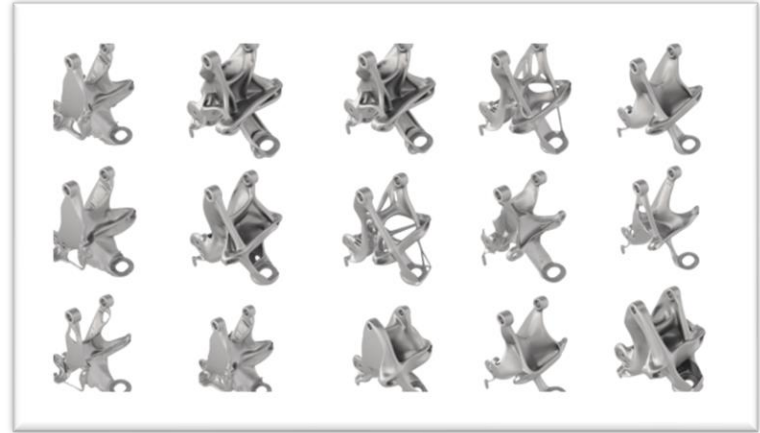
Topology Optimization

Topology Optimization is a mathematical method that optimizes material layout within a given design space, for a given set of loads, boundary conditions and constraints with the goal of maximizing the performance of the system.

Generative Design

- Recursive process

- Transformation approach

- Many organic design outcomes

Nose landing gear types

- Nose wheel type retractable

- High nose wheel type retractable

- Nose wheel type fixed

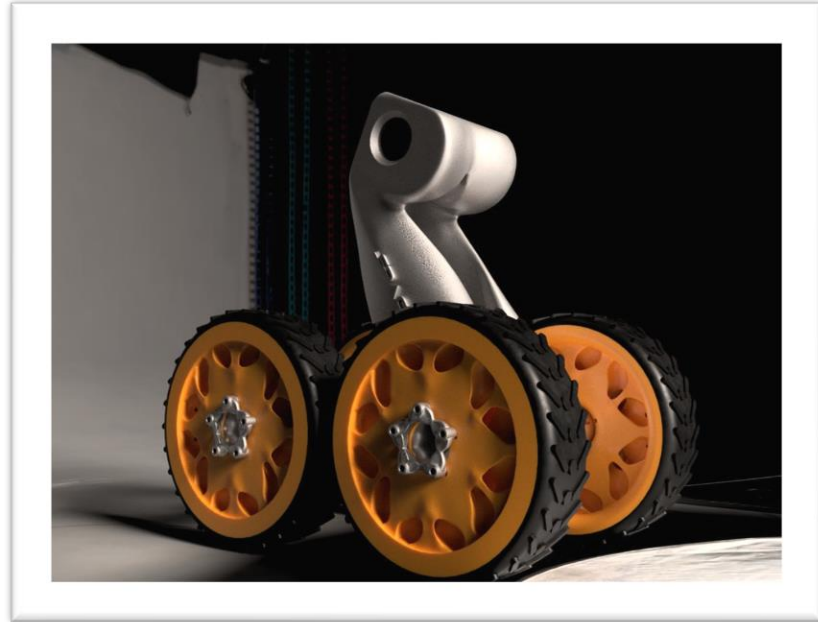- Tail wheel type fixed

Chosen aircraft type

Cessna Grand Caravan

Applying Generative Design

Expected results by using Generative Design

Considering the objectives which can be accomplished by the Generative Design technique

- Reduced weight

- Improved efficiency

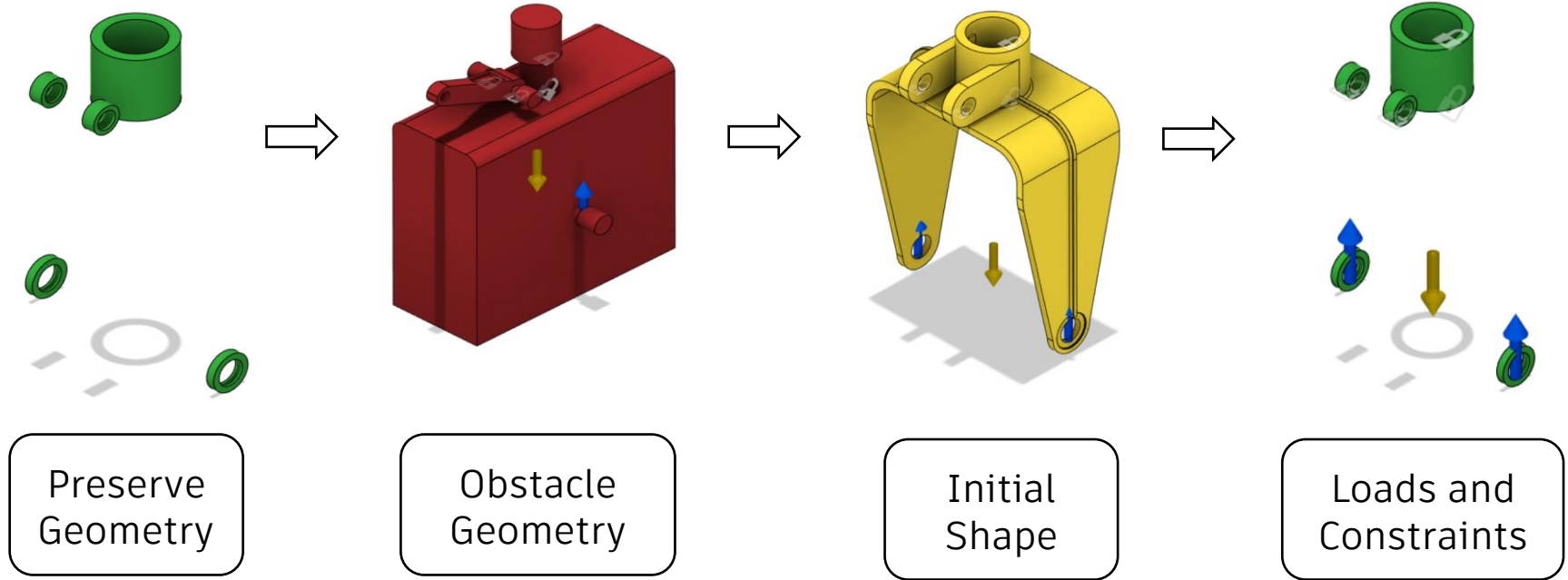- Customized product development

Generic design review

Standard engineering approach generic design

Characteristics

- Material - Aluminum 6061
- Weight - 963.27 grams
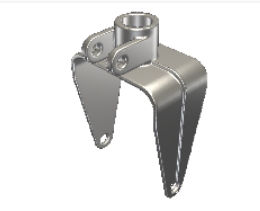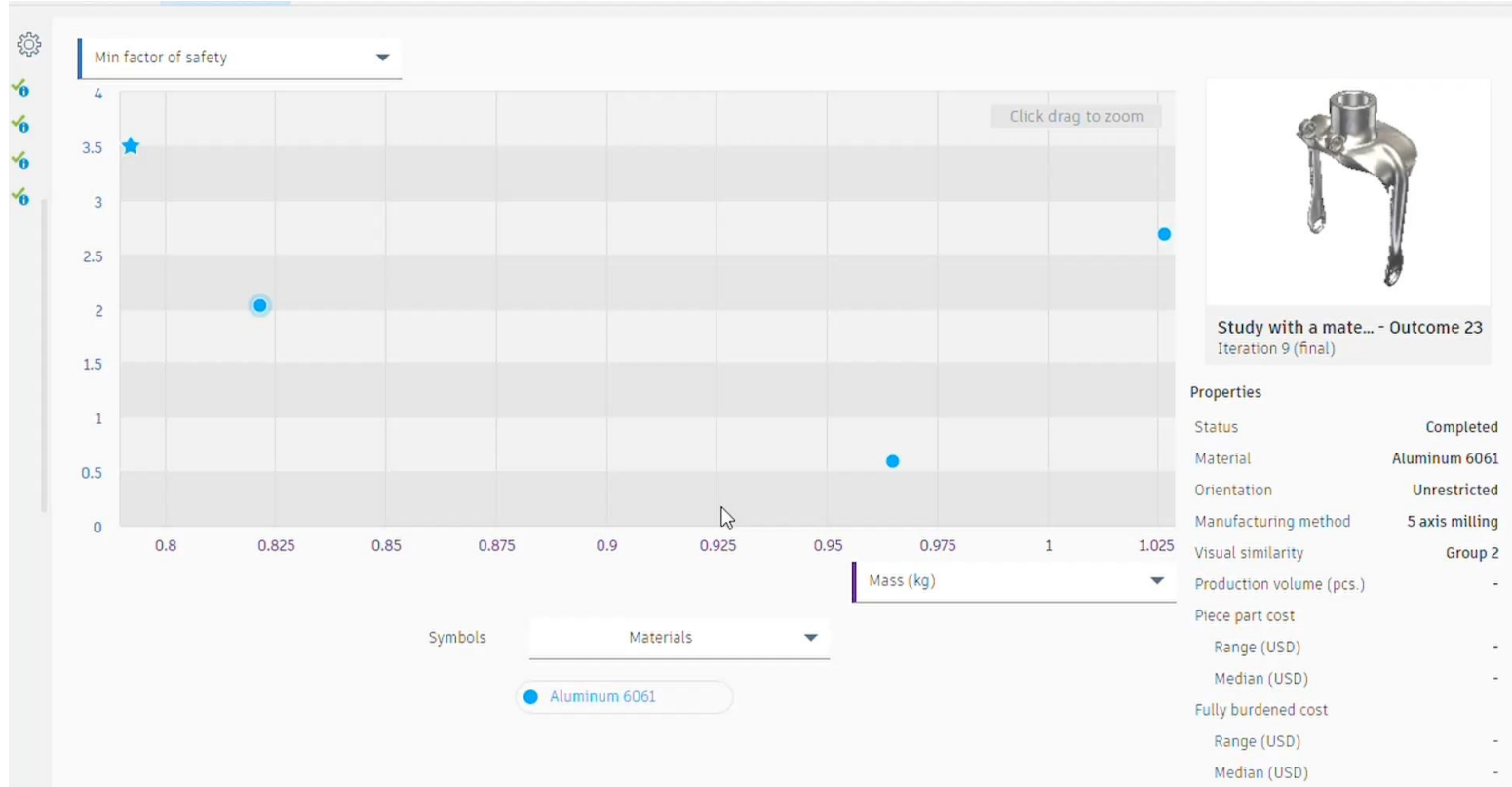- Manufacturing Method - Die Casting

Generative Design process

Preserve Geometry ⇒ Obstacle Geometry ⇒ Initial Shape ⇒ Loads and Constraints

Few other inputs:
- Objective - To minimize mass with a minimum safety factor of 2.
- Manufacturing methods, materials

Selection of best design

| Properties	Outcome 20	Outcome 21	Outcome 22	Outcome 23
	Study with a mate... - Outcome 20 Completed	Study with a mater...- Outcome 21 Completed	Study with a mate... - Outcome 22 Completed	Study with a mate... - Outcome 23 Completed
Status	Completed	Completed	Completed	Completed
Material	Aluminum 6061	Aluminum 6061	Aluminum 6061	Aluminum 6061
Orientation	-	Z+	X+, Y+, Z-	Unrestricted
Manufacturing method	Unrestricted	Additive	3 axis milling	5 axis milling
Visual similarity	Group 5	Group 3	Group 7	Group 2
Production volume (pcs.)	-	-	-	-
Piece part cost				
Range (USD)	-	-	-	-
Median (USD)	-	-	-	-
Fully burdened cost				
Range (USD)	-	-	-	-
Median (USD)	-	-	-	-
Volume (mm³)	357,333.68	293,373.49	380,131.02	304,261.22
Mass (kg)	0.965	0.792	1.026	0.822
Max von Mises stress (MPa)	465	78.6	102.6	135.7
Factor of safety limit	2	2	2	2
Min factor of safety	0.59	3.5	2.68	2.03
Max displacement global (mm)	5.76	0.52	1.06	0.95

Scatter plot results

Post processing
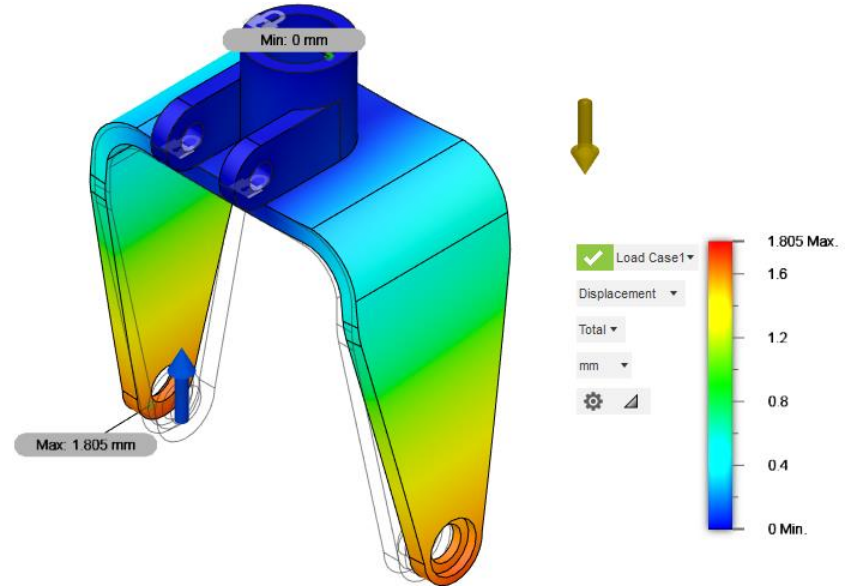and simulation

Post processing
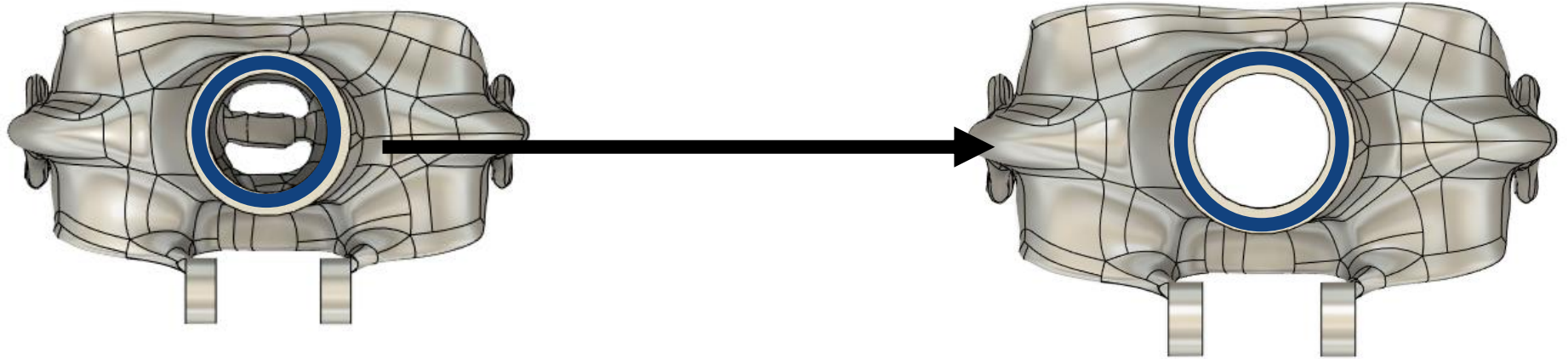
Simulation study - standard engineering design

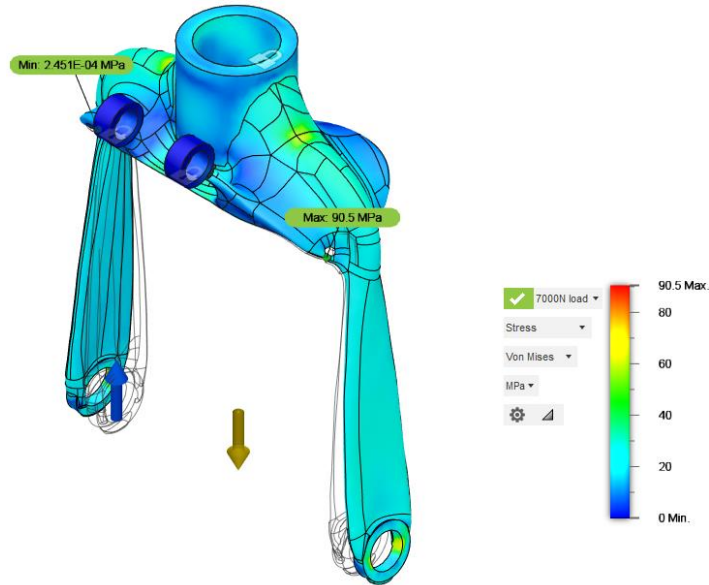**Stress distribution**
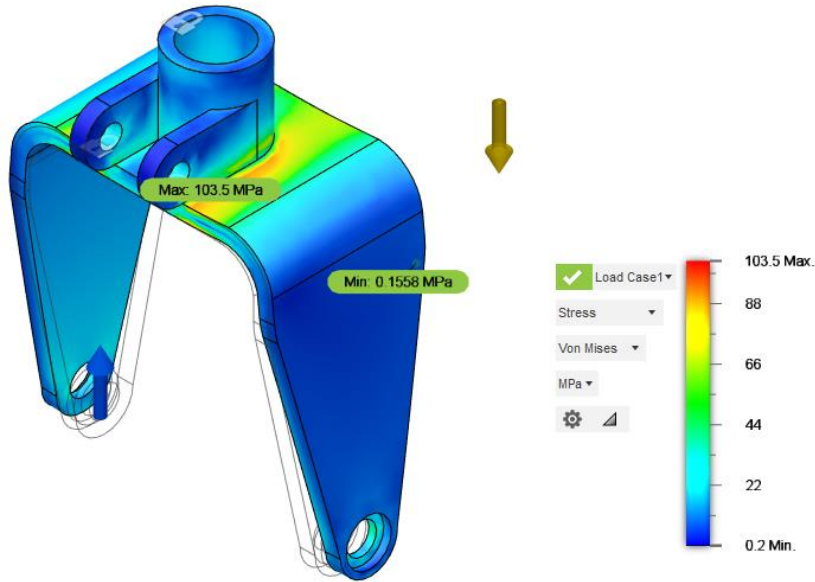
Maximum von Mises stress = 103.5 MPa

Displacement plot

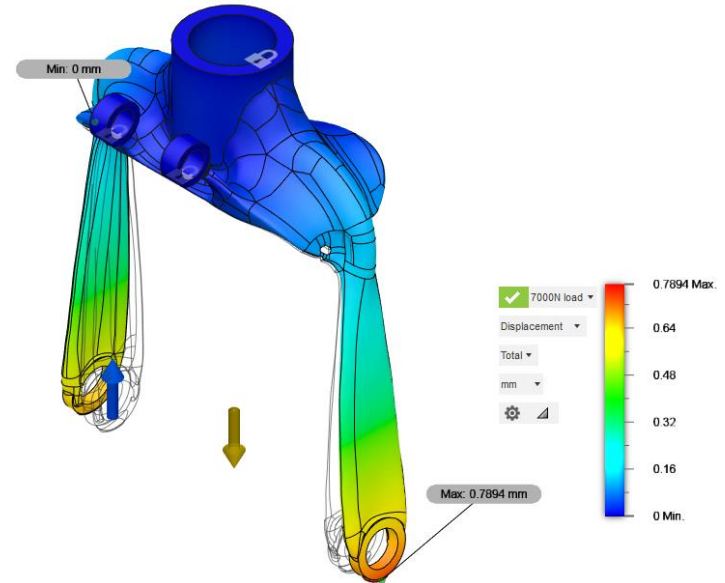

Maximum displacement global = 1.805 mm

Simulation study - Generative Design

Stress distribution

Displacement plot

Maximum von mises stress = 90.5 MPa

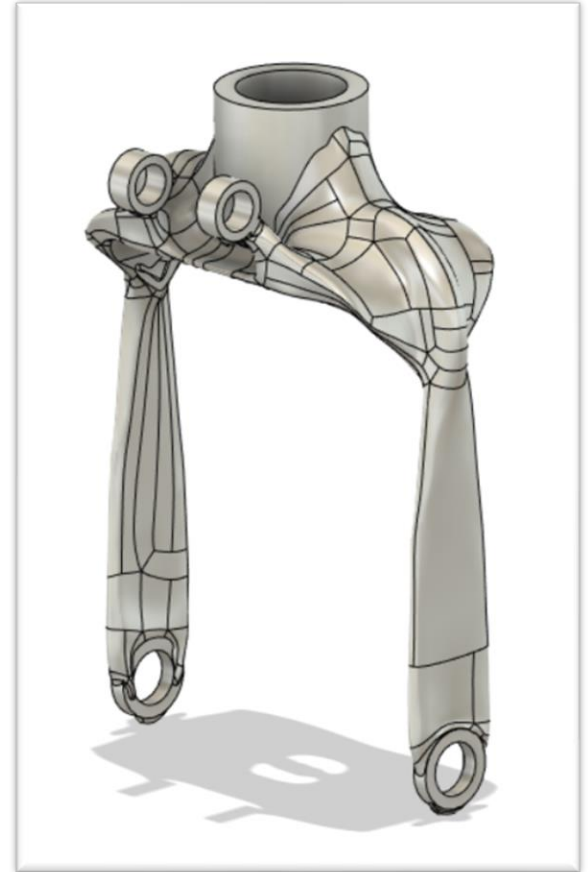Maximum displacement global = 0.7894 mm

Generative Design review

Generative Design approach initial design
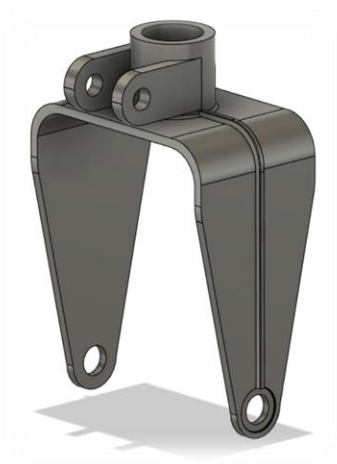
Characteristics:

- Material: Aluminum 6061
- Weight: 741.45 grams
- Max Von Mises Stress: 90.5 MPa
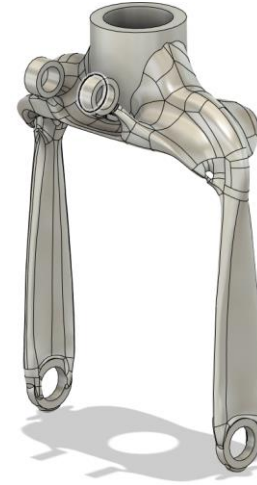- Max. displacement: 0.7894 mm

Comparison

Comparison between generic design and Generative Design part
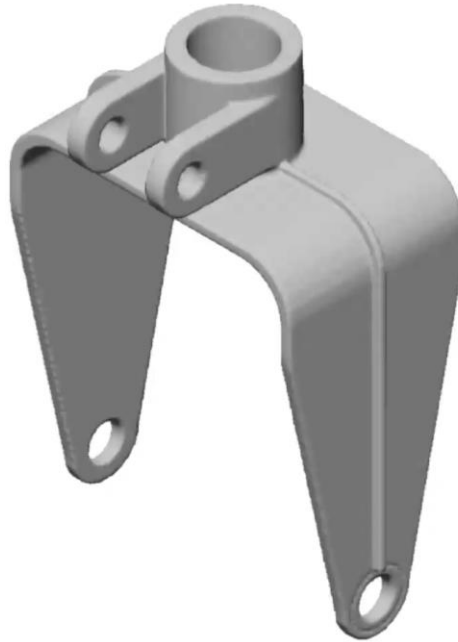
Generic design review

- Weight - 963.27 grams
- Displacement - 1.805 mm
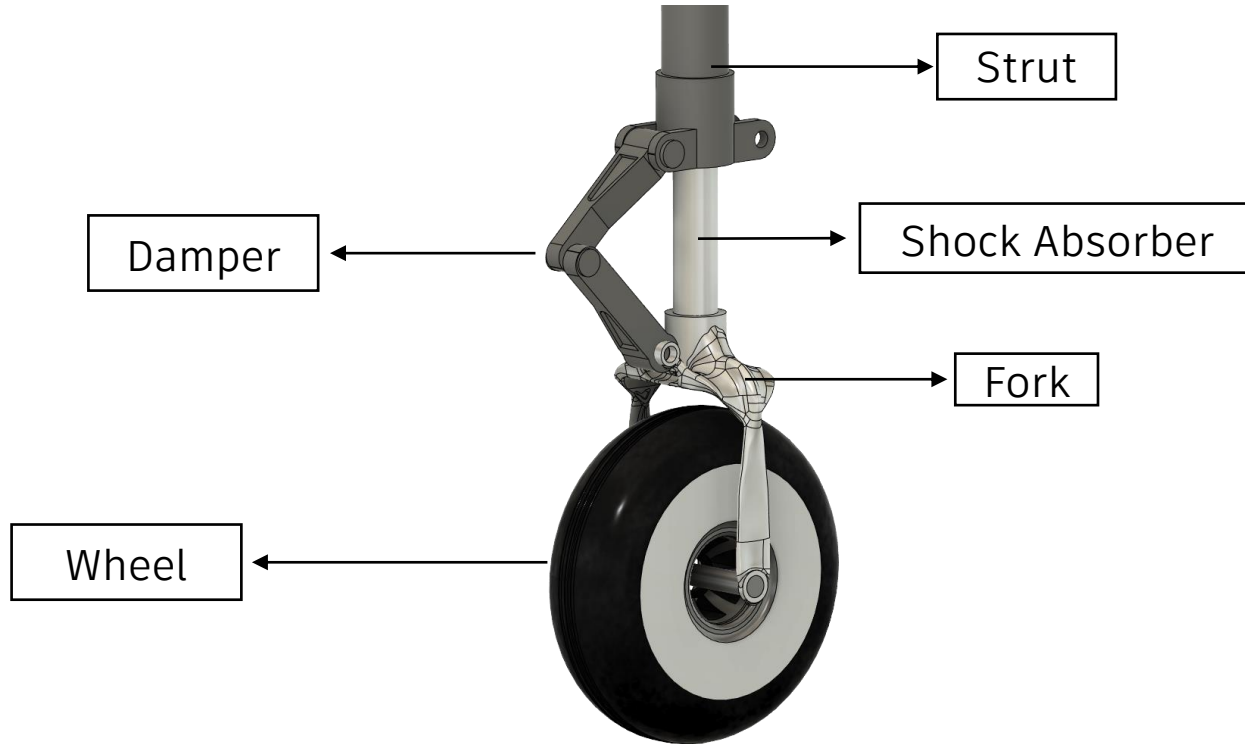
Generative Design review

- Weight - 741.45 grams (23% lighter)
- Displacement - 0.7894mm (56% reduction)
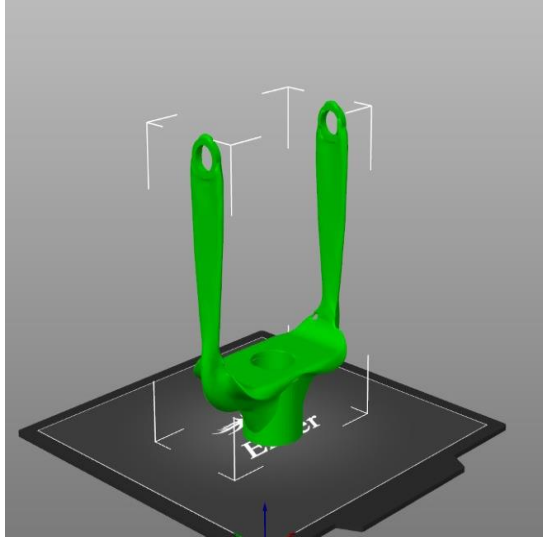
Generative Design model evolution

Generative Design model review

Full assembly of the landing gear with Generative Design part

3D printed fork

3D Printed using PLA Material

References for case study

- "Generative Design: What it is? How is it Being Used? Why it's a Game Changer!" https://www.carbodydesign.com/2018/05/gm-uses-generative-design-for-vehicle-lightweighting/ Matthew McKnight, (2017).

- Research, design and fabrication of quadcopter chassis by Generative Design and 3D printing.

- Design Space Exploration with Autodesk Generative Design by Kenny Cornett and Michael Musiol.

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