RHS FOOTPEG HOLDER

for a supersport bike

Prof.
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A Chassis and Body Design and Manifacturing M project by

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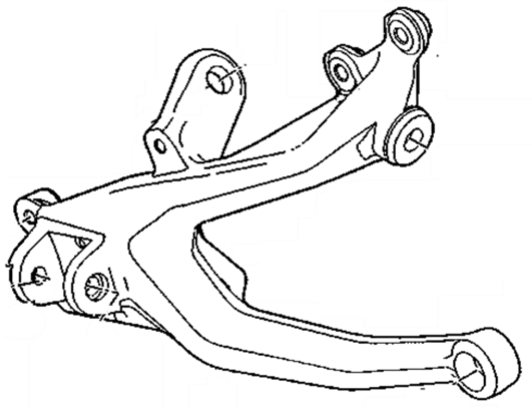
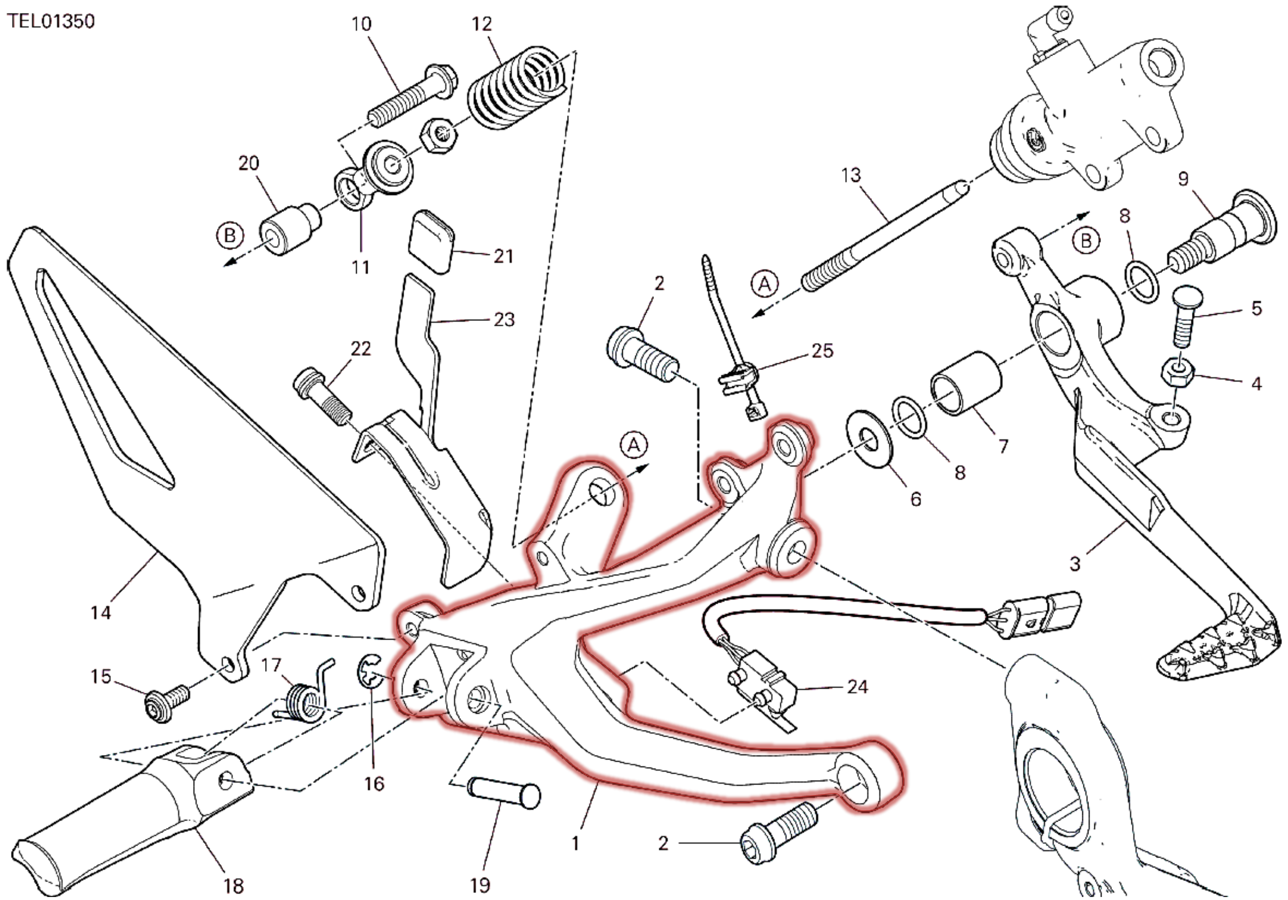
1 Project Assignment

Right Side Footpeg Holder

Design and validation of the footpeg support and mounting screws for Ducati Streetfighter



1 Project Assignment

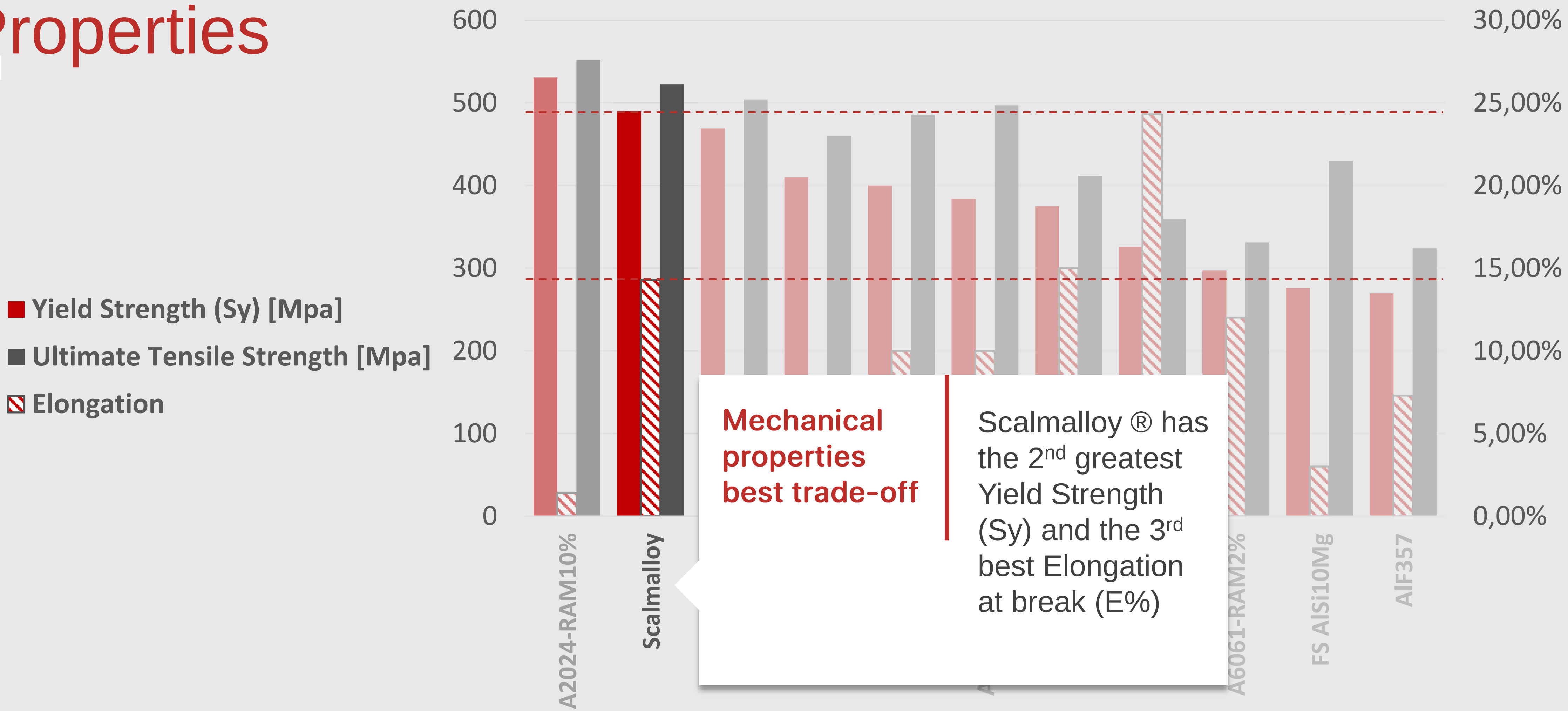


Ducati Streetfighter Solution

List of the main components of the Ducati solution that we will use for our schematic representation of the problem.

(1) Footpeg Holder Plate
(2) TCEIF Screws
(3) Brake pedal
(11) Joint
(13) Brake Pump Shaft
(18) Footpeg

2 Material Properties



Mechanical properties best trade-off

Scalmalloy ® has the 2nd greatest Yield Strength (Sy) and the 3rd best Elongation at break (E%)

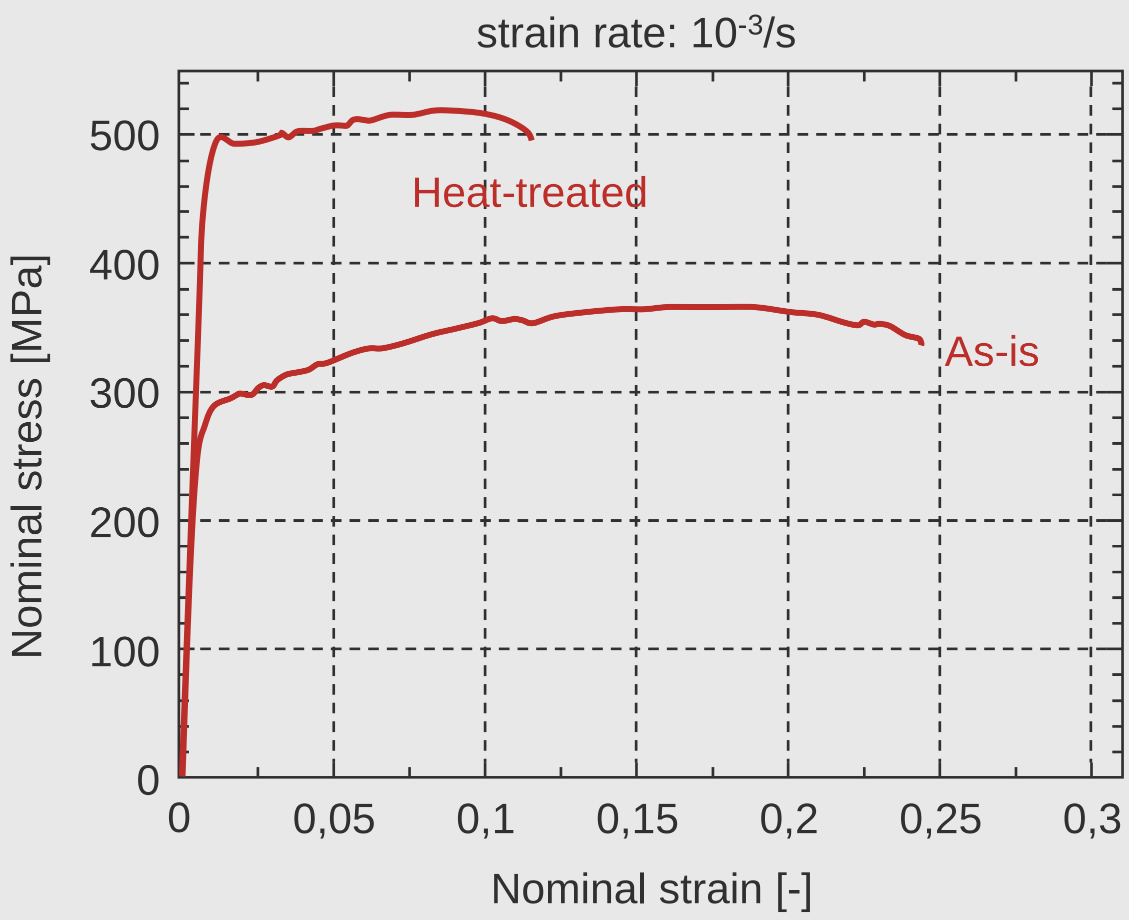
Source: Totalmateria, APWORKS

2 Material Properties

Data

Chemical Composition	Al	Mg	Sc	Zr	Mn
	≈93	4,6	0,66	0,42	0,49

Type	Additive Manufacturing Aluminium
Commercial Name	Scalmalloy®
Yield Strength	470 MPa
Tensile Strength	520 MPa
Elongation	13%
Young's Modulus	70 GPa
Density	2,67 kg/dm^3
Vickers Hardness	180 HV
Supply Condition	Heat treated and machined
Manufacturer	AIRBUS APWORKS Gmbh
Price	4.000 – 6.000 €/kg



Source: Totalmateria, apworks

2 Material Properties

Microstructure

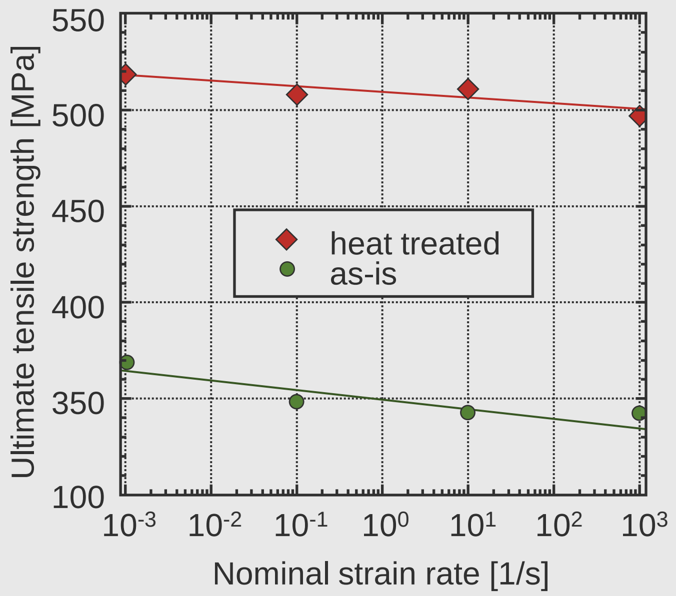
Due to the high cooling rates and rapid solidification, a unique microstructure is achieved
Lightweight, corrosion resistant and with high ductility

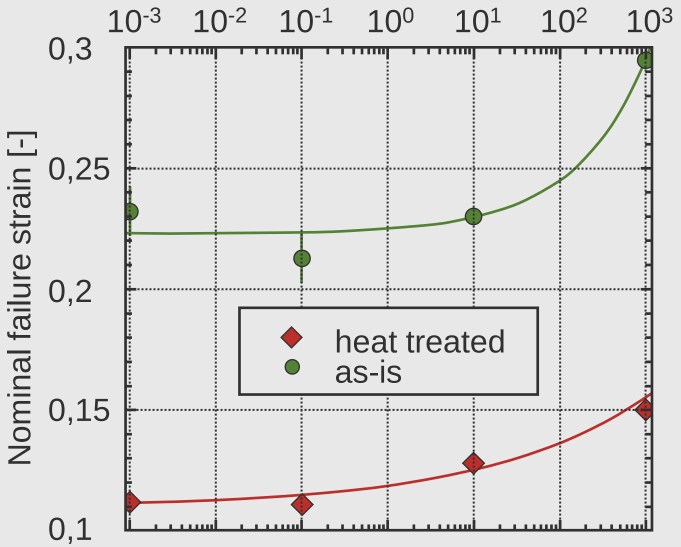
Topological Optimization

Coupling these material properties with the design freedom provided by AM processes can enable high performance parts with a level of functionality previously impossible to achieve.

Applications

Wide range of highly loaded functional applications in aerospace, motorsport, automotive and robotics





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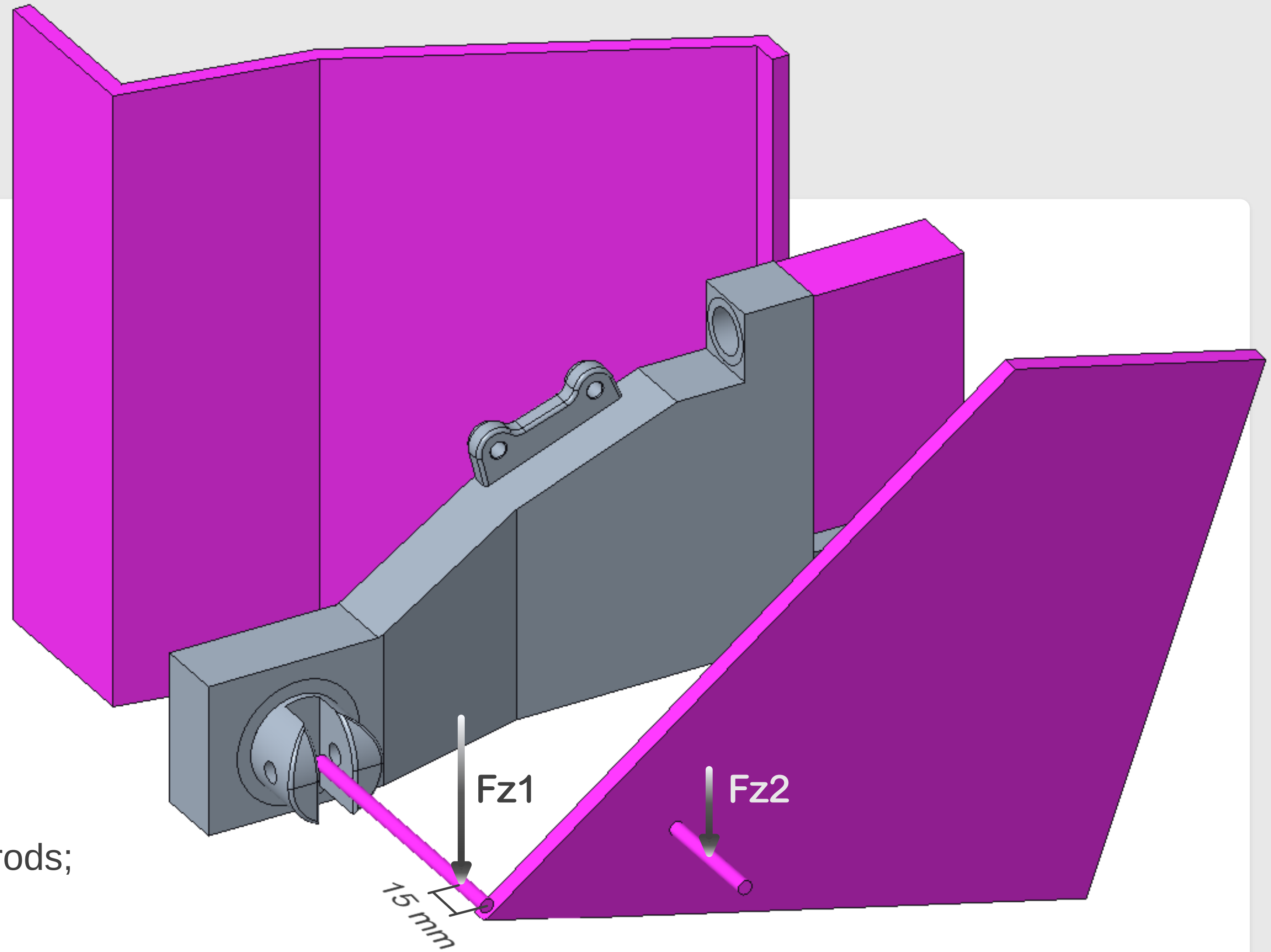
3 Structural Analysis

2D General Hypothesis

- Initial assigned loads Fz1 and Fz2
- Geometric references imposed as initial constraints
- Holder and brake lever developed in the plane;
- All loads are acting in the same plane;
- No bending moment derived from Fz1 and Fz2 transportations in the transversal direction;
- Brake pedal at end stop;
- The holder is understood as a V-shaped beam;
- The brake leverage is developed as a system of rods;
- The pump mounts are schematised as one.



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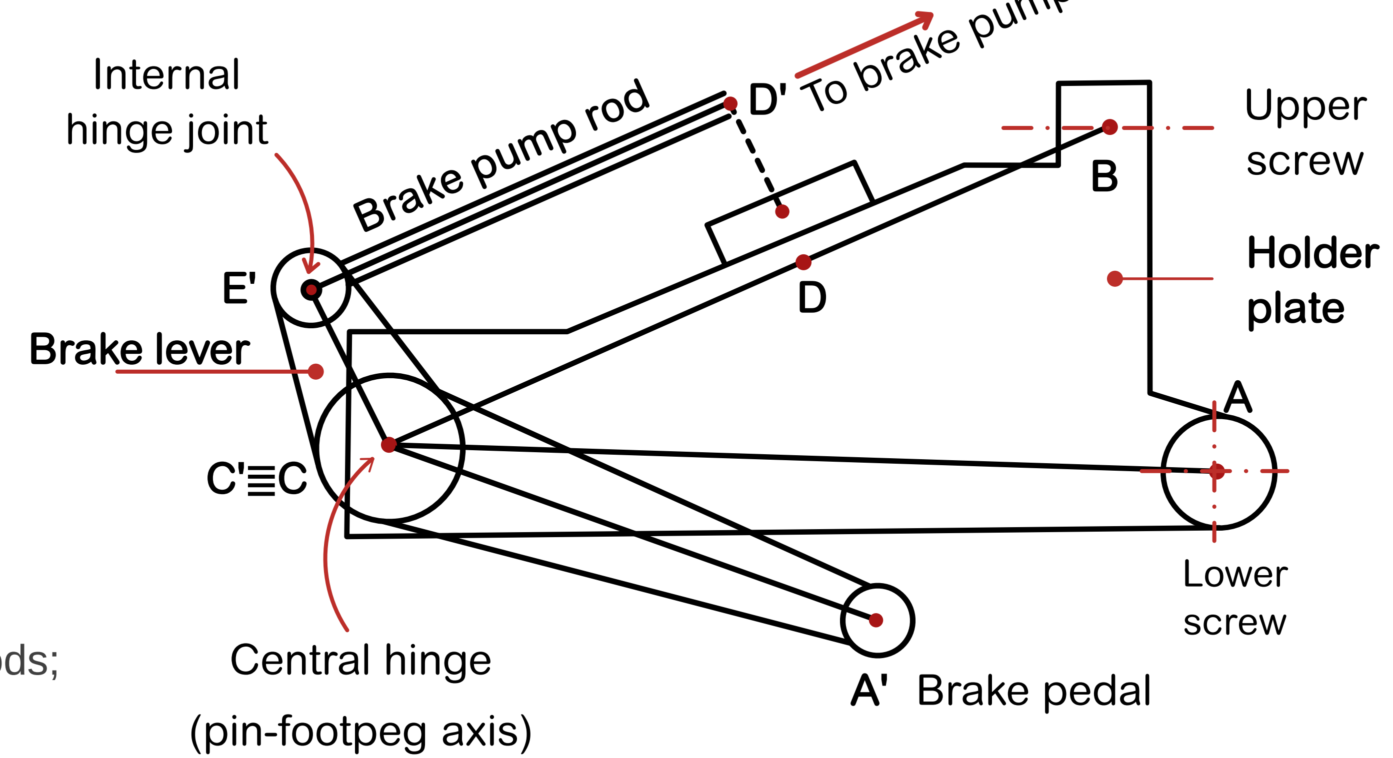
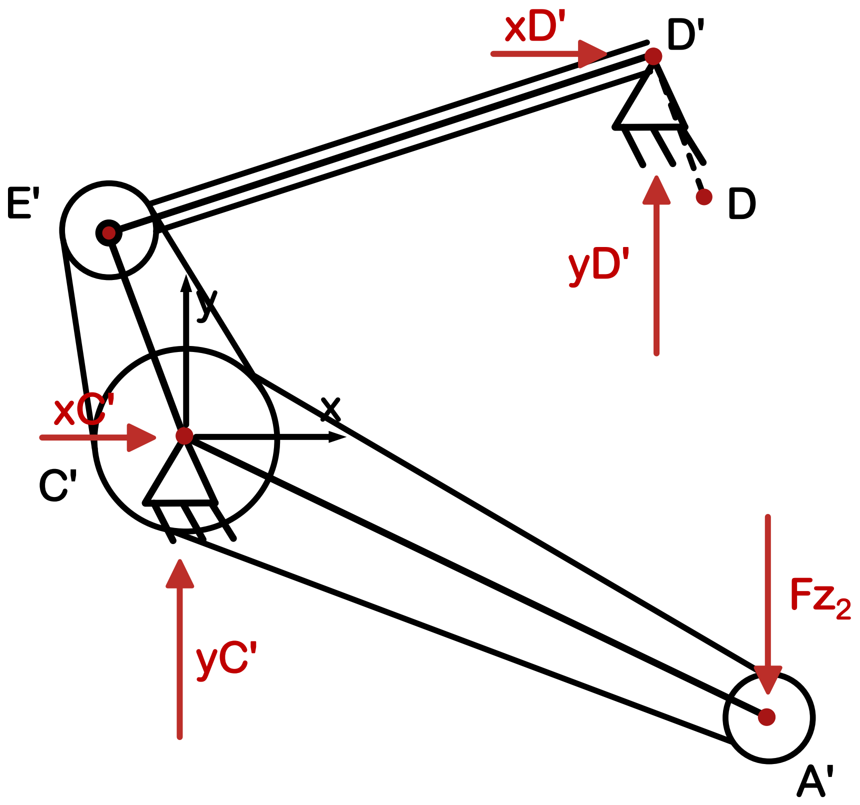




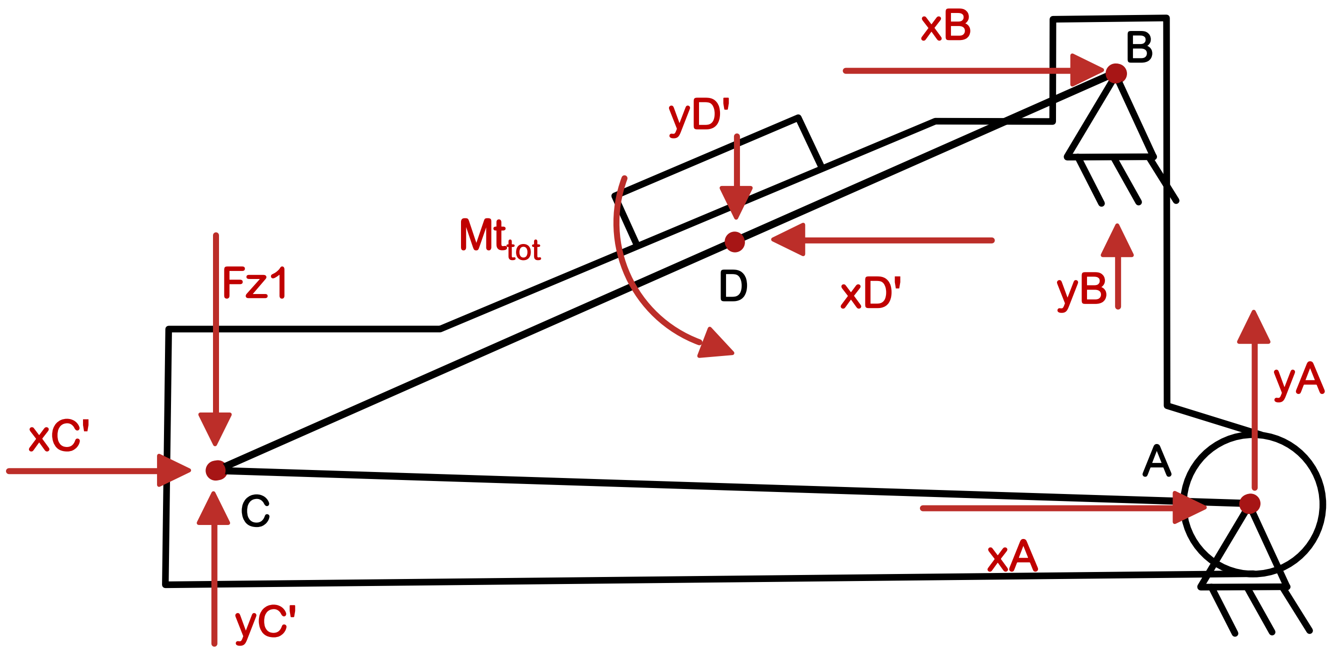
Constraint reactions

Let's calculate the reactions: they will be part of the external loads of the footpeg holder plate.

$y_{C'}$ = 875 N
$x_{C'}$ = 1.270 N
$y_{D'}$ = -375 N
$x_{D'}$ = -1.270 N

Brake Leverage

Node A' is the point of application of the braking force, node C' is the hinging point in line with the footpeg, node E' is the pivot point and node D' is the anchor point of the pump to the plate. In the end, due to the way the constraints have been placed, the structure is completely isostatic.



Constraint reactions

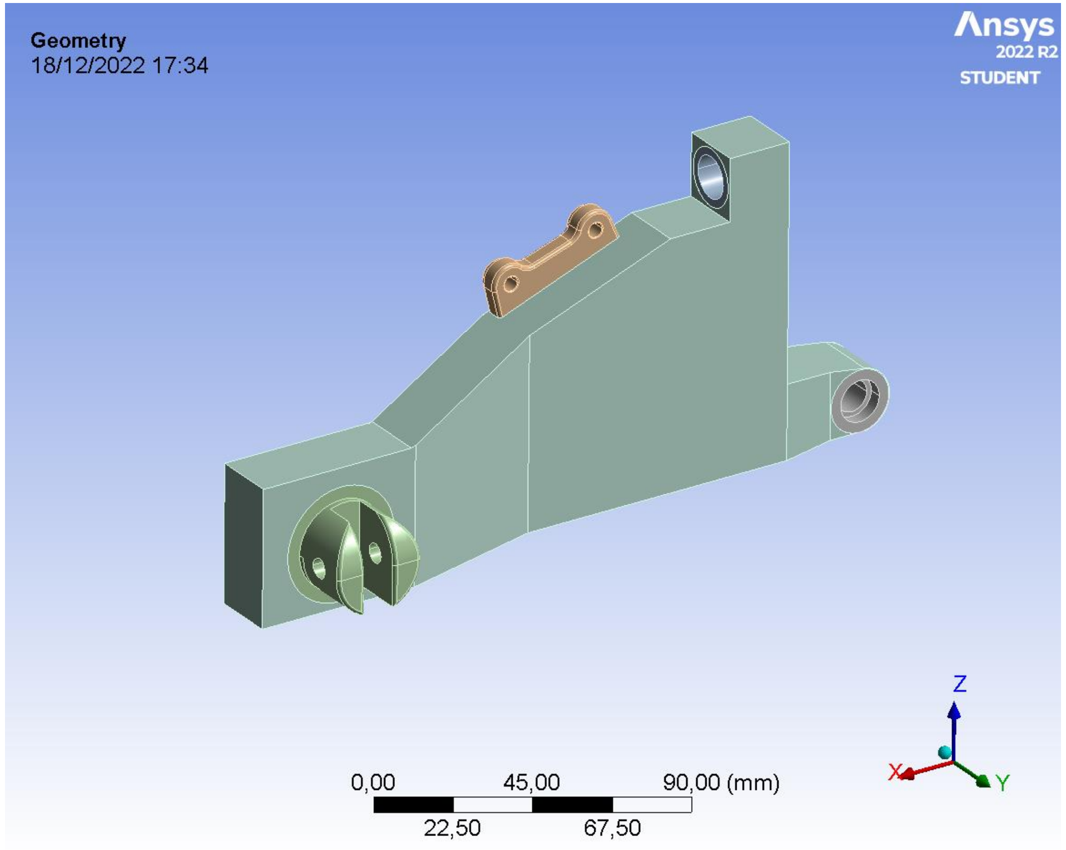
Let's calculate the reactions taking also the external loads due to the constraints of the break leverage.

y_A = 844 N
x_A = 2.707 N
y_B = 156 N
x_B = -2.707 N

Footpeg Holder

Nodes A and B are the anchoring points of the structure by means of threaded joints, node C is the projection of the footpeg axis (coaxial to the one of the brake lever hinge) and node D is the anchor point of the brake pump to the plate: the structure is iperstatic.

4 FEM Validation

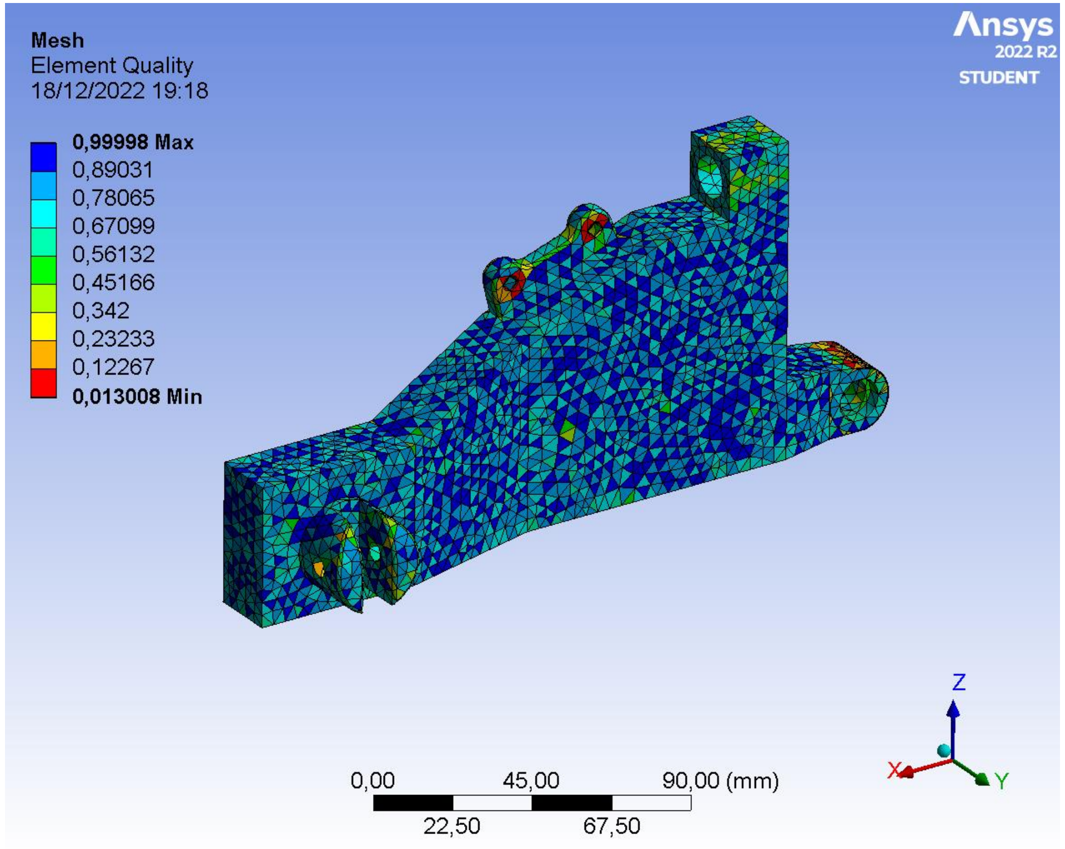


3D CAD Model Geometry

To construct the FEM model and validate it, it is necessary to start from a 3D CAD geometry that takes account of

- Previous general assumptions
- Footpeg assumed as a rigid for displacement calculation;
- No permanent deformation allowed upon unloading;
- The surplus material needed to make topological optimiser work;
- The commercial solution.

4 FEM Validation

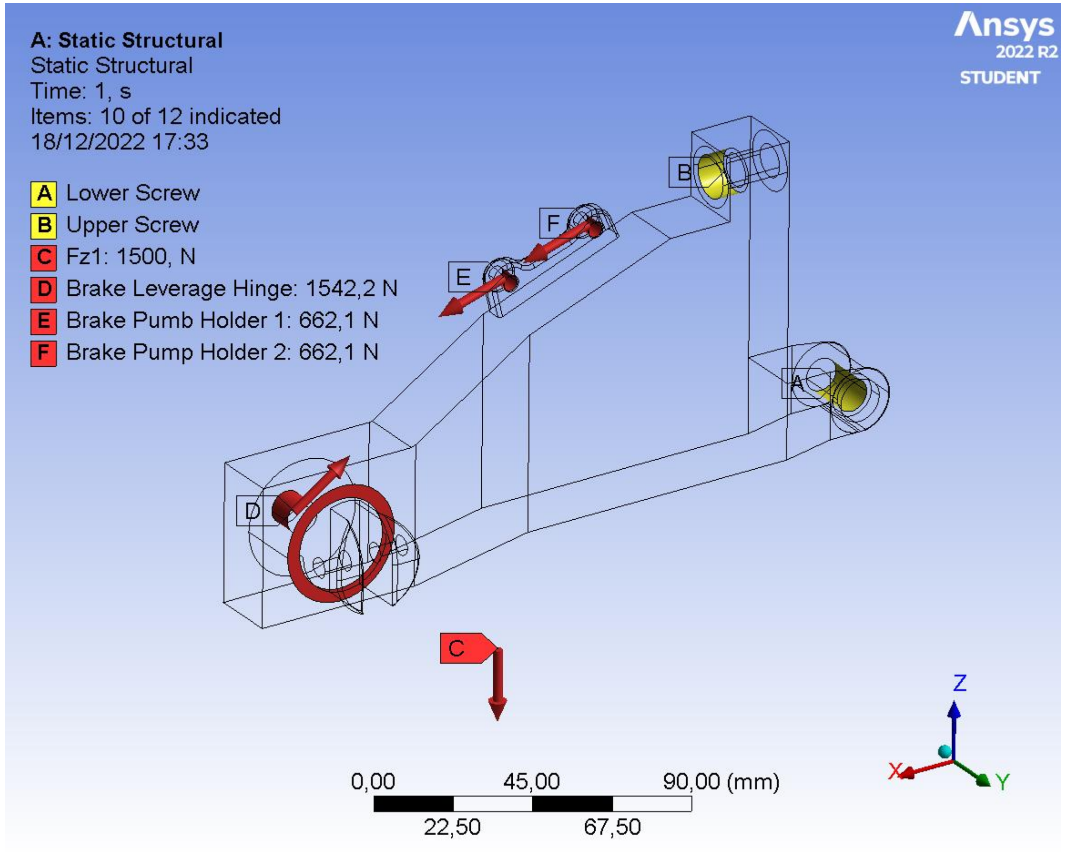


ANSYS Static Stractural Set Up

The simulation uses the previous CAD geometry with a minimum mesh size of 4 mm with a growth factor of 1.2 and no capture curvature or proximity features.

A. Lower Screw modelled as a remote displacement;
B. Upper Screw modelled as a remote displacement;
C. Fz1 load applied on a Remote Point set at 15 mm from the tip of the footpeg;
D. Brake Leverage Hinge reaction modelled as a remote force applied at the hinge surface;
E. Brake Pump Holder load applied halfway on the two support surfaces through two remote forces.

4 FEM Validation



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4 FEM Validation

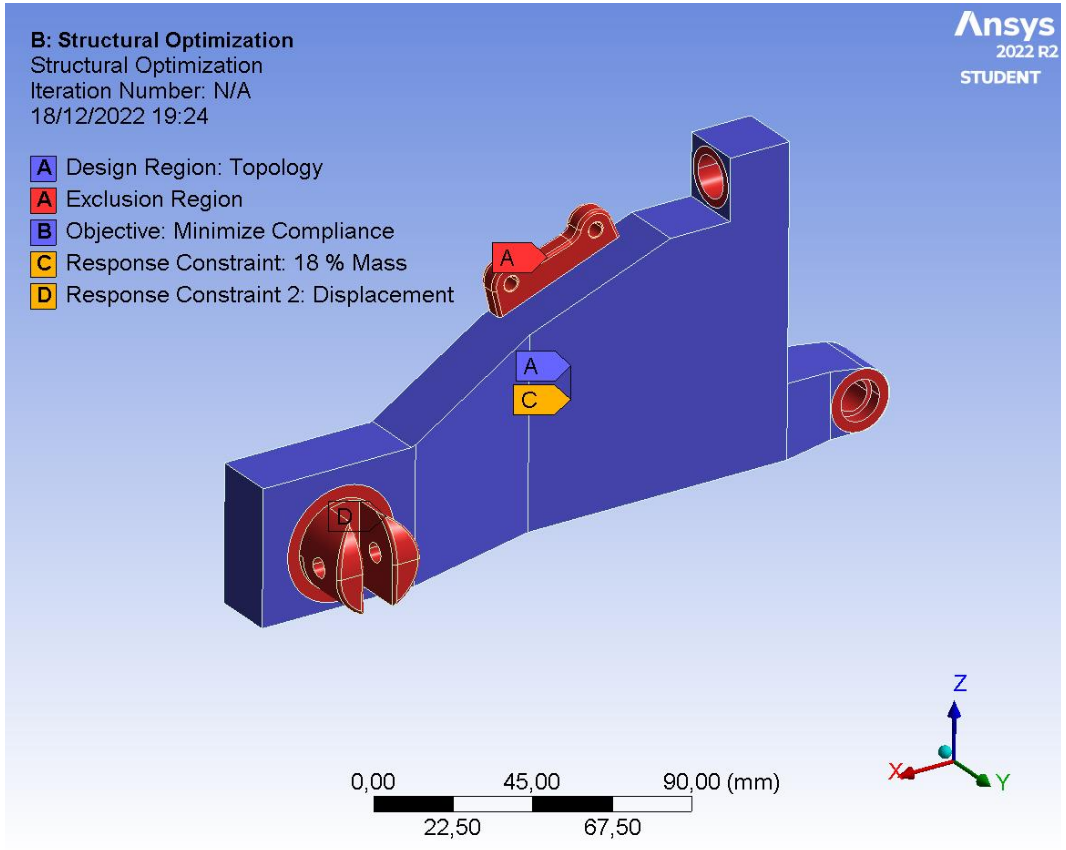
Comparison among Analytical and Validation Results

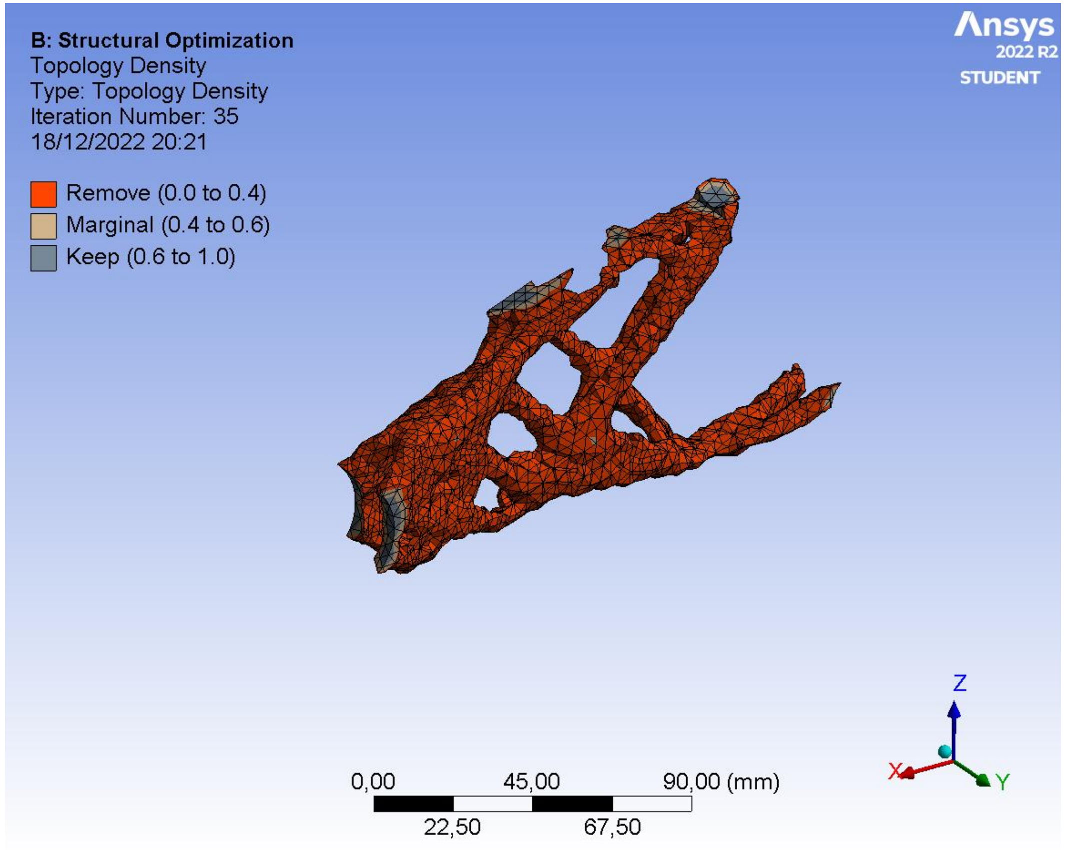
Results		Analytical	Warped_REV.wbpj	
			FEM	E%
Top Screw Reaction [N]	X	2707	2,584.30	-4.53%
	Y	-	-1,791.90	-
	Z	156	176.10	12.88%
Bottom Screw Reaction [N]	X	-2707	-2,854.30	5.44%
	Y	-	1,791.90	-
	Z	844	823.89	-2.38%
Footpeg Tip Displacement (Remote Point) [mm]		-0.04064	-0.77299	1802.04%

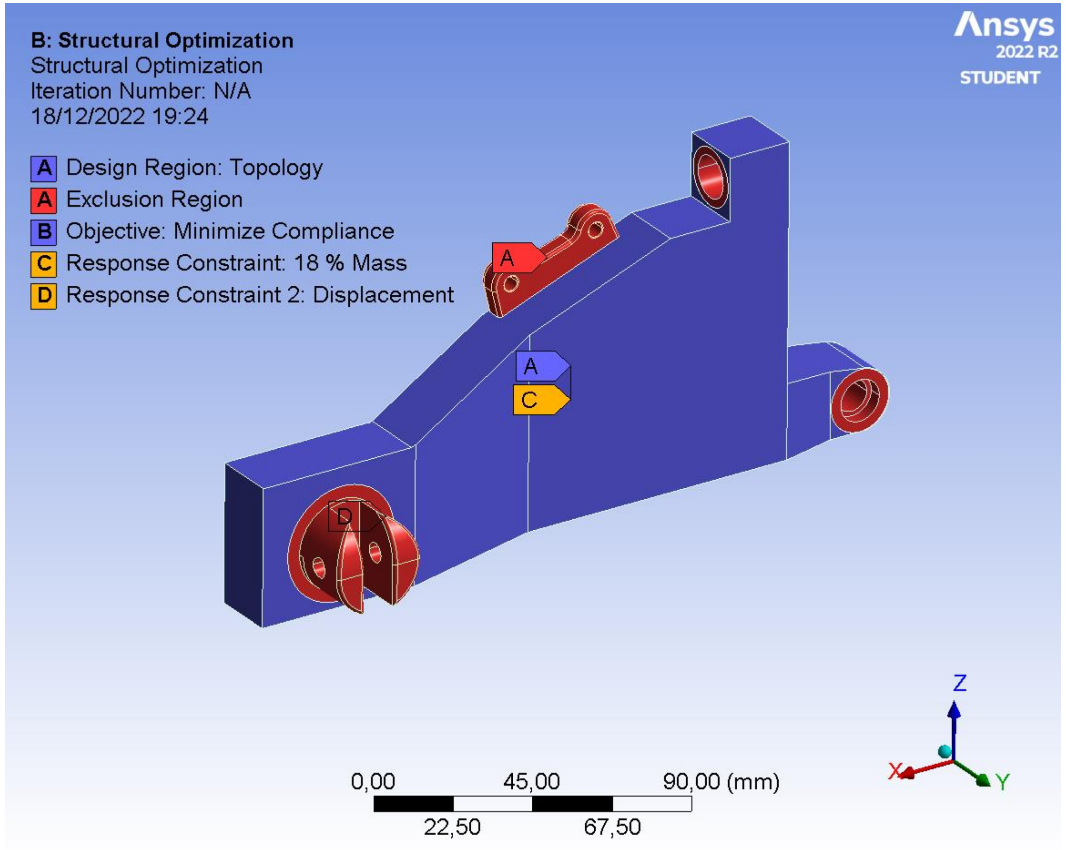
ANSYS Topological Optimization Set Up

The previous structural simulation results were used as input for topological optimization.

A. The Design Region include the entire body except the Exclusion Region like the screws holes, the pump support flange and holder's region of attachment to the footpeg.
B. The Objective is to minimize the compliance;
C. The Mass Retainment is set to 18%;
D. The 2nd constraint of the optimization is set to achieve a remote point's displacement of 8 mm.





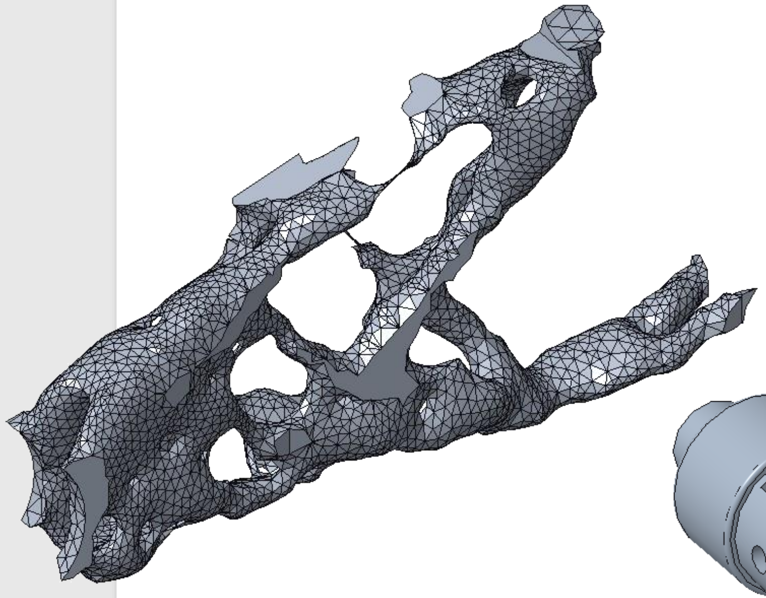


Topology Density

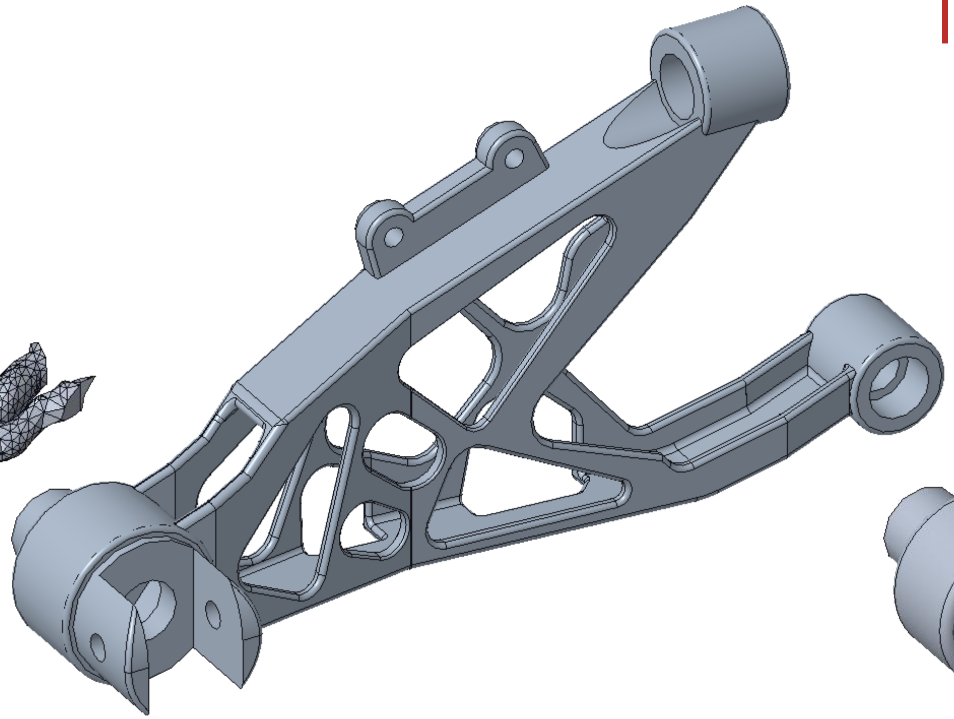
The output mesh file shows some cut off sub-structures due to the removal of material. In order to get a proper mesh structure, it is required to modify the mass retain threshold to restore part of the material.

6 Reverse Engineering

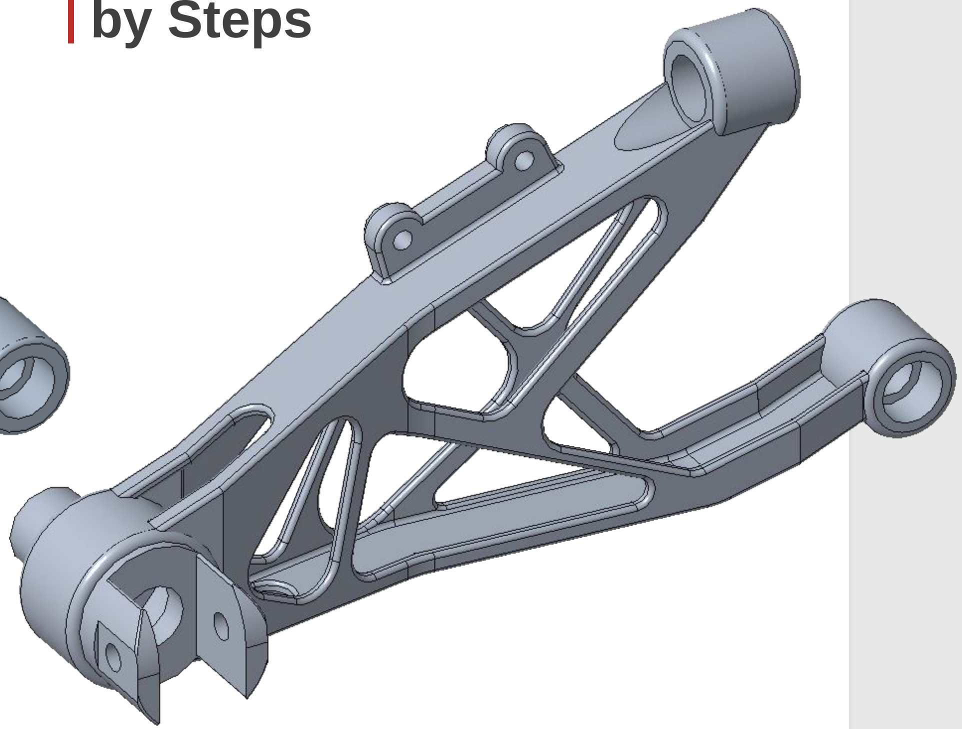
Reverse the Holder by Steps



Optimized Mesh



REV 6



REV 10

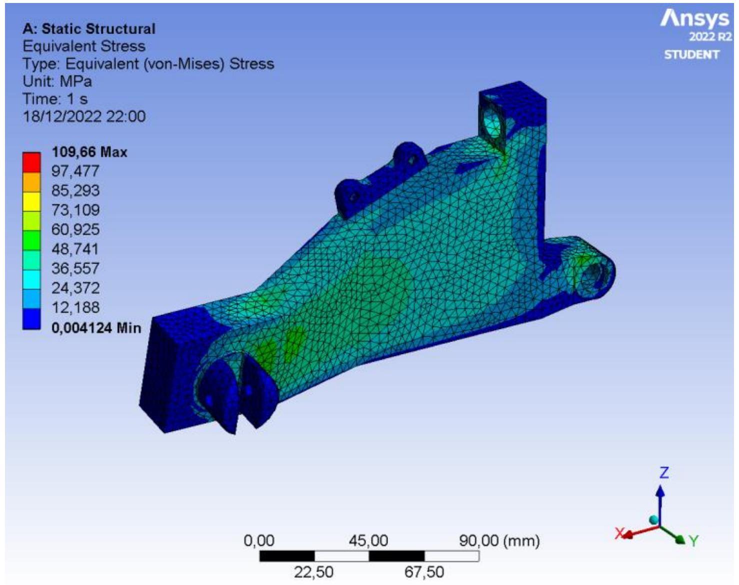
6 Reverse Engineering

Reverse Modelling Iterations

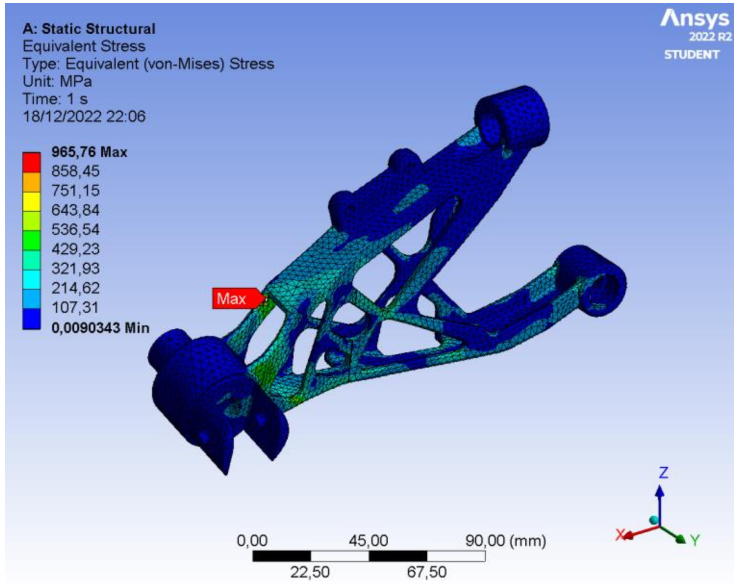
Results		Analytical	REV1	REV2	REV3	REV4	REV5	REV6	REV7	REV8	REV9	REV10
Top Screw Reaction	X	2707	1882,4	2155,7	2174,3	2175,6	2173,6	1918,0	2202,5	2199,3	1925,2	-2194,9
	Y	-	-1618	-1574,2	-1571,8	-1558,2	-1557,7	-1591,9	-1543,3	-1533,2	-1531,2	-1530,3
	Z	156	1026,5	1431,1	1420,4	1426,5	1426,8	892,6	1176,3	1173,7	1156,7	1165,4
Bottom Screw Reaction	X	-2707	-1882,4	-2155,7	-2174,3	-2175,6	2173,7	1918	2202,5	2199,3	2185,1	2194,9
	Y	-	1618	1574,2	1571,8	1558,2	1557,7	-1591,9	1534,3	1533,2	1531,2	1530,3
	Z	844	-401,55	-431,14	-420,35	-426,55	-426,84	-267,60	-176,26	-173,69	-156,67	-165,46
Footpeg Tip Displacement		-0,04064	-2,9804	-3,9468	-4,2995	-5,8599	-6,1697	-7,3000	-7,7262	-7,3982	-6,7993	-6,5686

6 Reverse Engineering

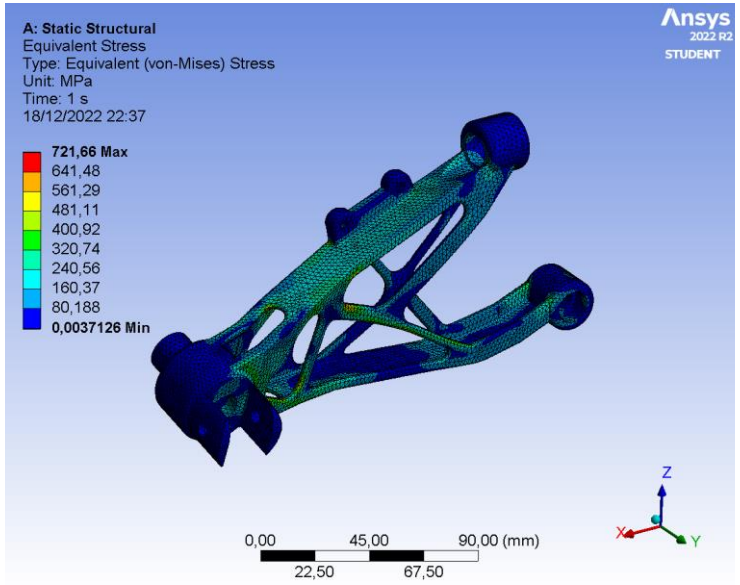
Equivalent Stress Peaks



Optimized Mesh



REV 6

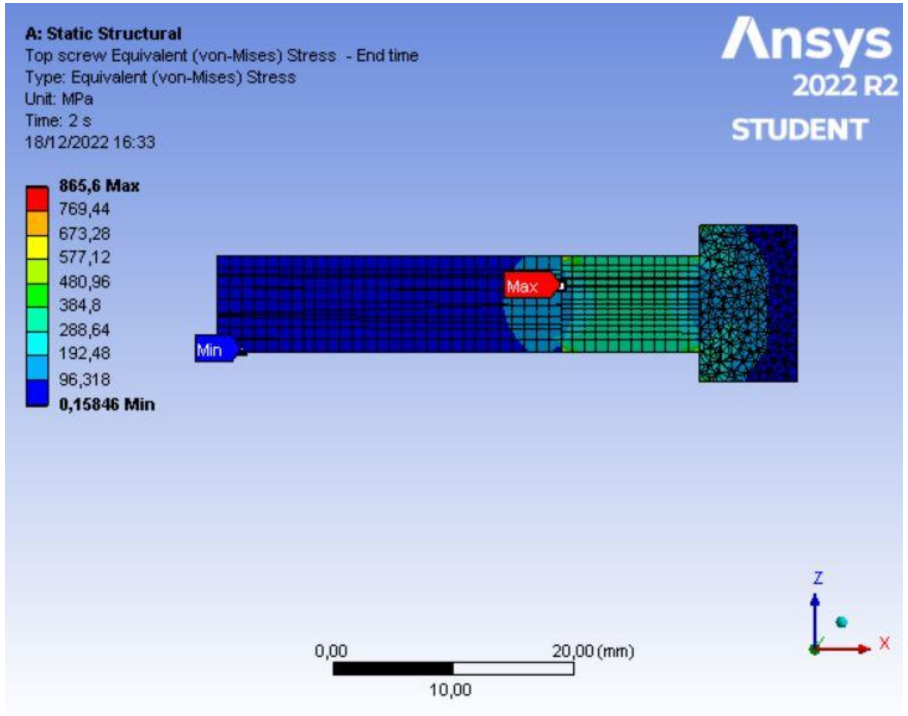


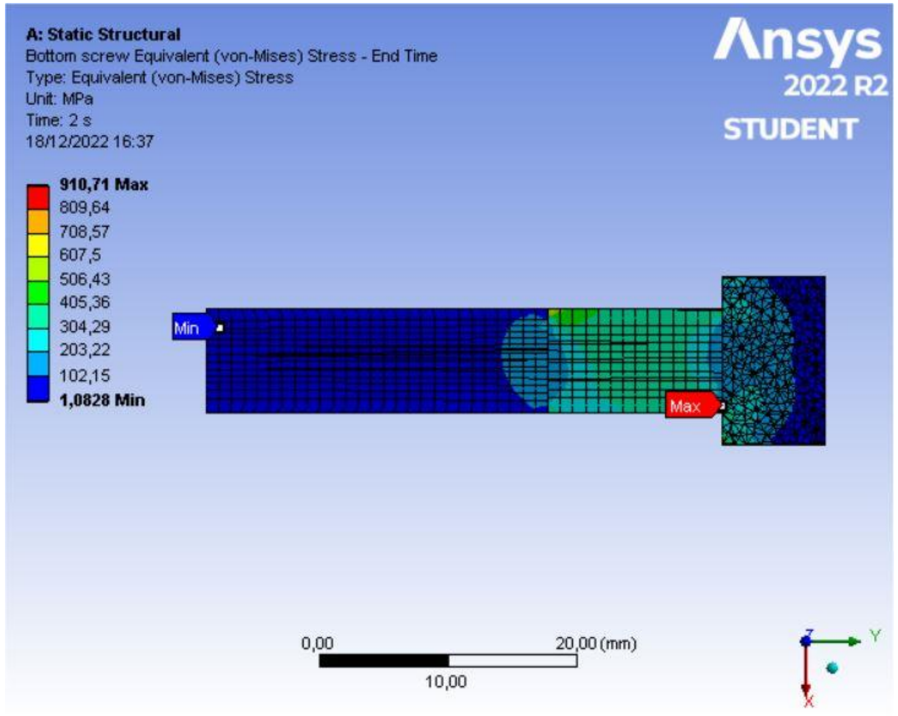
REV 10

7 Screws Validation

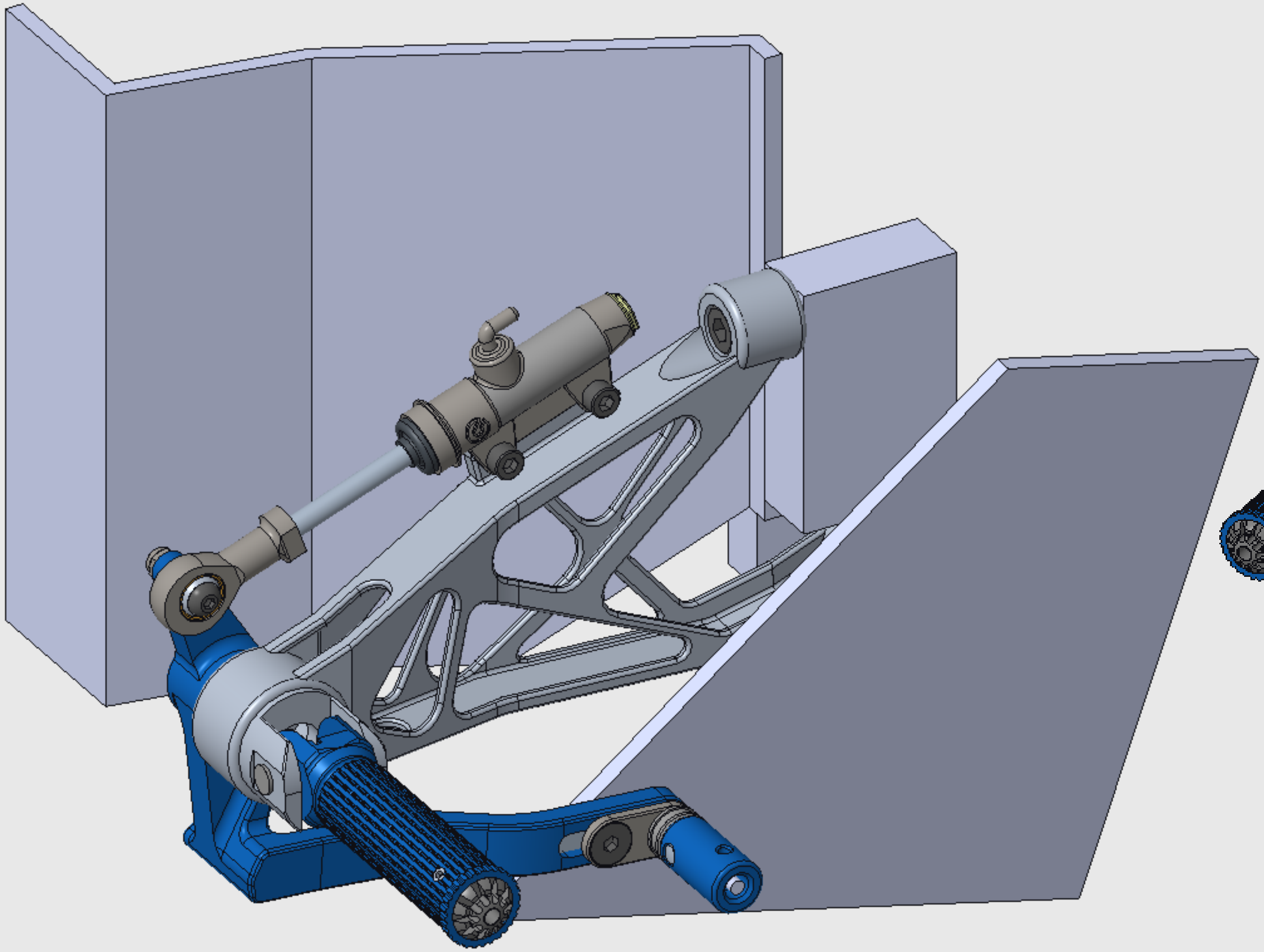
Right Side Footpeg Holder

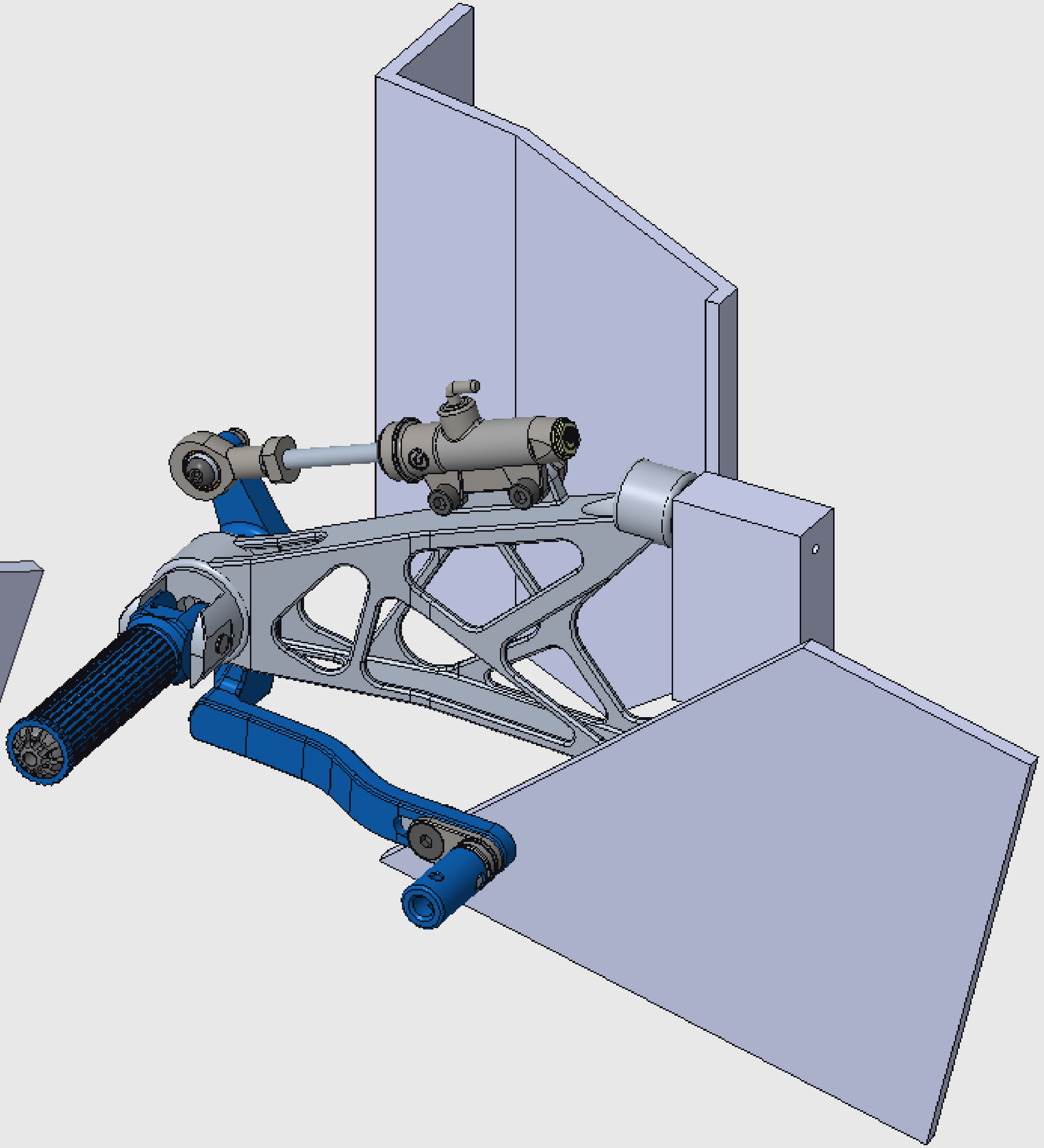
To evaluate stresses distribution on them, a section plane cutting each screw into two bodies through their axis was created and, apart from little stress concentration superficial zones, screw design was validated.





8 Assembly Review





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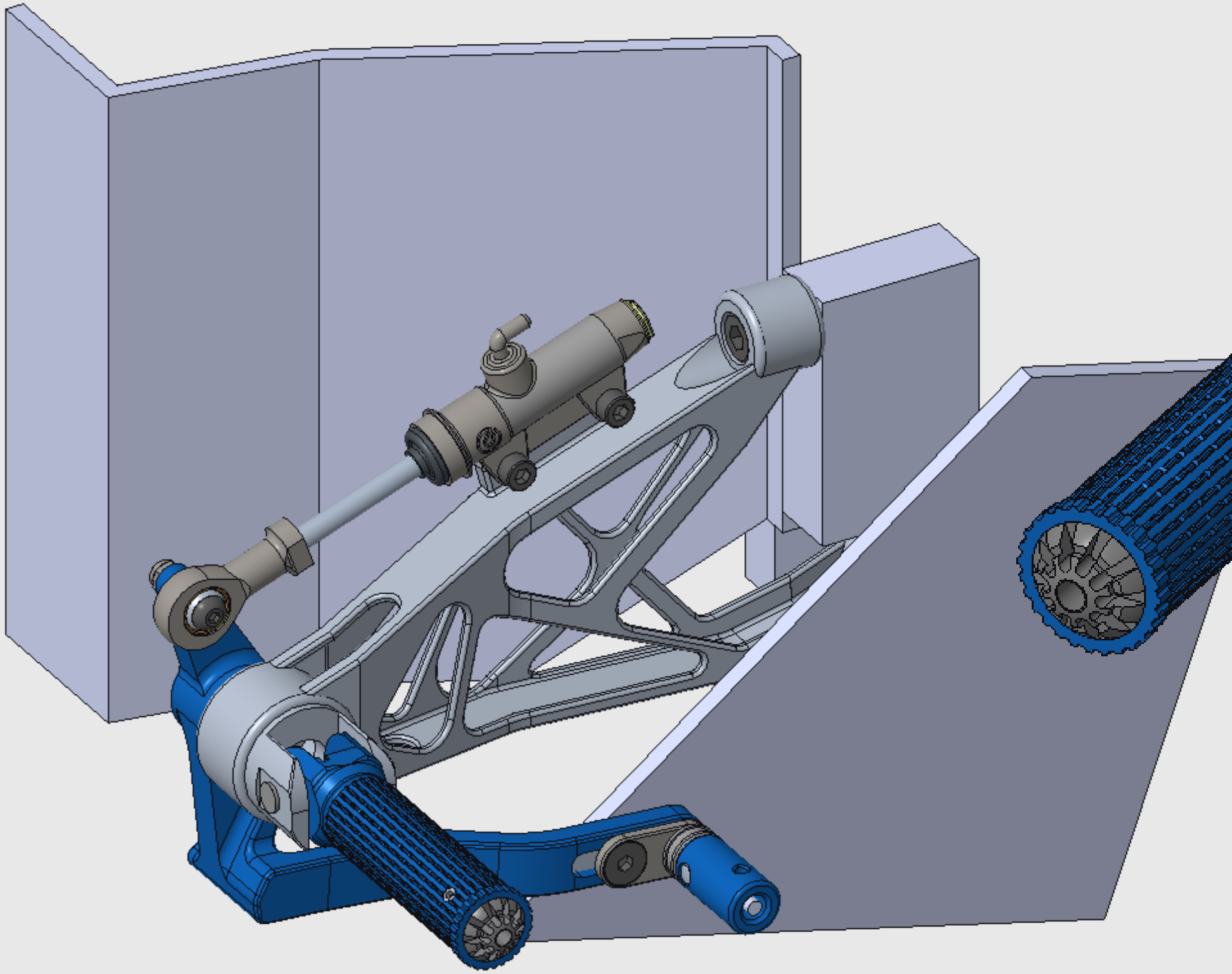
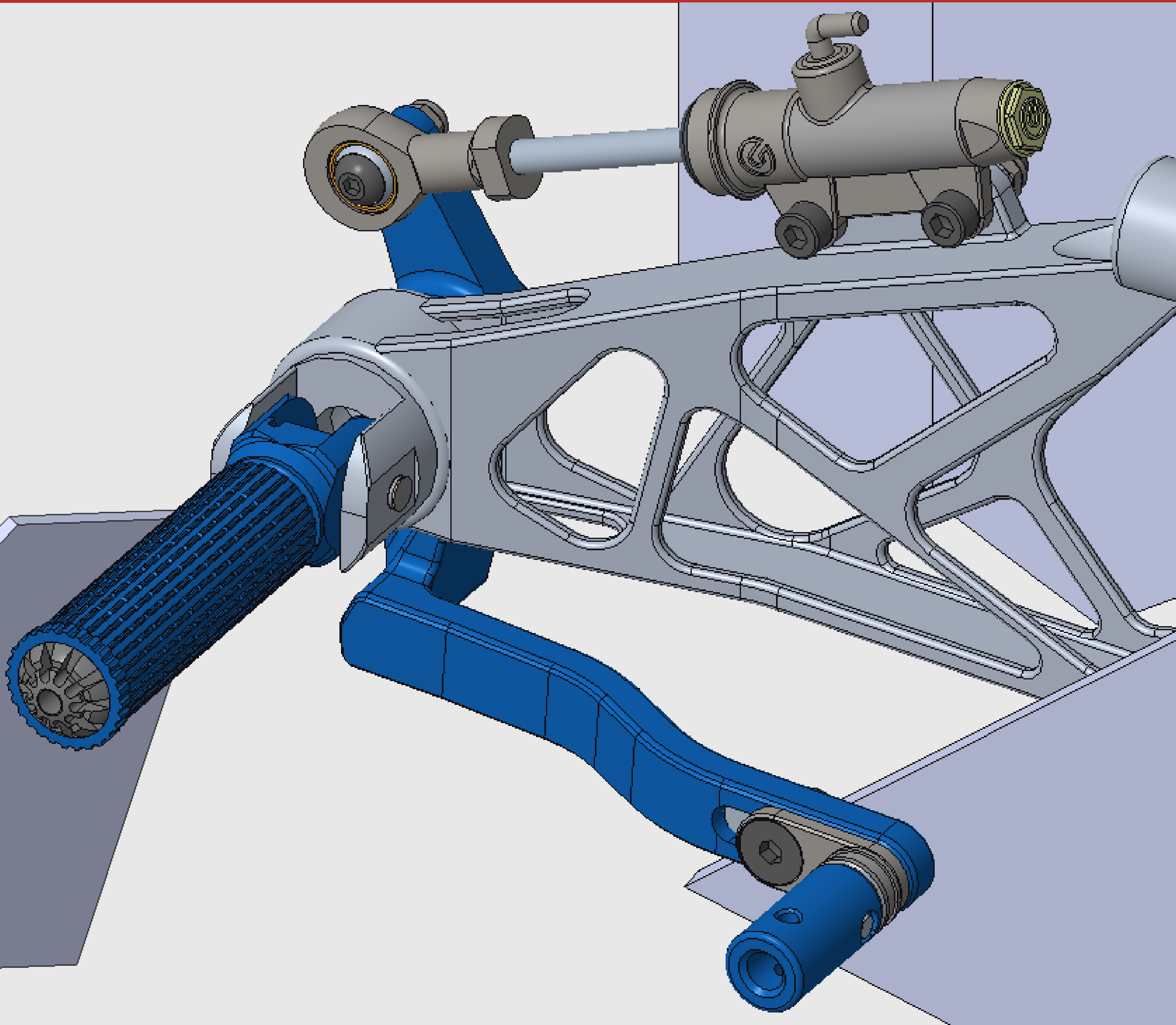


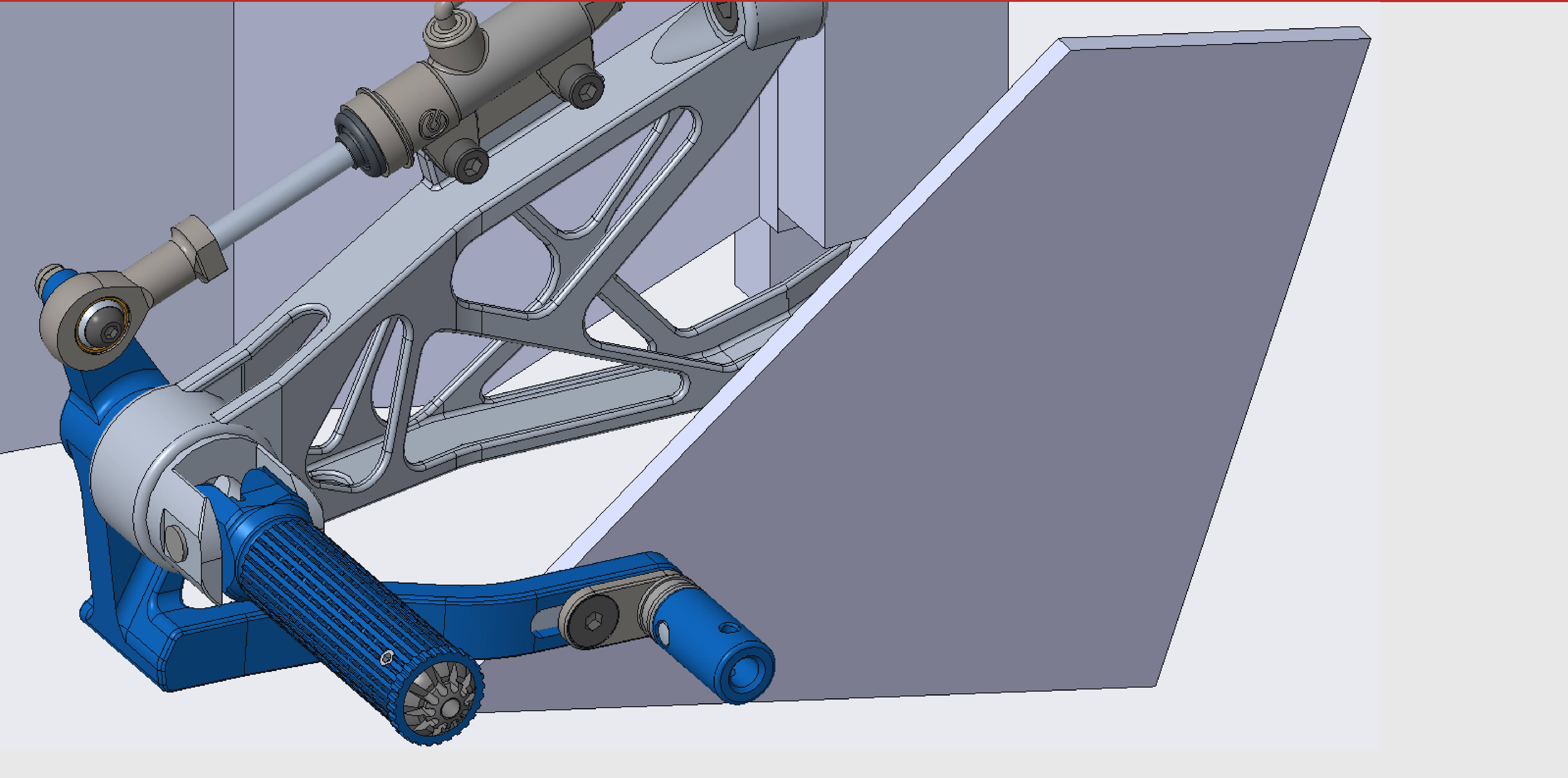


Chassis and Body Design
and Manifacturing M

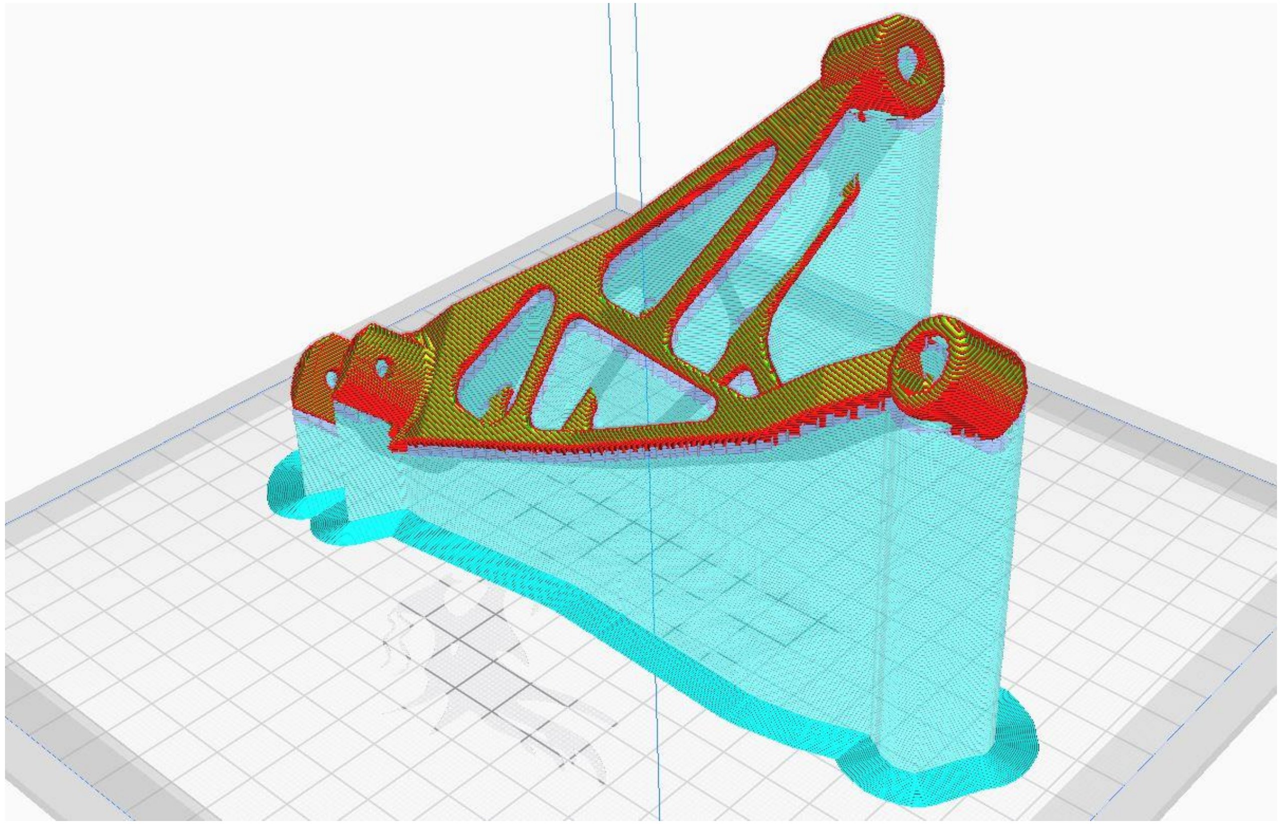
PROJECT 4

RIGHT SIDE FOOTPEG HOLDER

for a supersport bike



8 Printing Preview



Printing Strategies

Once the final CAD model of the component has been obtained, it is possible to study some printing strategies: its particular warped shape makes it necessary to prepare the body with a certain inclination with respect to the printing plane, in order to correctly construct the piece and the supporting infrastructure.