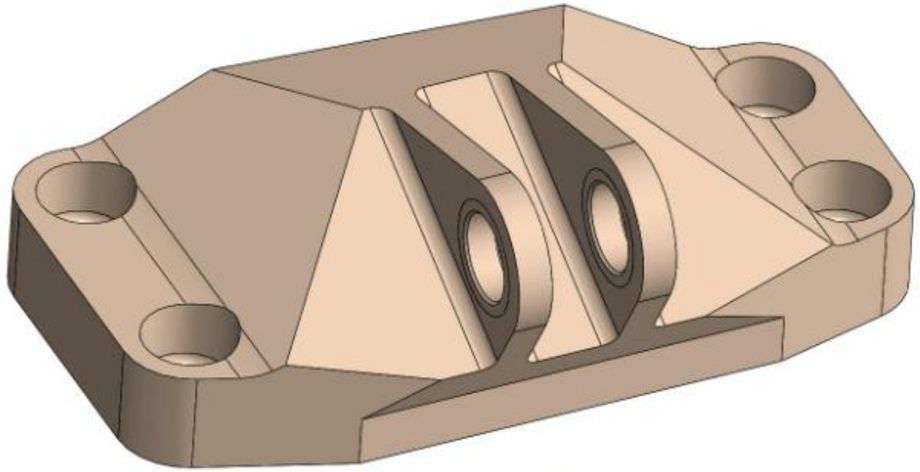
TOPOLOGY

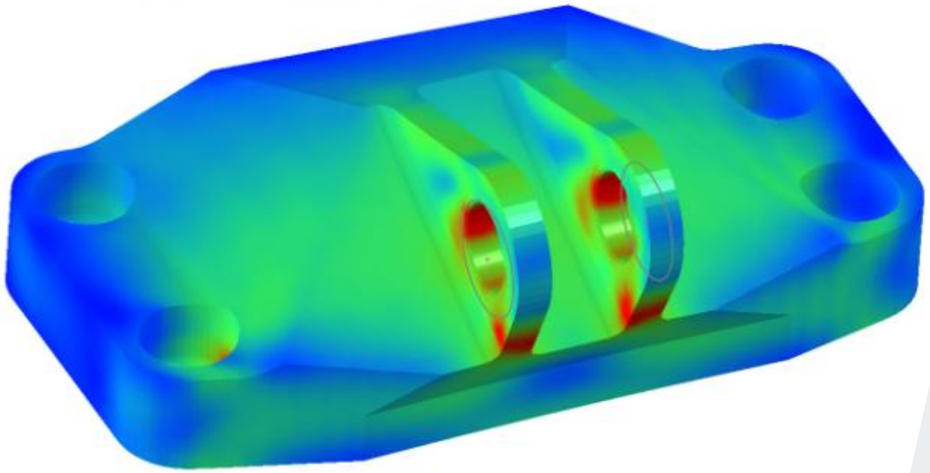
Topology optimization을 통한 Formula 차량 서스펜션 로커 경량화 설계

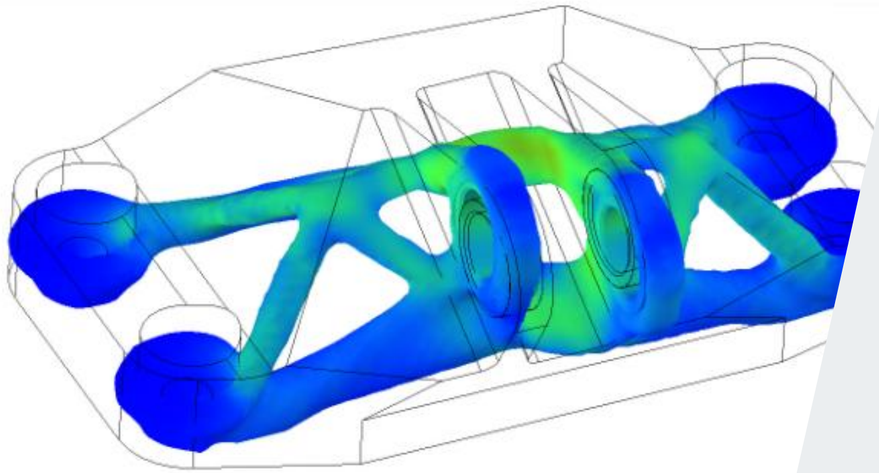
TEAM

2020054775 이재홍

2020044975 권성준

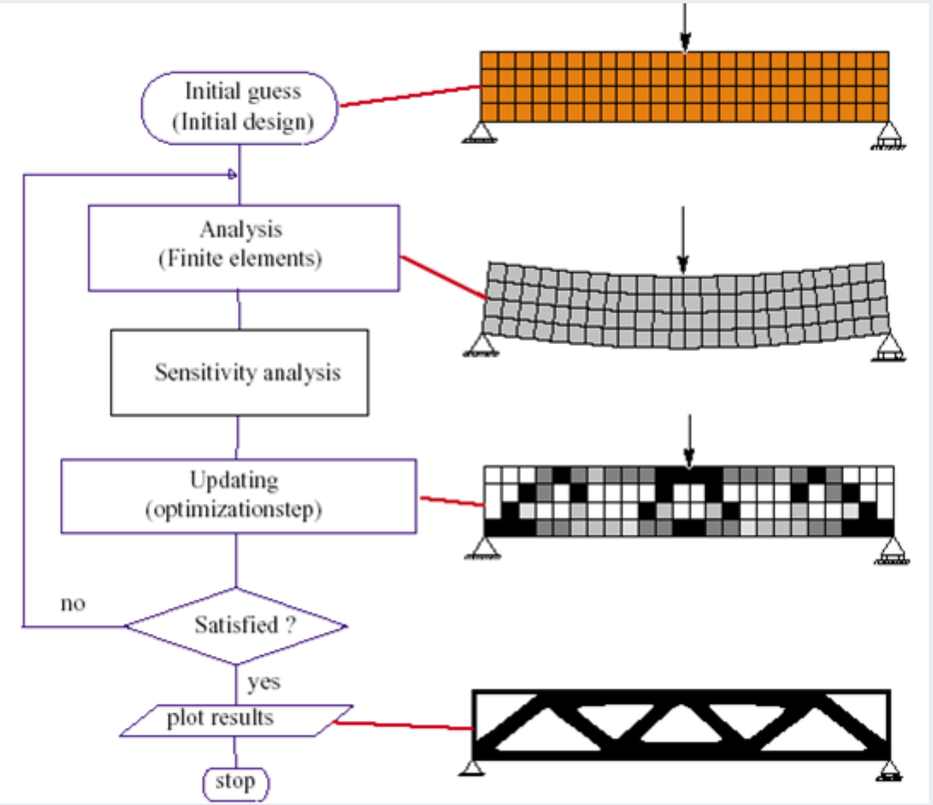




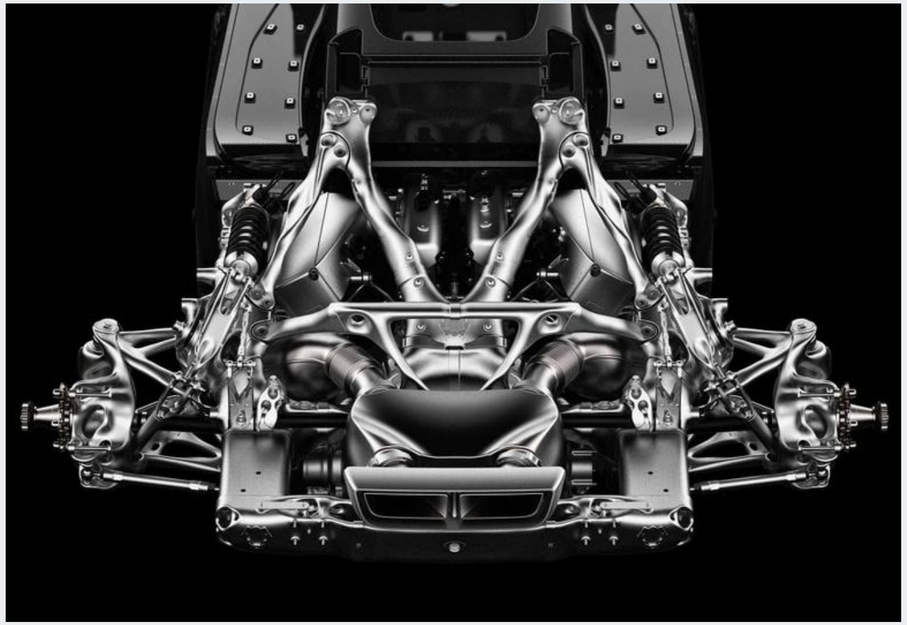


MOTIVATION FOR THE PROJECT

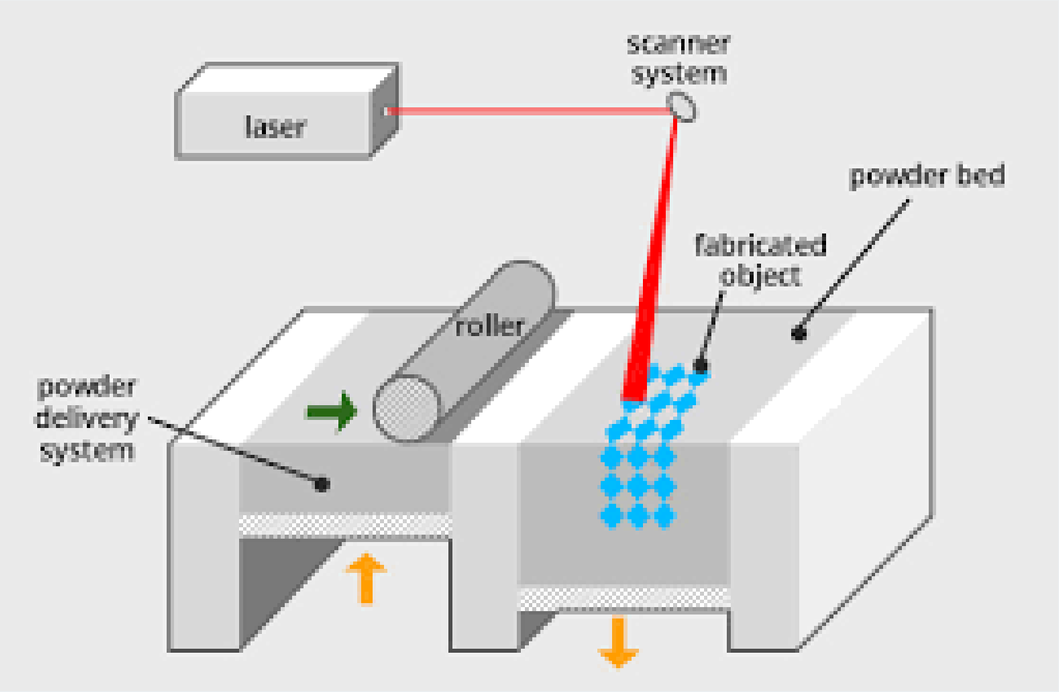
WHAT IS TOPOLOGY OPTIMIZATION?

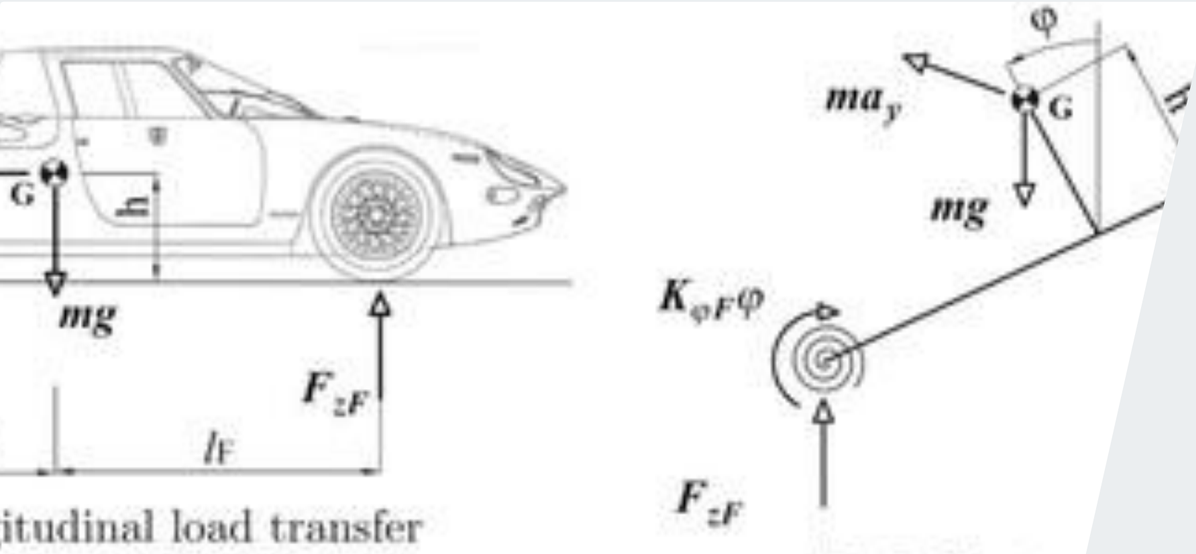


APPLICATION CASE



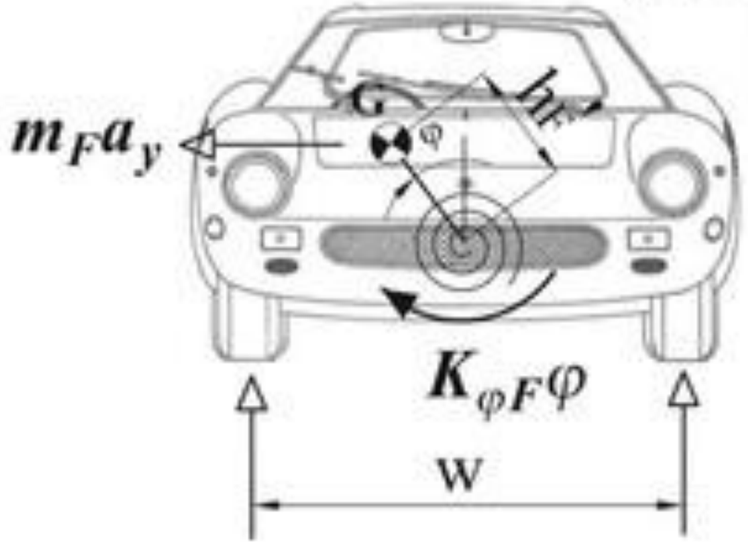
SLM 3D PRINTING





itudinal load transfer

(b) Roll axis

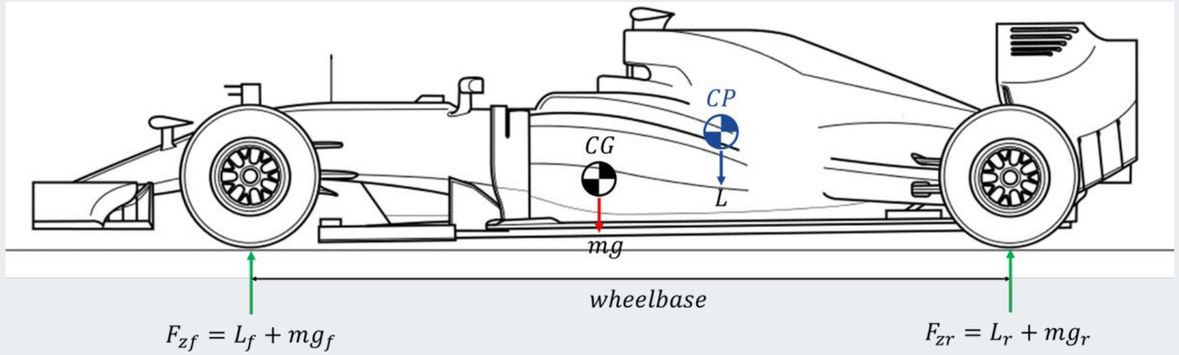


$$\frac{F_{zF}}{2} + \Delta z \qquad \frac{F_{zF}}{2}$$

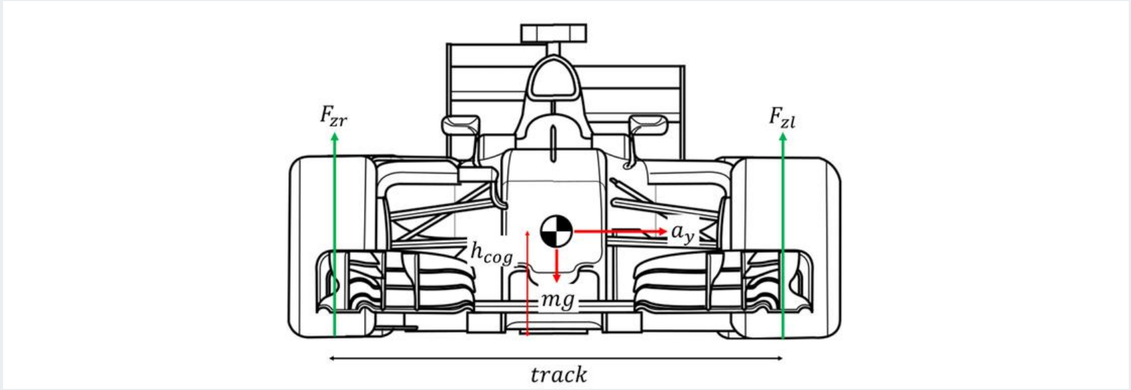
(c) Lateral load transfer (front a

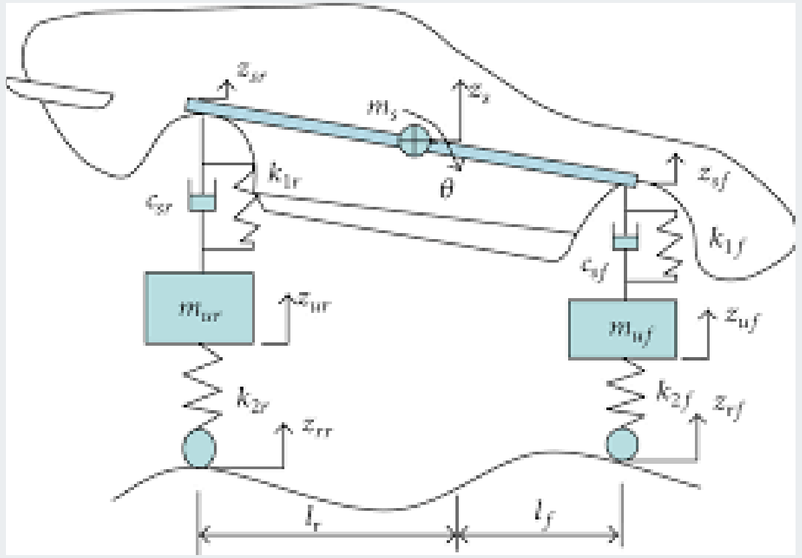
DYNAMIC LOAD ON A VEHICLE

Longitudinal

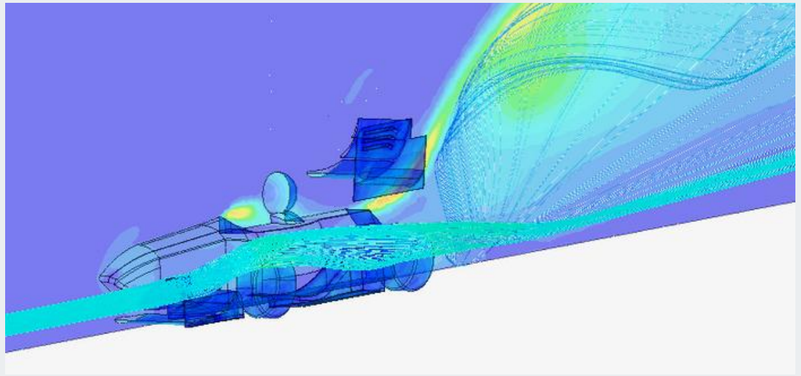


Lateral



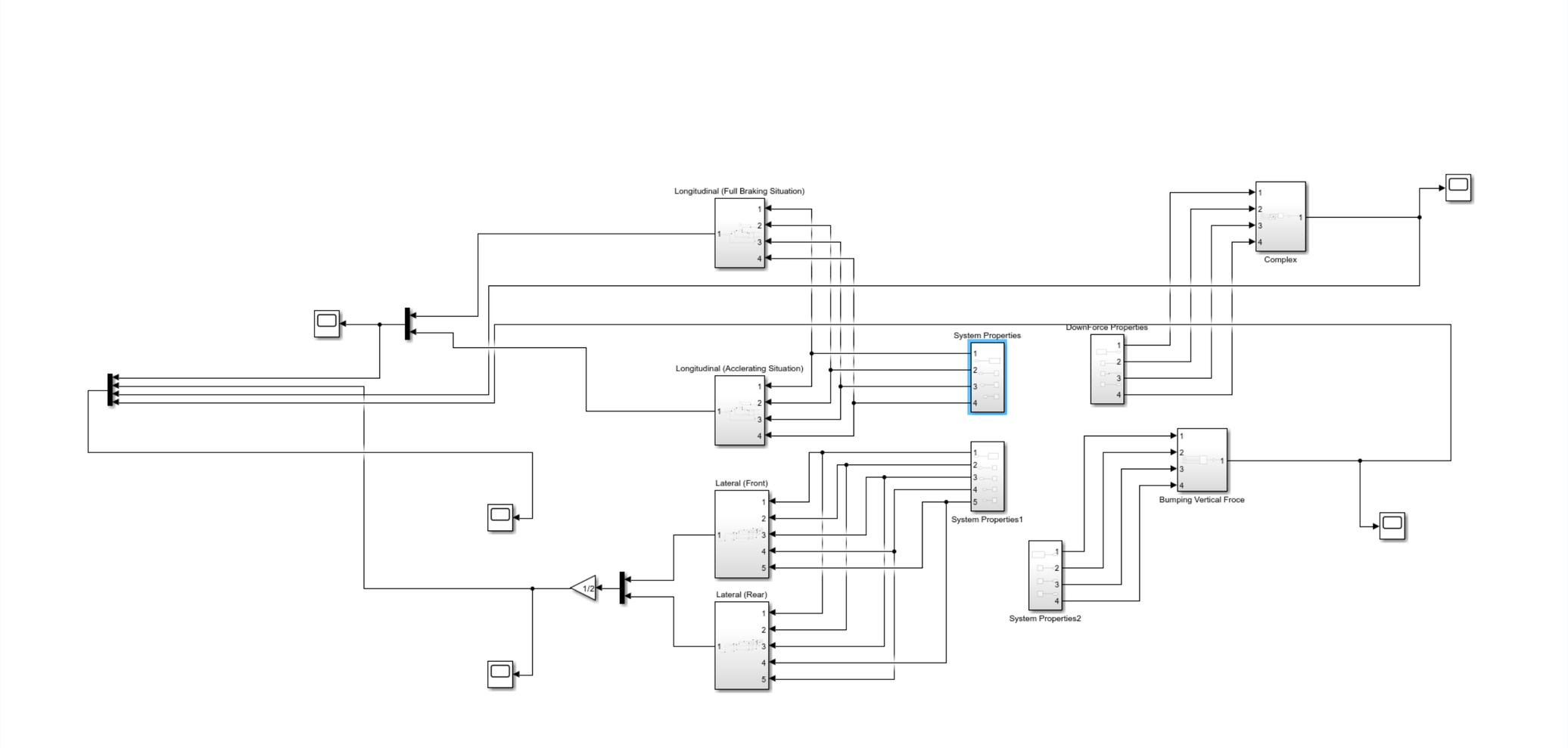


Bumping



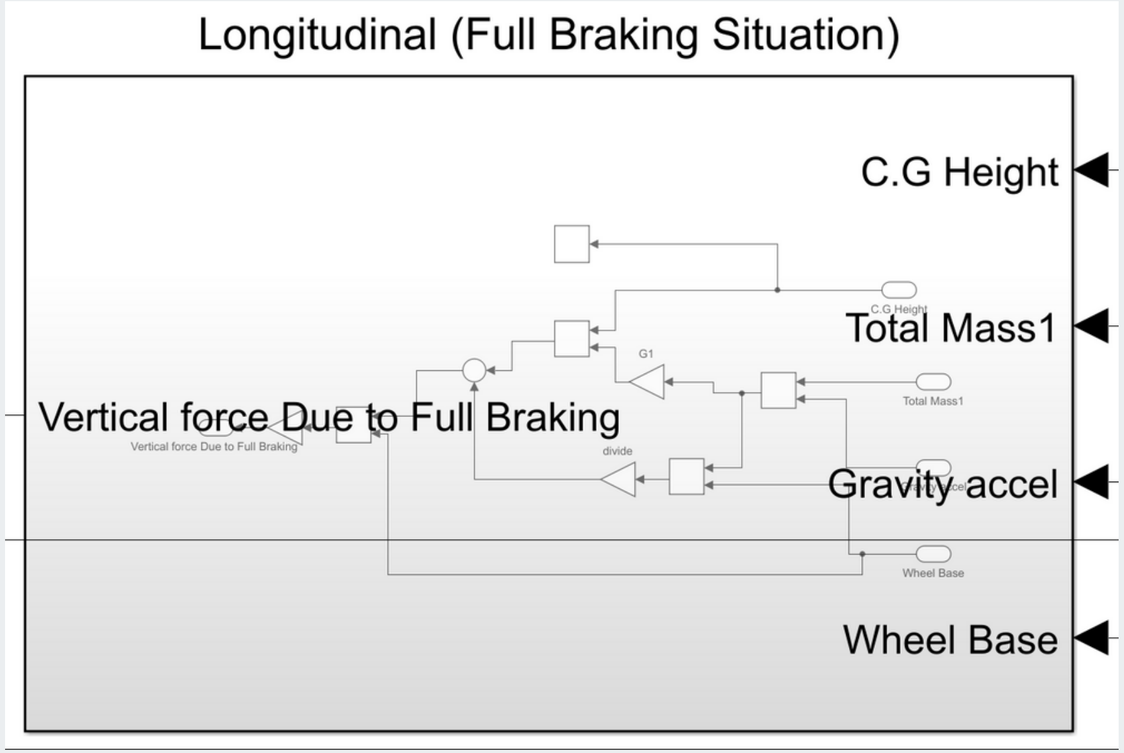
Aero Down Force

MAXIMUM FORCE CALCULATION PROCESS



MAXIMUM FORCE CALCULATION

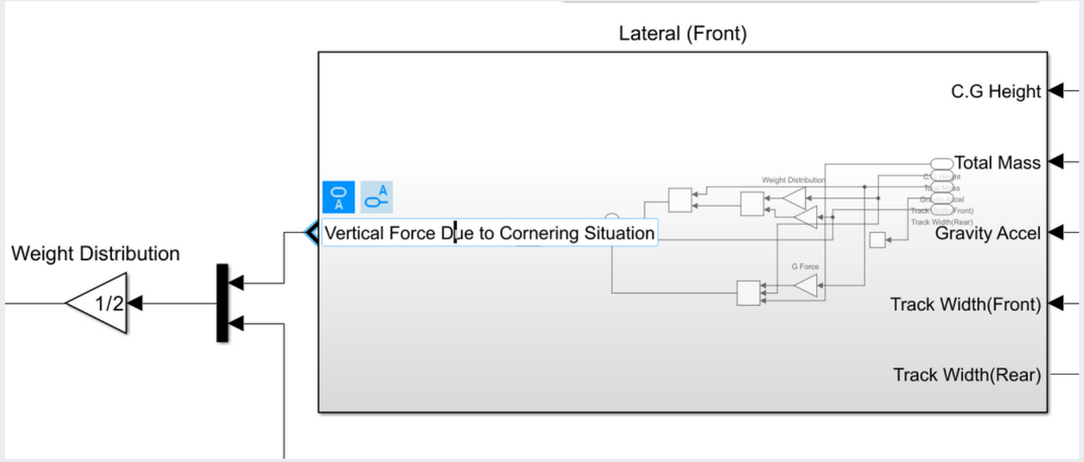
Longitudinal



LONGITUDINAL

Acceleration (g) (Vehicle Weight (lb)*cg Height (in)/Wheelbase)

Lateral



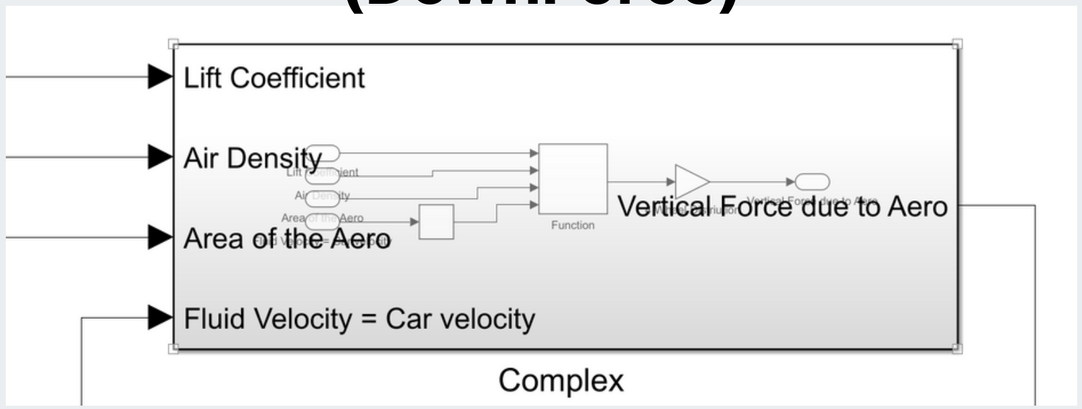
LATERAL:

Lateral acceleration (g)*Weight (lb)*C.G Height/Track width

출처: DESIGN & ANALYSIS OF ROCKER ARM SUSPENSION SYSTEM USED IN FSAE

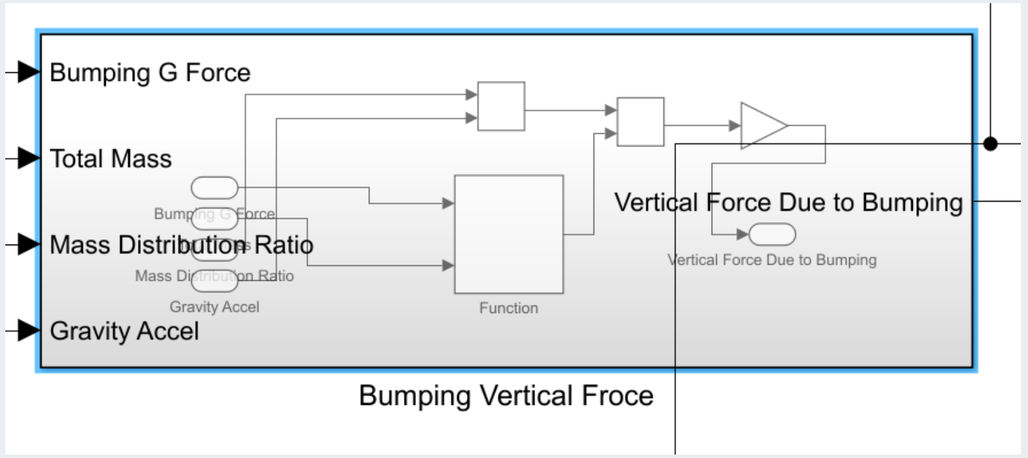
MAXIMUM FORCE CALCULATION

Complex Force 1 (DownForce)



$$C_l = \frac{F}{\frac{1}{2} * \rho * V^2 * A}$$

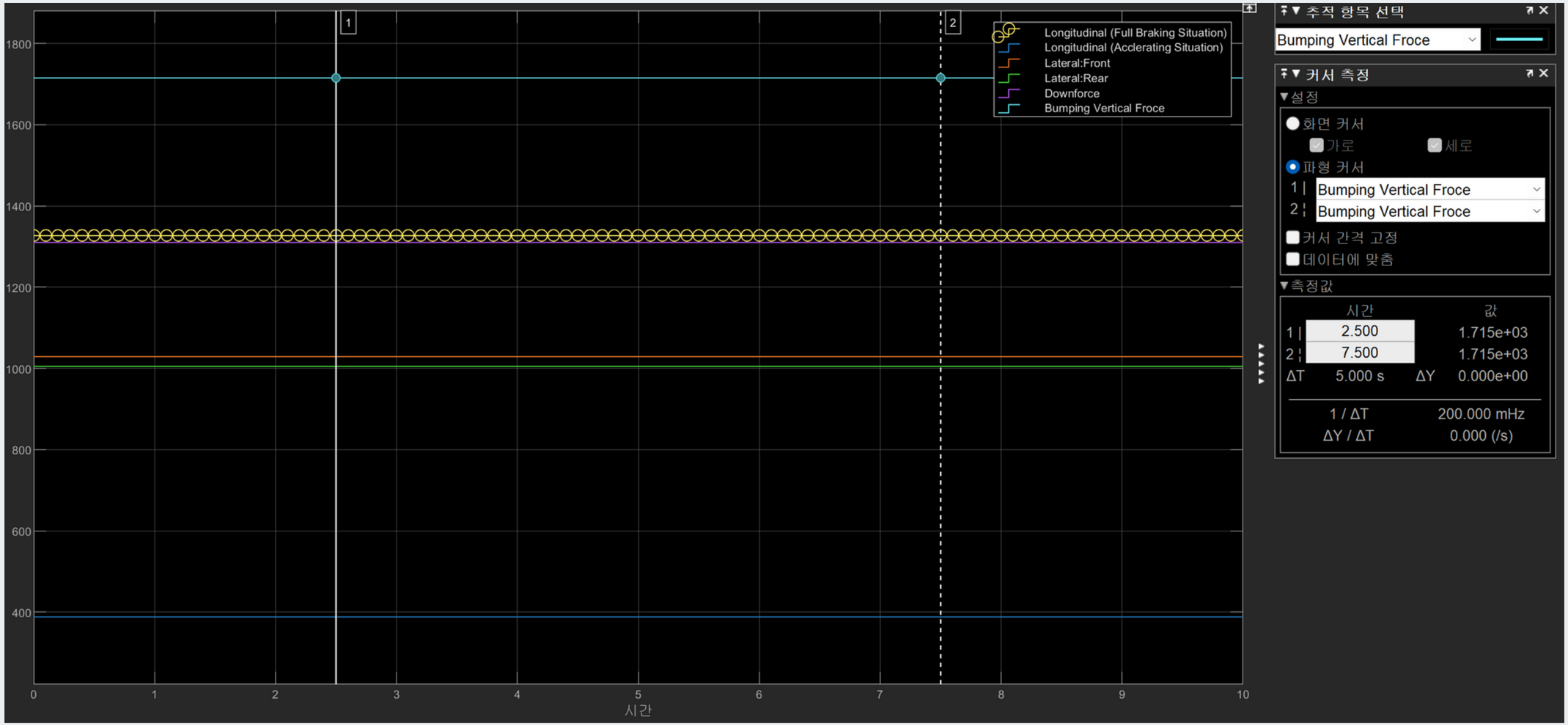
Complex Force 2 (Bumping)



Vertical Force at Bump: The vertical load transfer occurs at bump and as per load theories 3g of weight applies on vehicle at the time of bump.

출처: DESIGN & ANALYSIS OF ROCKER ARM SUSPENSION SYSTEM USED IN FSAE

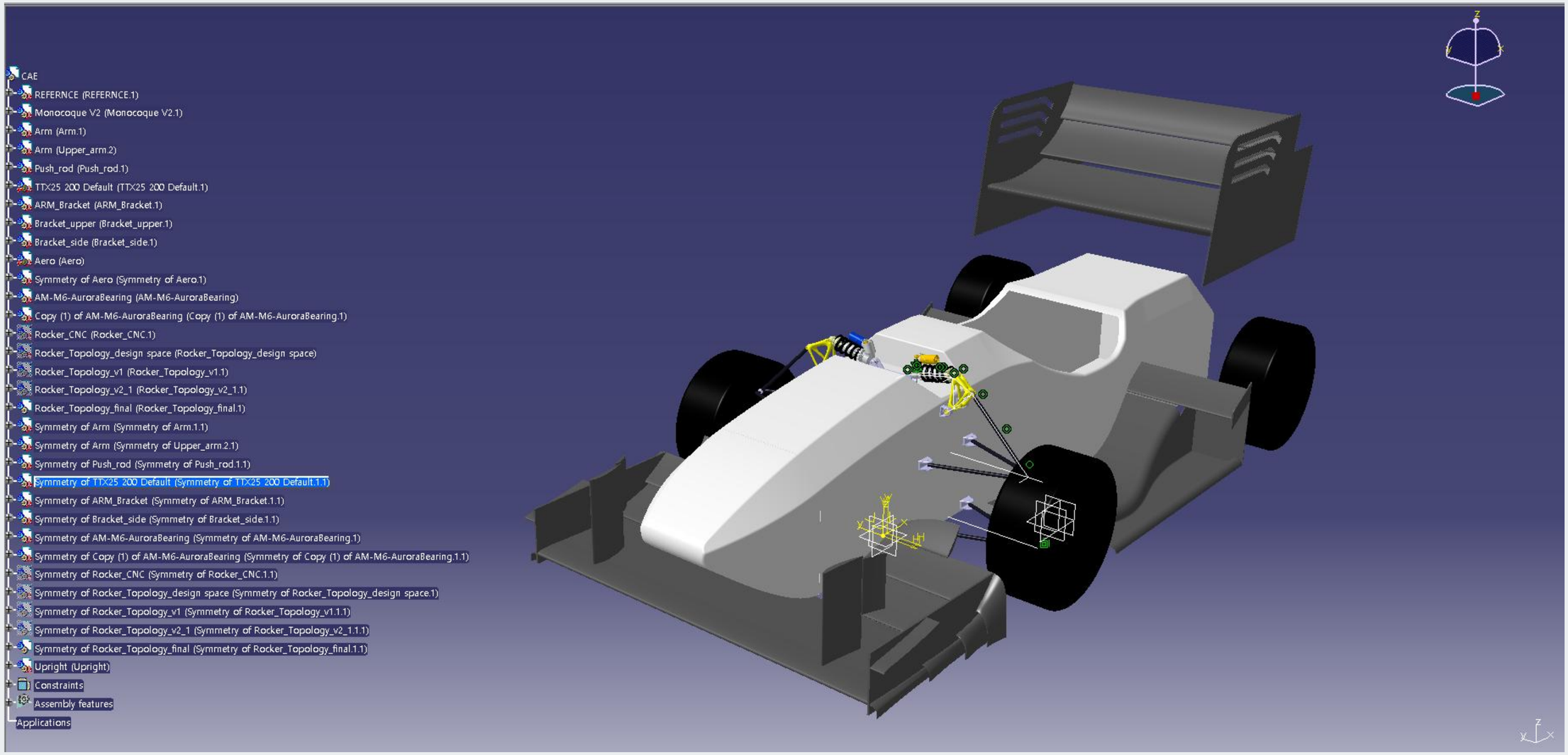
MAXIMUM FORCE CALCULATION



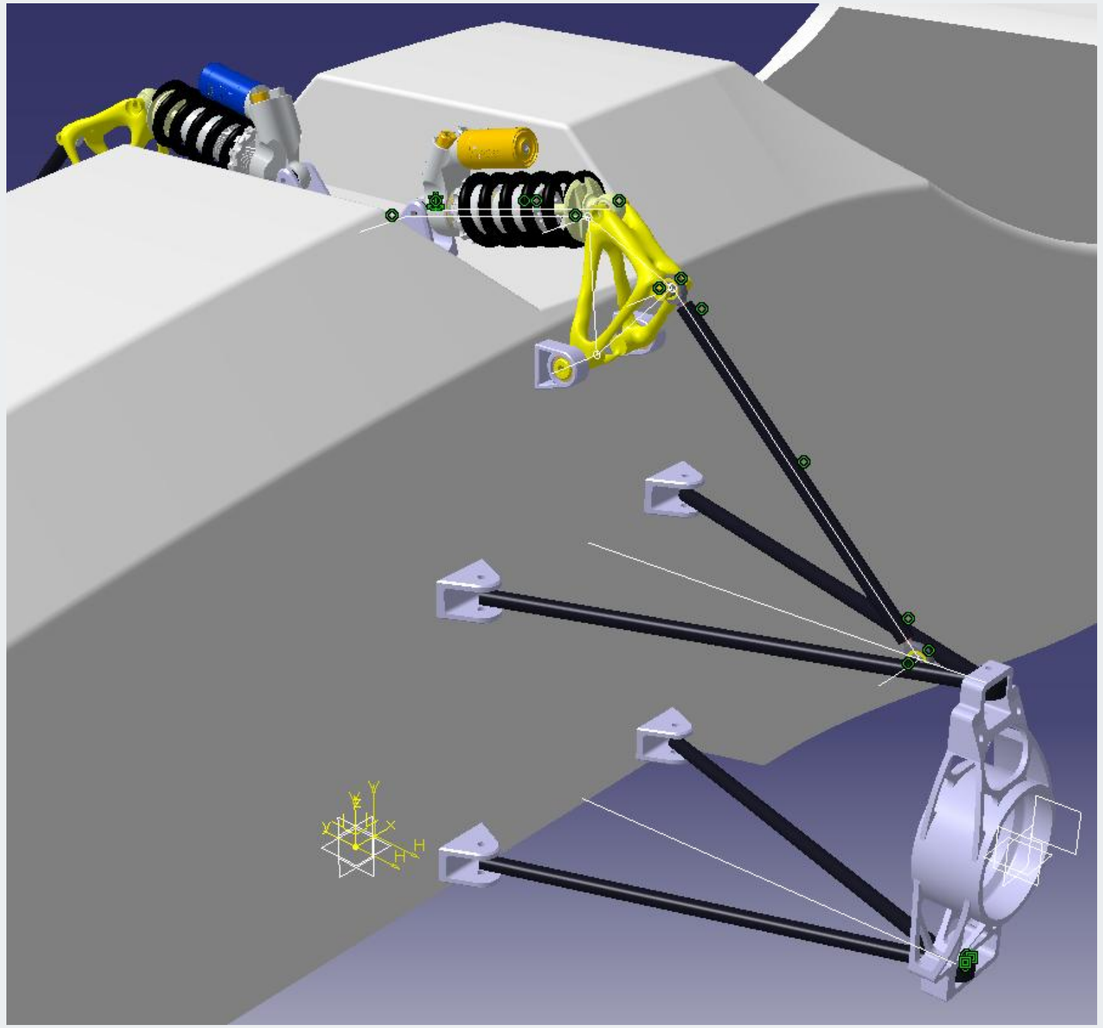
출처: DESIGN & ANALYSIS OF ROCKER ARM SUSPENSION SYSTEM USED IN FSAE

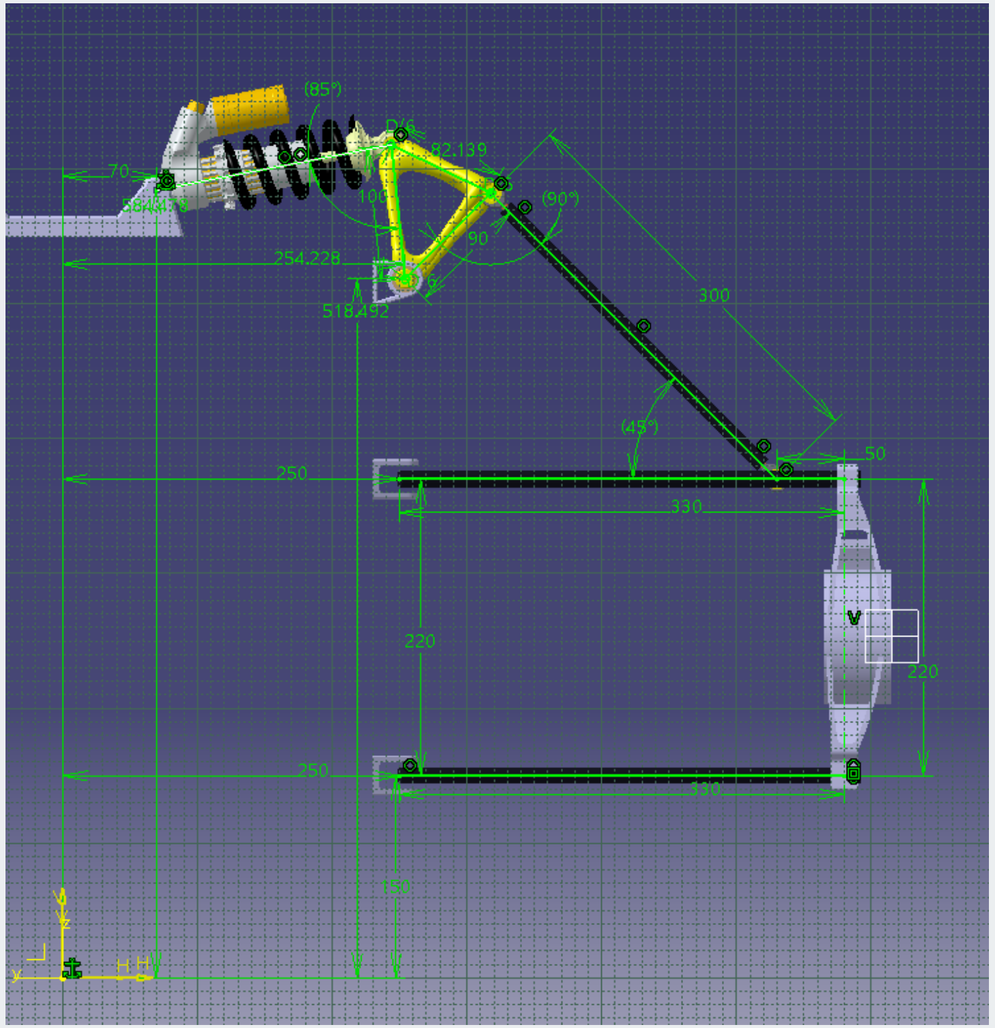
ENGINEERING PROCESS

FULL MODEL


CAE
REFERNCE (REFERNCE.1)
Monocoque V2 (Monocoque V2.1)
Arm (Arm.1)
Arm (Upper_arm.2)
Push_rod (Push_rod.1)
TTX25 200 Default (TTX25 200 Default.1)
ARM_Bracket (ARM_Bracket.1)
Bracket_upper (Bracket_upper.1)
Bracket_side (Bracket_side.1)
Aero (Aero)
Symmetry of Aero (Symmetry of Aero.1)
AM-M6-AuroraBearing (AM-M6-AuroraBearing)
Copy (1) of AM-M6-AuroraBearing (Copy (1) of AM-M6-AuroraBearing.1)
Rocker_CNC (Rocker_CNC.1)
Rocker_Topology_design space (Rocker_Topology_design space)
Rocker_Topology_v1 (Rocker_Topology_v1.1)
Rocker_Topology_v2_1 (Rocker_Topology_v2_1.1)
Rocker_Topology_final (Rocker_Topology_final.1)
Symmetry of Arm (Symmetry of Arm.1.1)
Symmetry of Arm (Symmetry of Upper_arm.2.1)
Symmetry of Push_rod (Symmetry of Push_rod.1.1)
Symmetry of TTX25 200 Default (Symmetry of TTX25 200 Default.1.1)
Symmetry of ARM_Bracket (Symmetry of ARM_Bracket.1.1)
Symmetry of Bracket_side (Symmetry of Bracket_side.1.1)
Symmetry of AM-M6-AuroraBearing (Symmetry of AM-M6-AuroraBearing.1)
Symmetry of Copy (1) of AM-M6-AuroraBearing (Symmetry of Copy (1) of AM-M6-AuroraBearing.1.1)
Symmetry of Rocker_CNC (Symmetry of Rocker_CNC.1.1)
Symmetry of Rocker_Topology_design space (Symmetry of Rocker_Topology_design space.1)
Symmetry of Rocker_Topology_v1 (Symmetry of Rocker_Topology_v1.1.1)
Symmetry of Rocker_Topology_v2_1 (Symmetry of Rocker_Topology_v2_1.1.1)
Symmetry of Rocker_Topology_final (Symmetry of Rocker_Topology_final.1.1)
Upright (Upright)
Constraints
Assembly features
Applications

SUSPENSION GEOMETRY





SLM 3D PRINTING

AlSi10Mg

Mechanical Data[2]	Formula Symbol and Unit	As-Built[3]
Tensile strength	R_m [MPa]	435
Offset yield strength	$R_{p0,2}$ [MPa]	260
Elongation at break	A [%]	7
Reduction of area	Z [%]	5
Young's modulus	E [GPa]	75
Vickers hardness	HV10	125
Roughness average	Ra [µm]	15
Mean roughness depth	Rz [µm]	65

GABRIAN
INTERNATIONAL (H.K.) LTD

6061 Aluminum Alloy: Properties

Mechanical Properties

Property	6061-T6
Tensile Strength	310 MPa | 45000 psi
Yield Strength	276 MPa | 40000 psi
Modulus of Elasticity	68.9 GPa | 10000 ksi

DESIGN TARGET

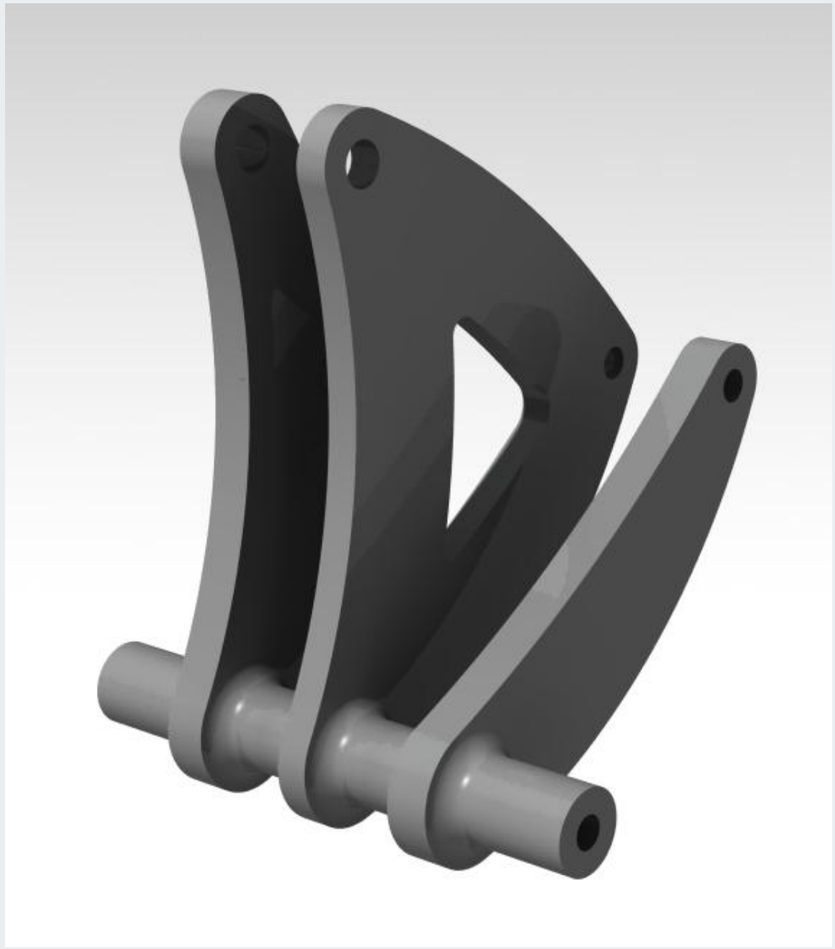
01 **SAFTY FACTOR : 1.5 OR HIGHER**

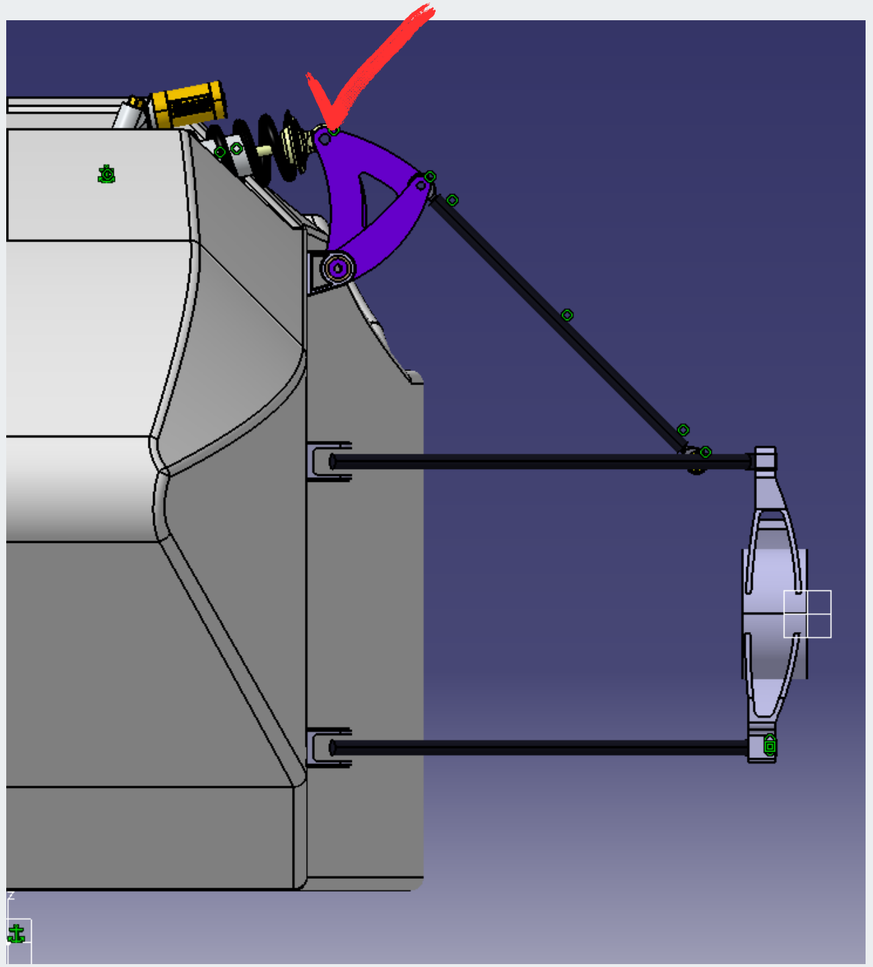
02 **VON MISES STRESS [MPA] : ~184(CNC), ~173(TOPOLOGY)**

0 **MAXIMUM DISPLACEMENT [MM] : 1 MM**

3

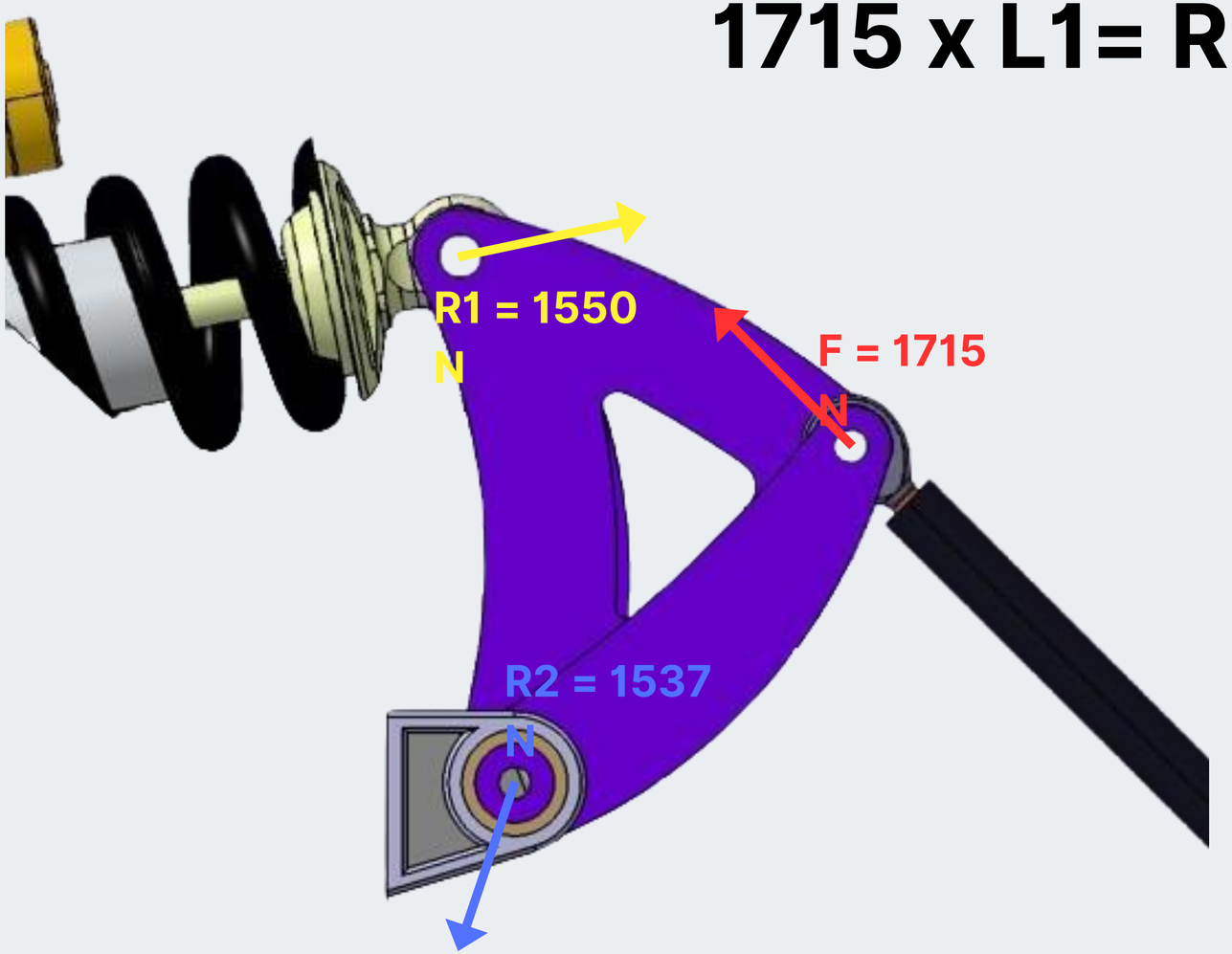
CNC ROCKER ARM MODEL DESIGN

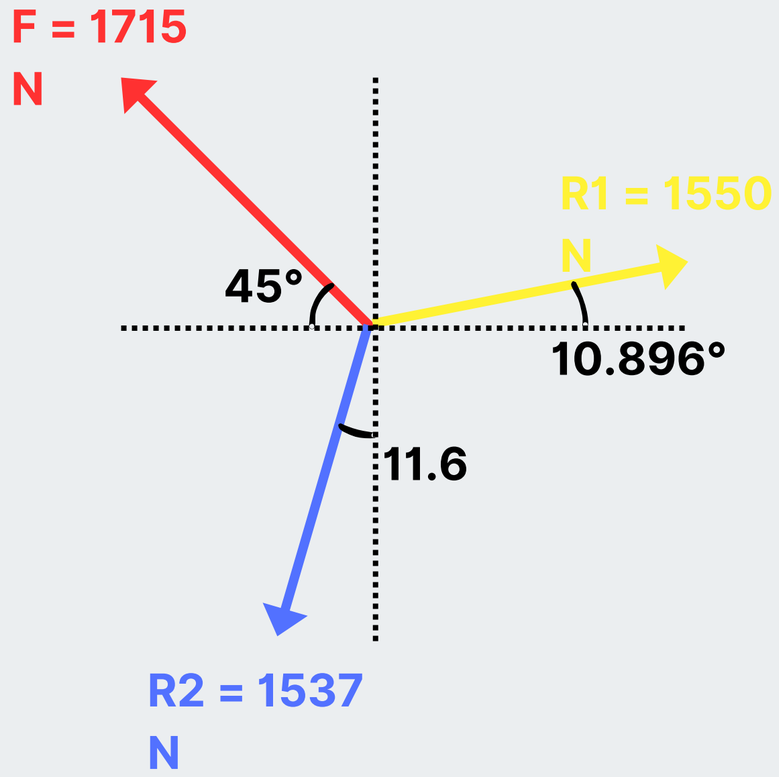




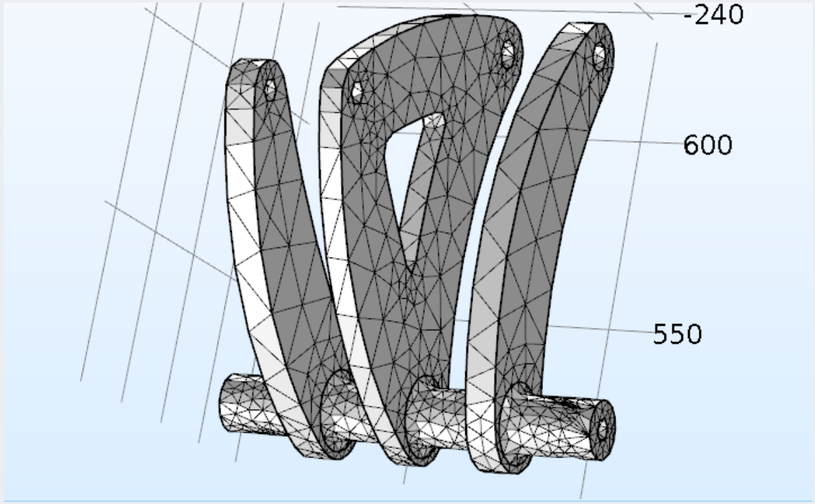
LOAD CALCULATION

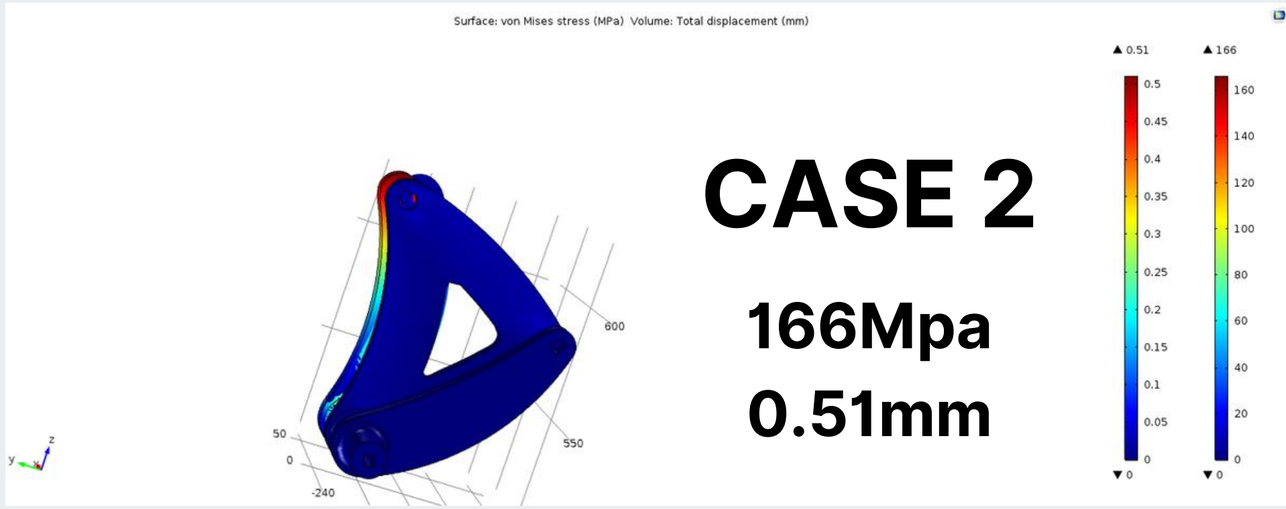
1715 x L1= R1 x L2





LOAD CALCULATION

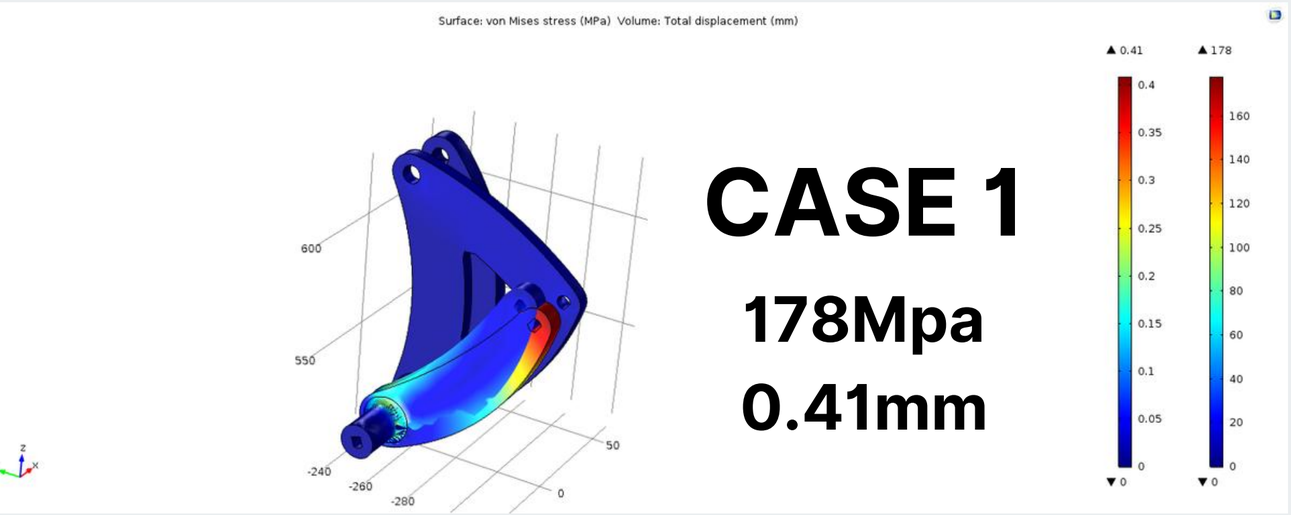




CASE 2

166Mpa

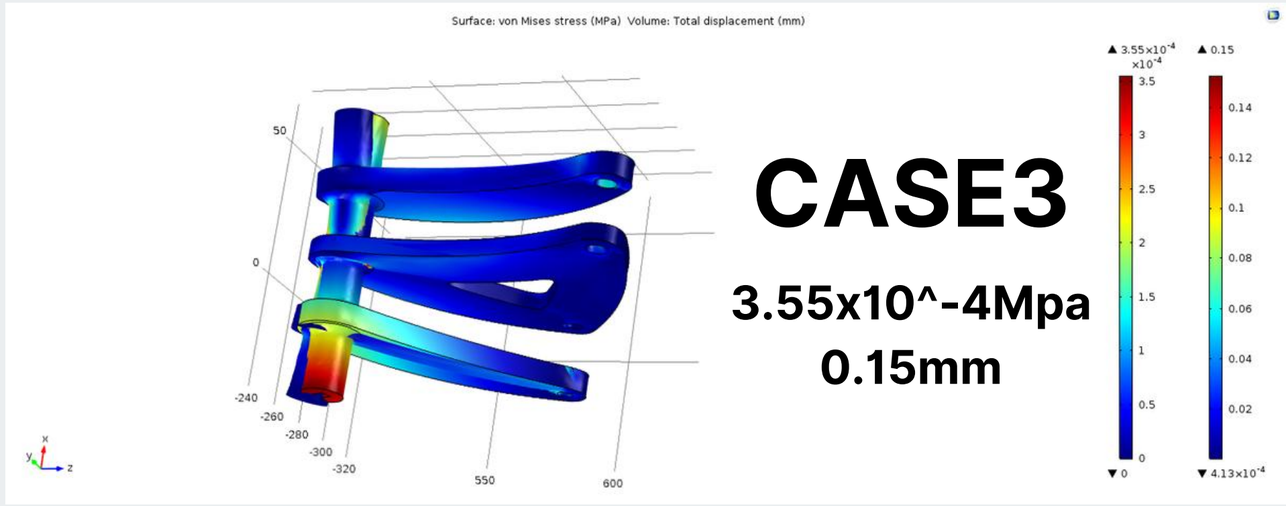
0.51mm



CASE 1

178Mpa

0.41mm

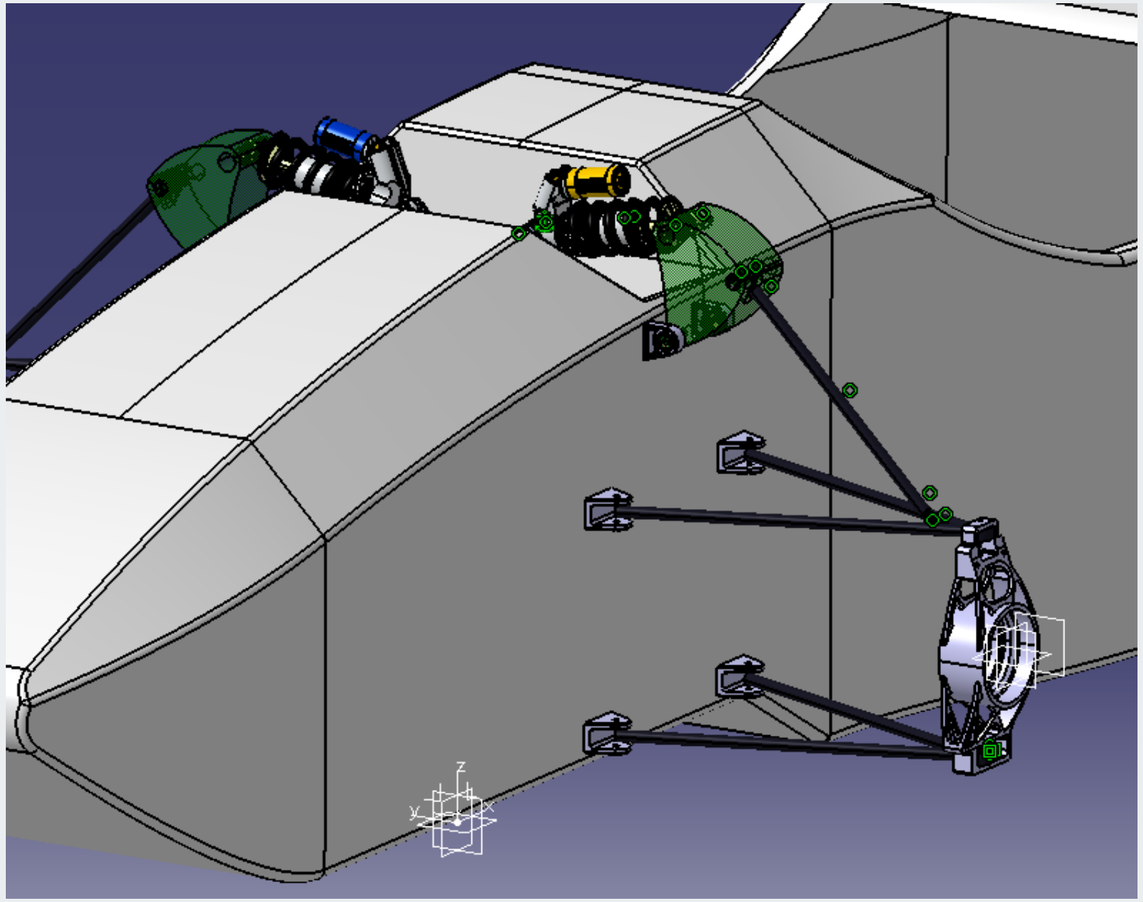


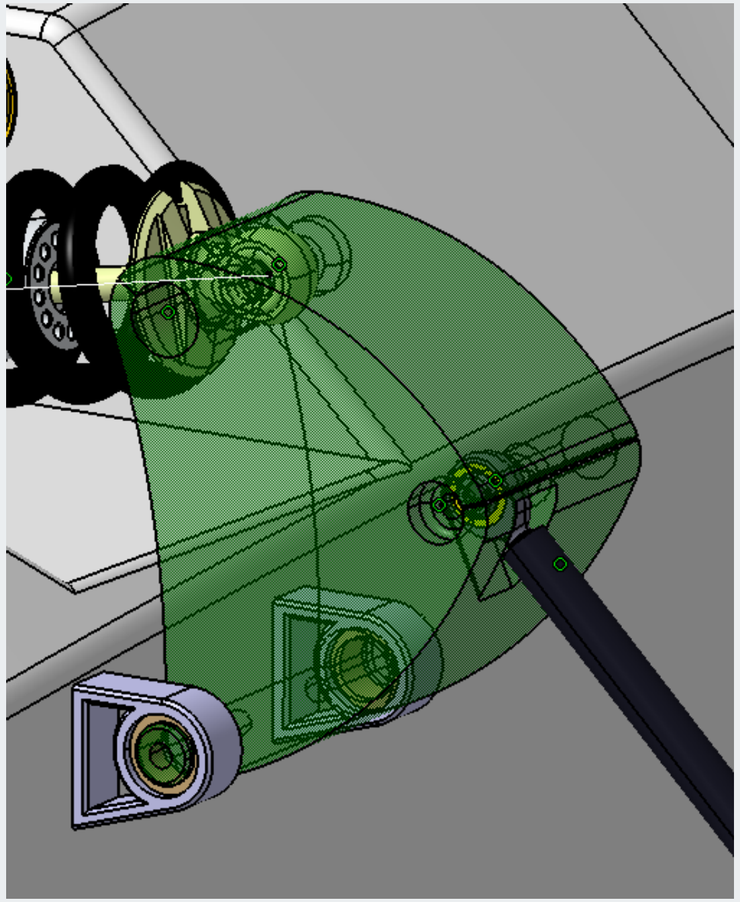
CASE3

3.55x10^-4Mpa

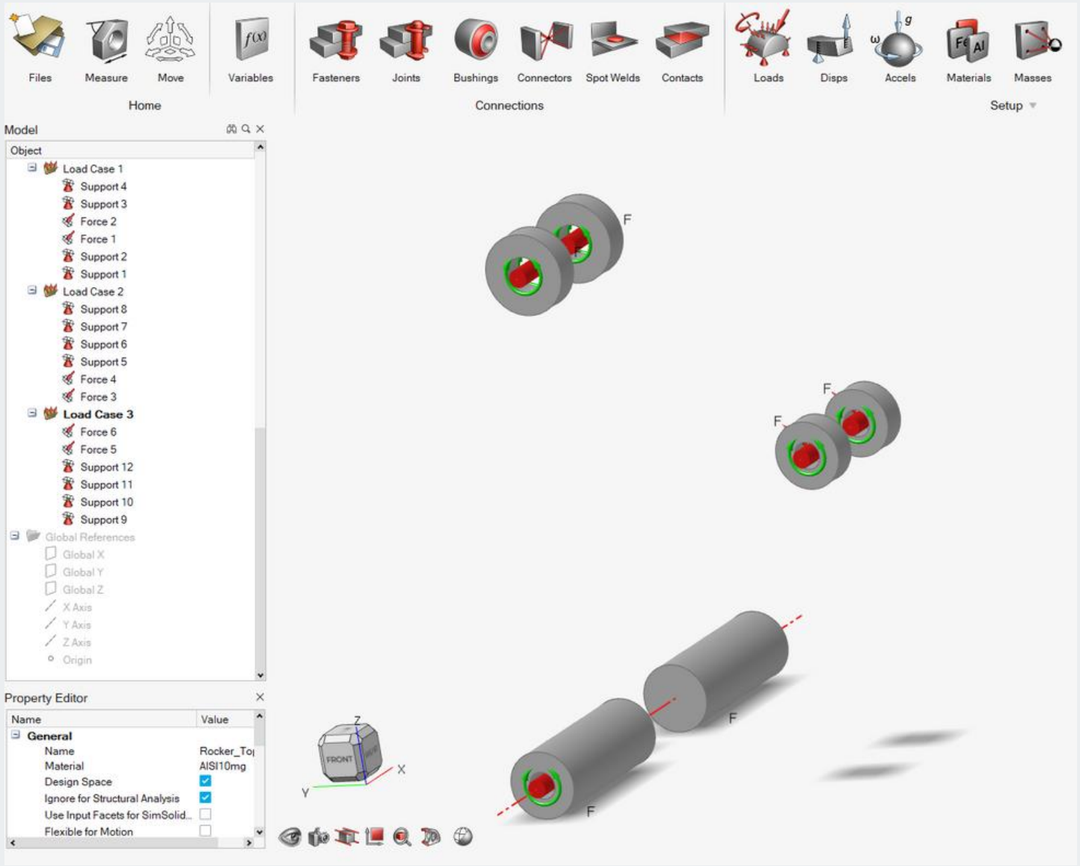
0.15mm

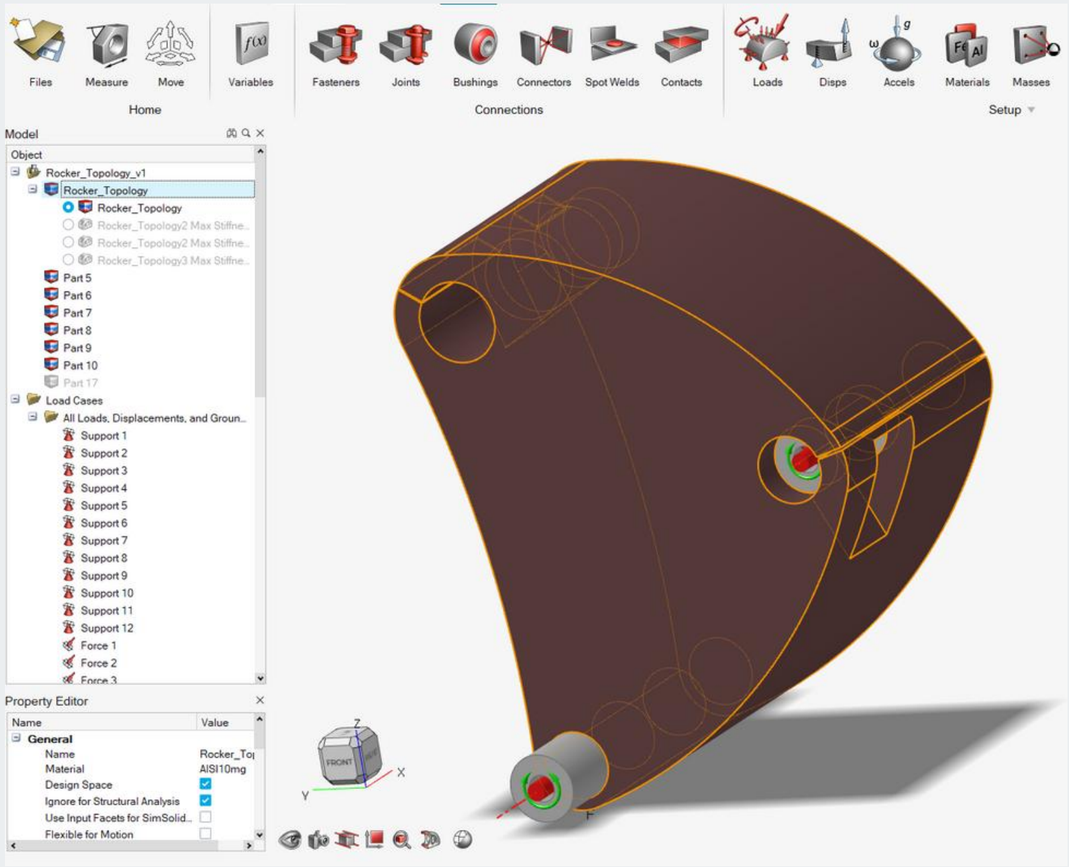
DESIGN SPACE FOR TOPOLOGY





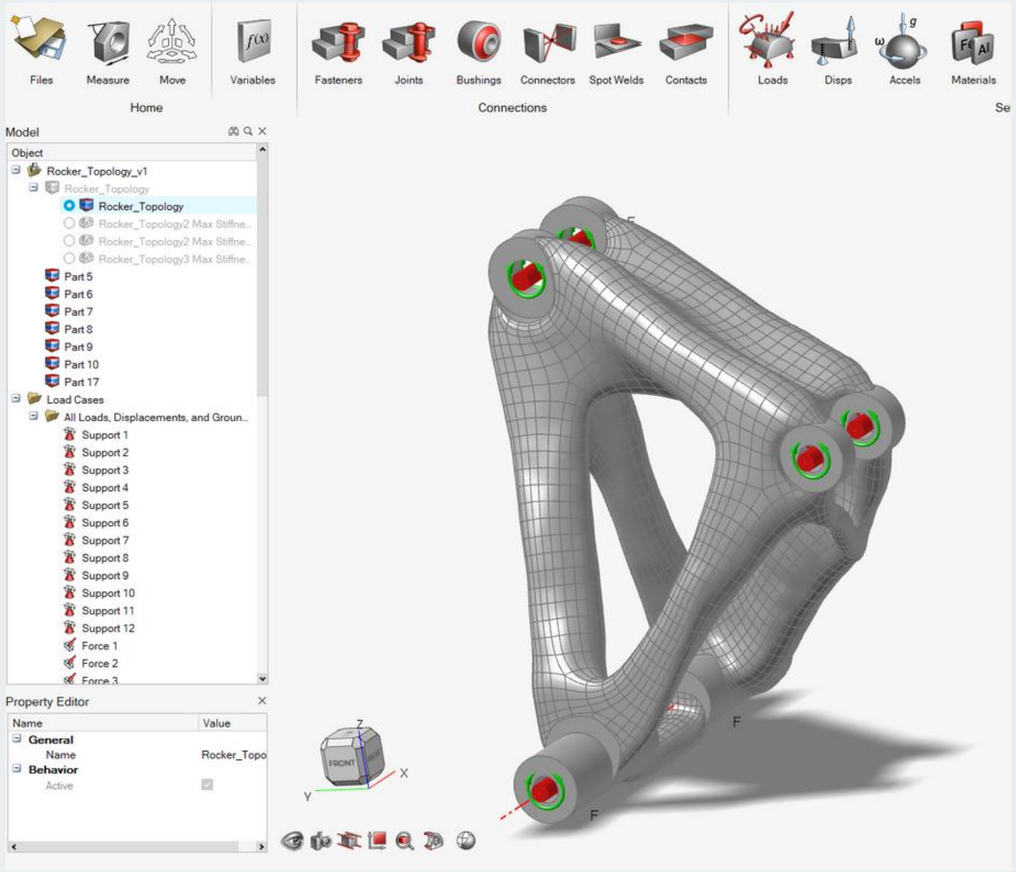
IMPORT TO INSPIRE

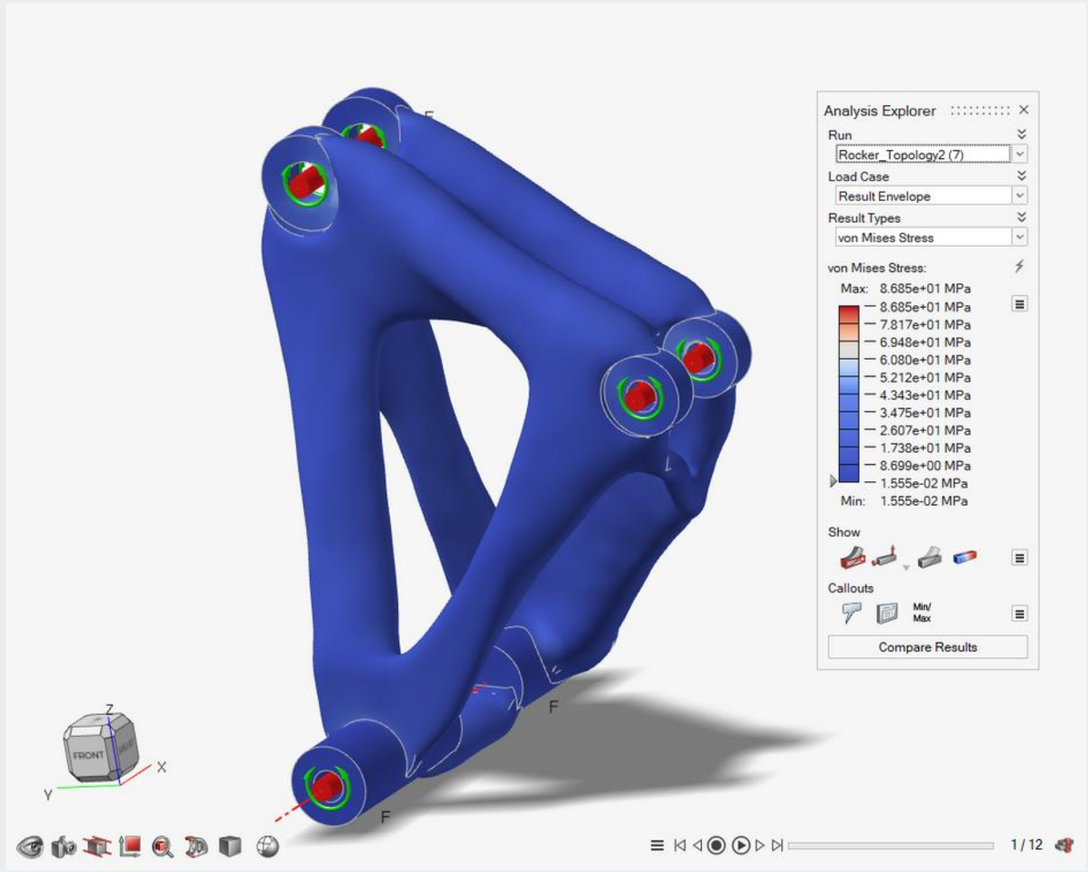




TOTAL DESIGN SPACE MASS : 1466 G

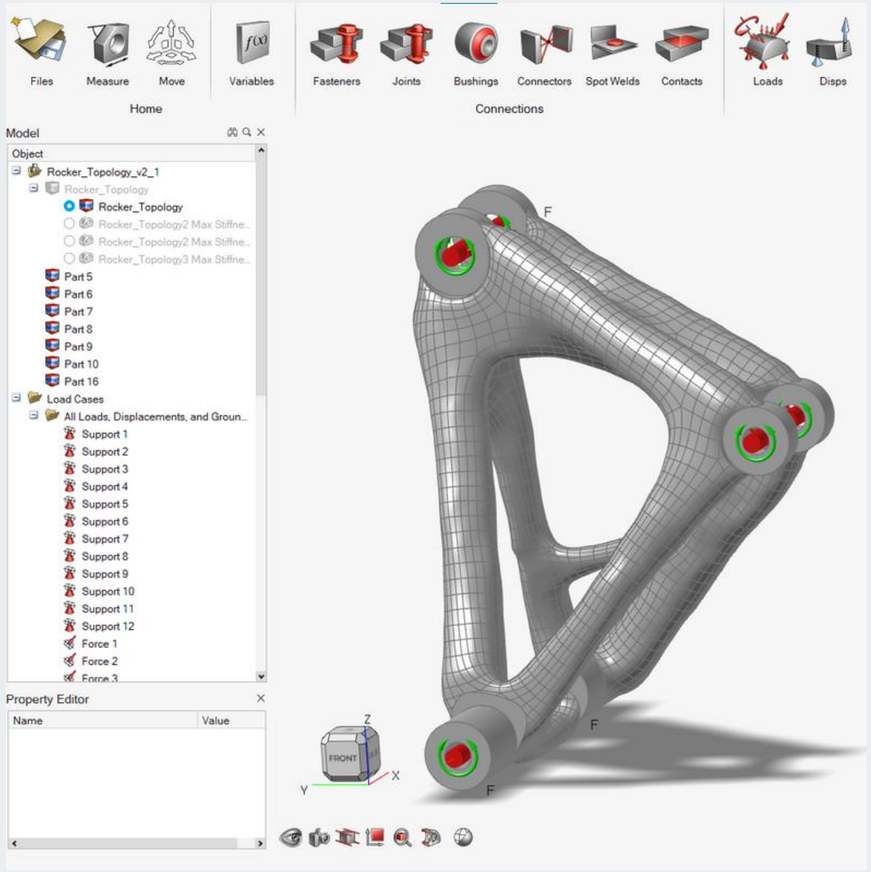
ROCKER
V1

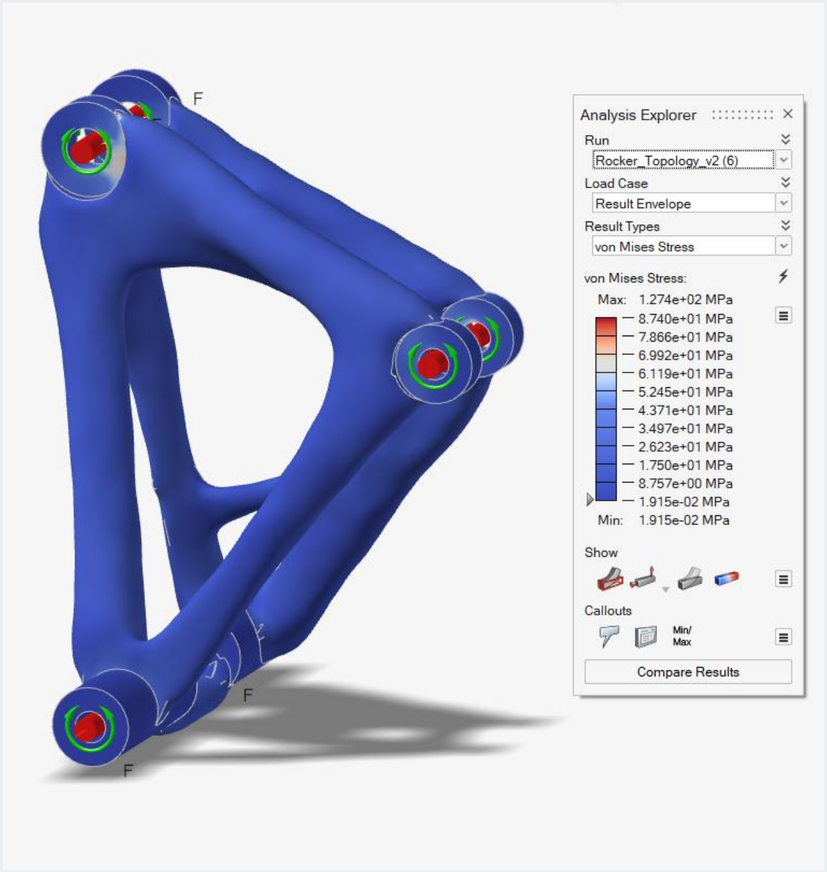


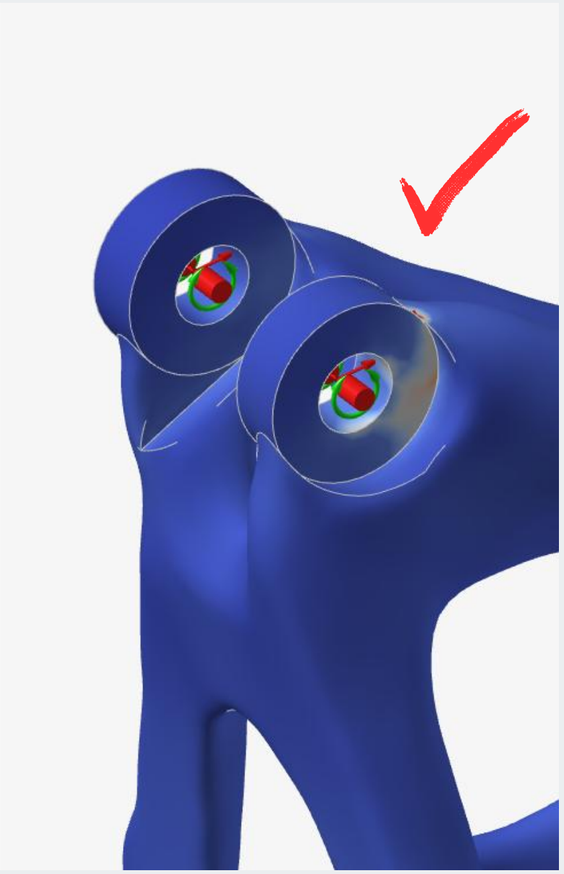


% OF TOTAL DESIGN SPACE VOLUME : 18% (263 G)

ROCKER
V2

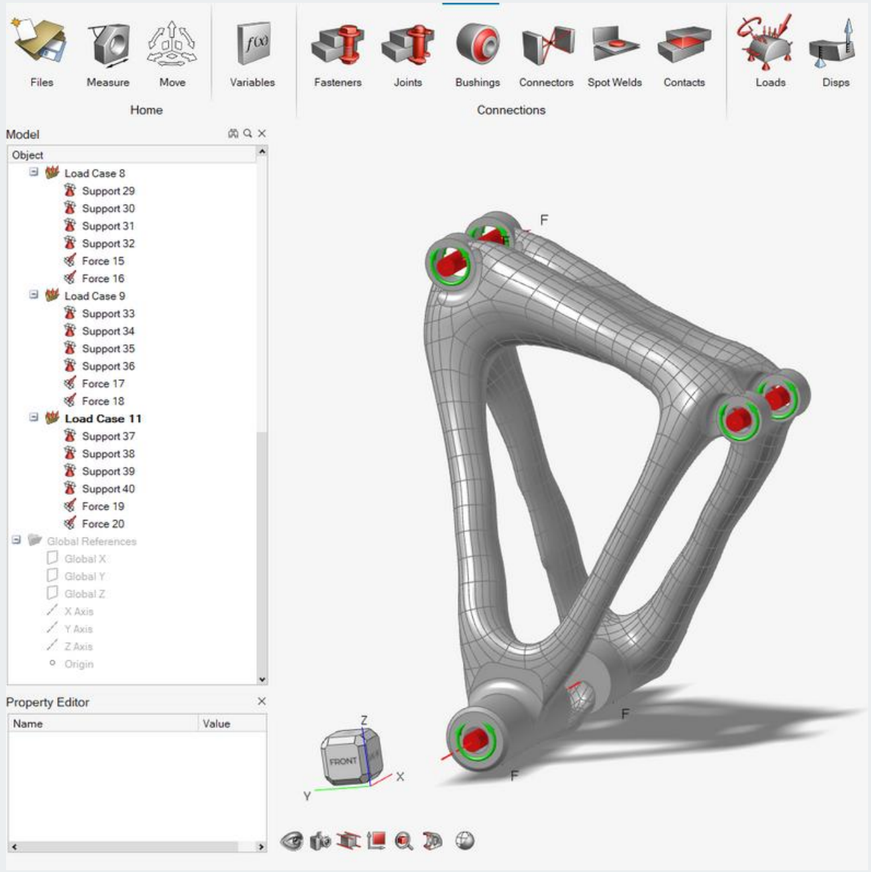


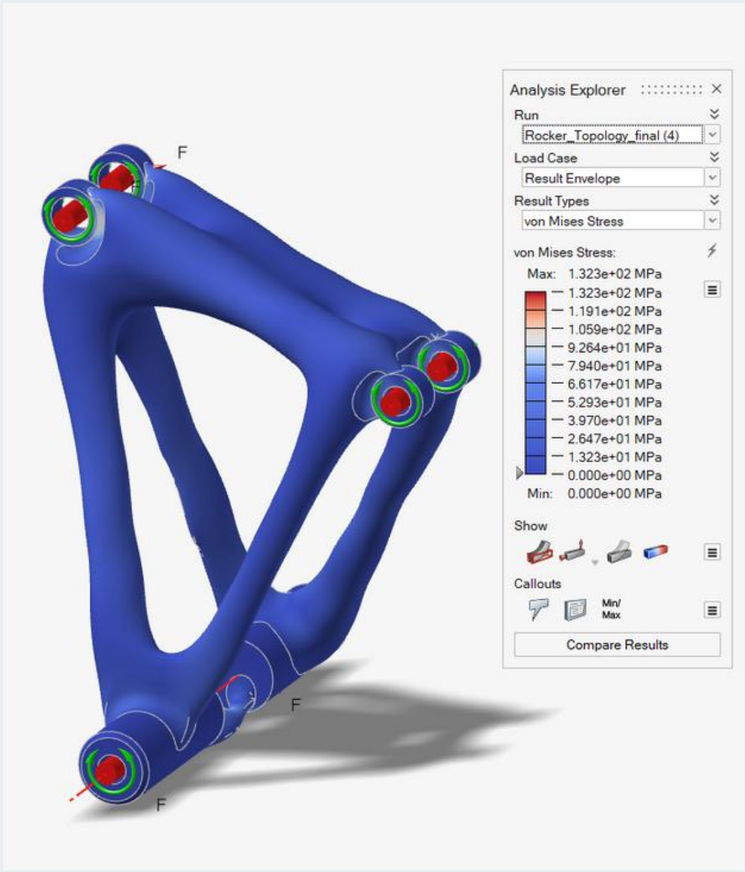


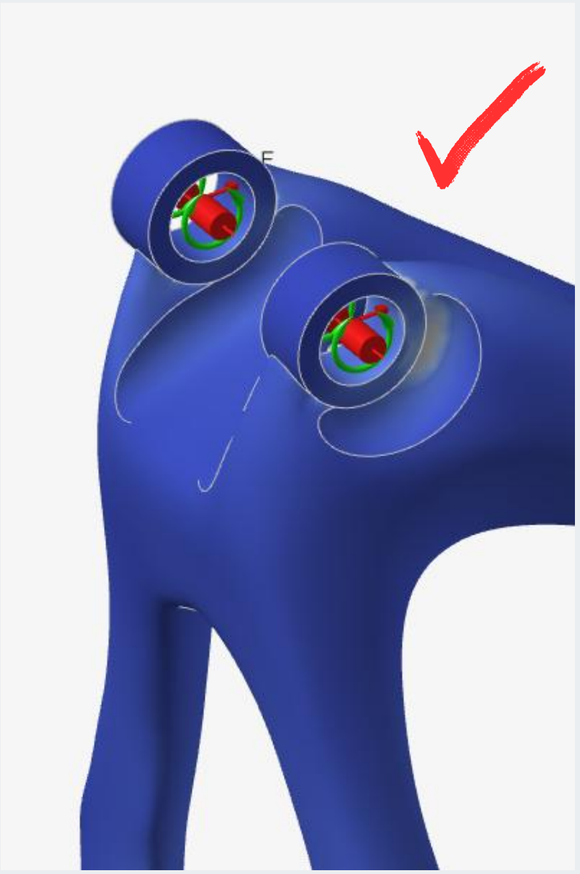


% OF TOTAL DESIGN SPACE VOLUME : 12% (178 G)

ROCKER
FINAL

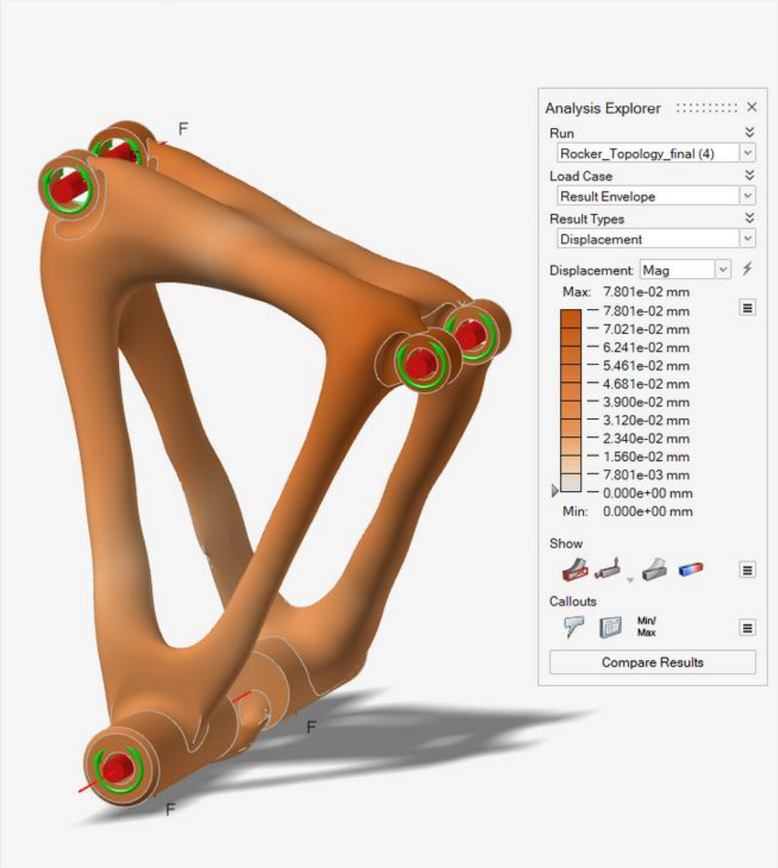




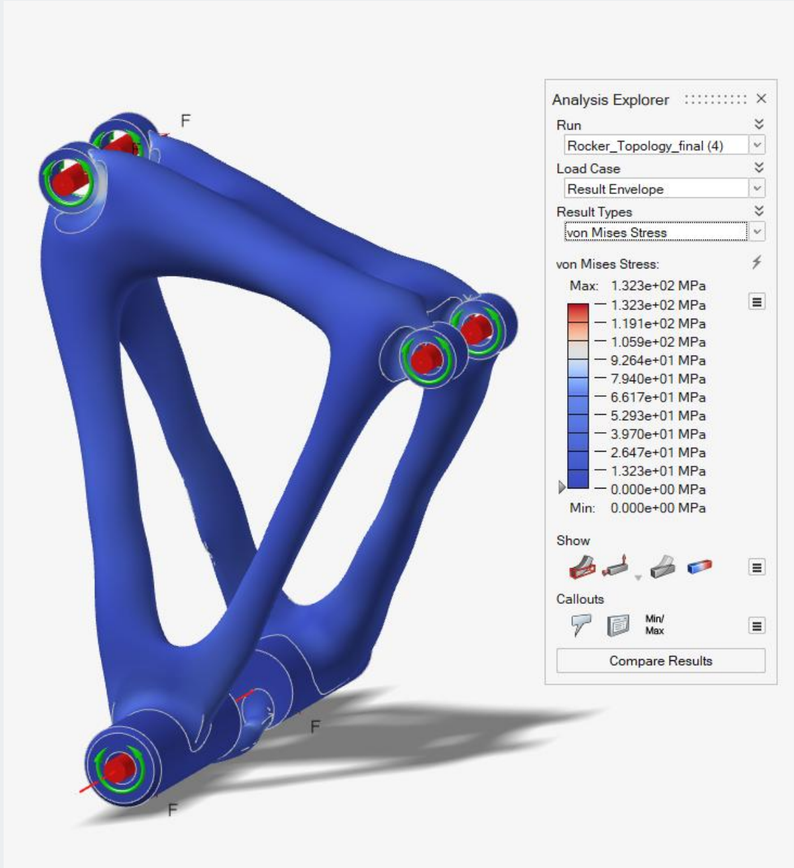


% OF TOTAL DESIGN SPACE VOLUME : 10% (151 G)

ROCKER FINAL

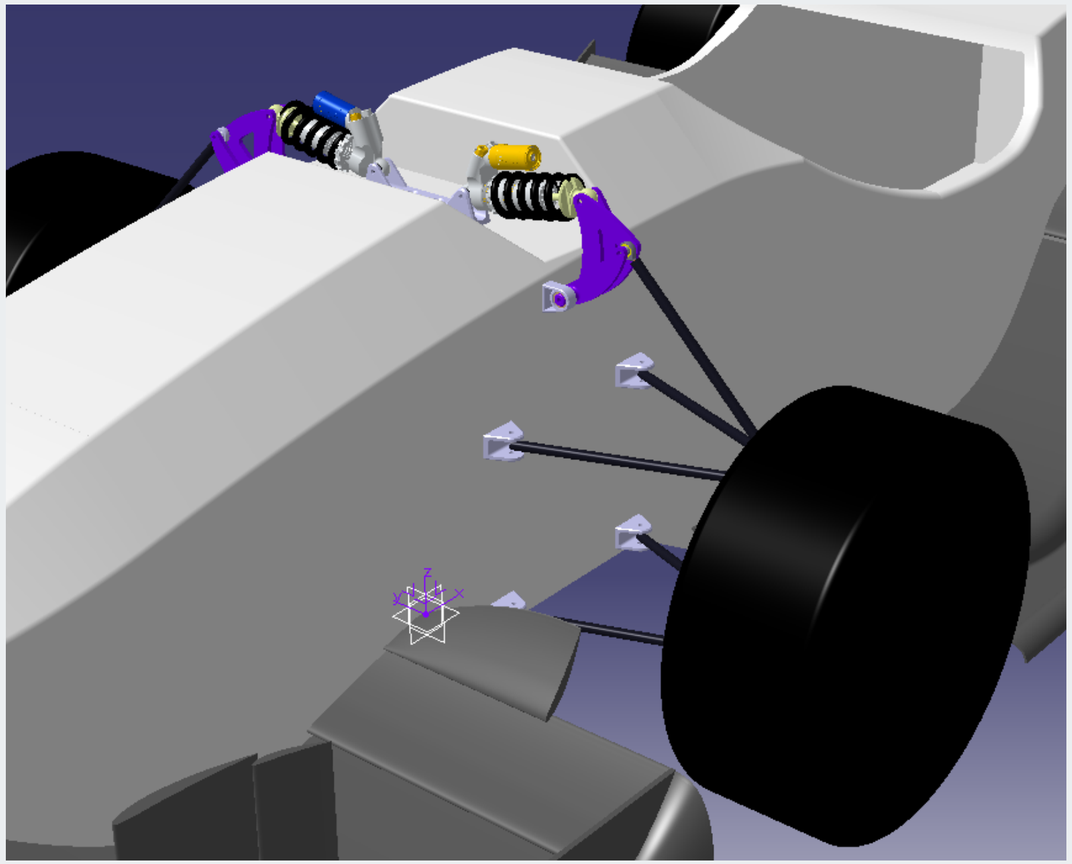


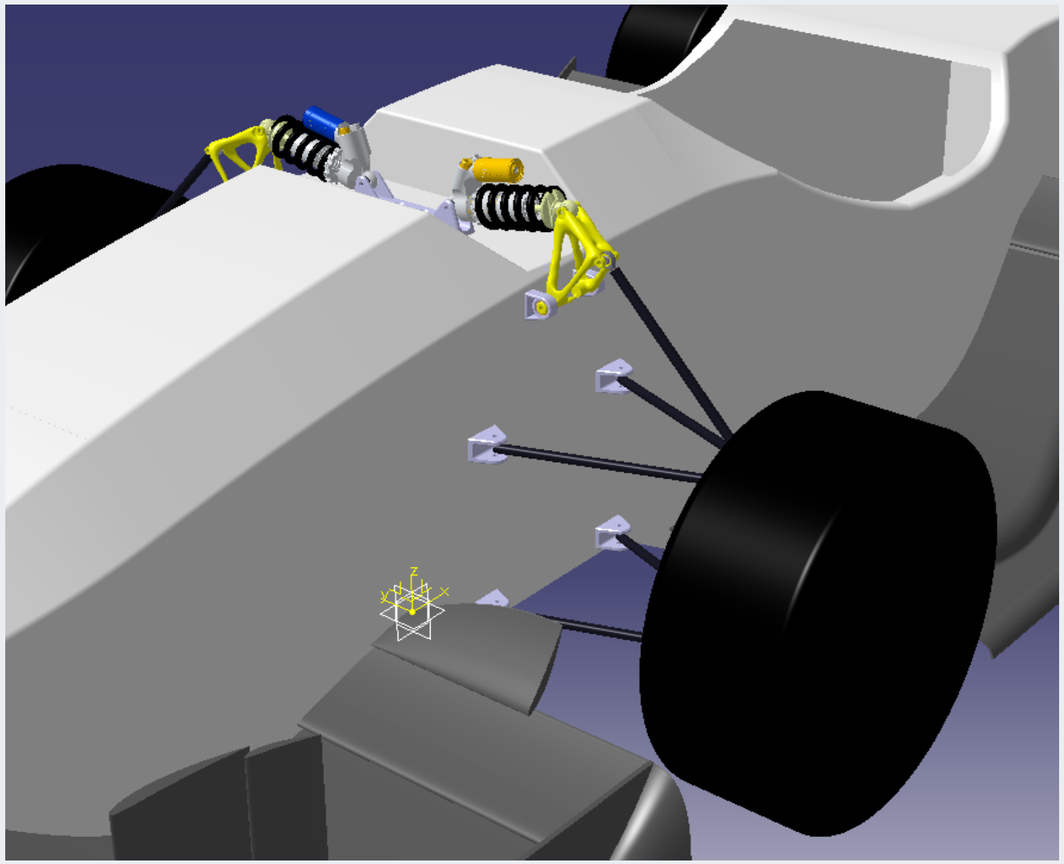
- 0.078 MM

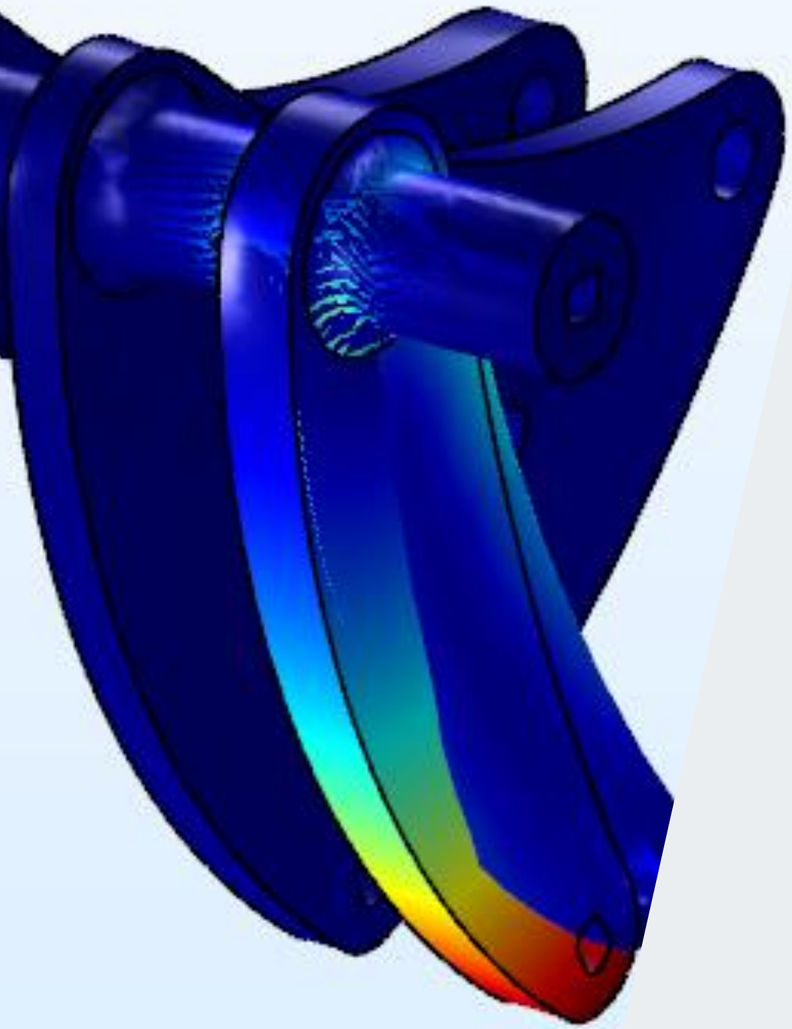


- 132.2 MPA

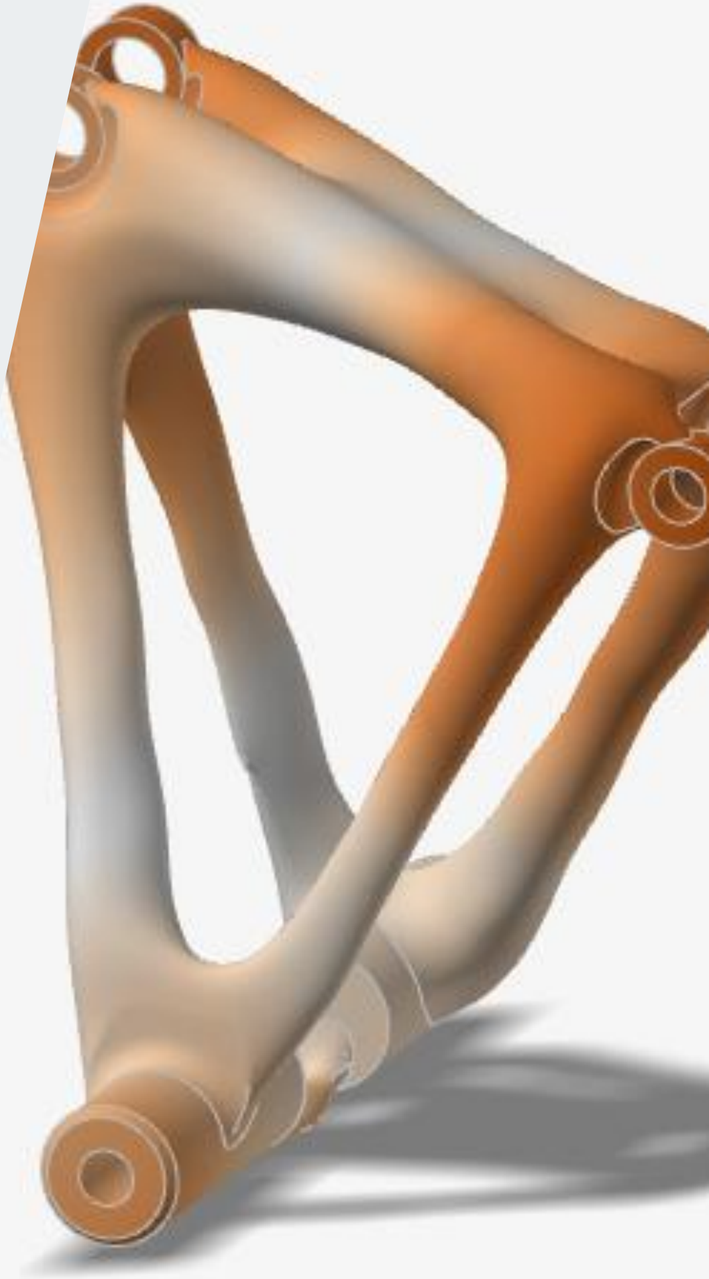
IMPORT TO CAD MODEL







CONCLUSION



COMPARISON

	DESIGN TARGET	CNC MACHINED	TOPOLOGY OPTIMIZATION
VON MISES [MPa]	~184 (CNC) ~173 (Topology)	178	132
SAFTY FACTOR	1.5	1.55	1.97
MAXIMUM DISPLACEMENT [mm]	1	0.51	0.078
WEIGHT [g]		251	187

$$\sigma' = \left(\sigma_A^2 - \sigma_A\sigma_B + \sigma_B^2\right)^{1/2}, \quad n = \frac{S_y}{\sigma'}$$

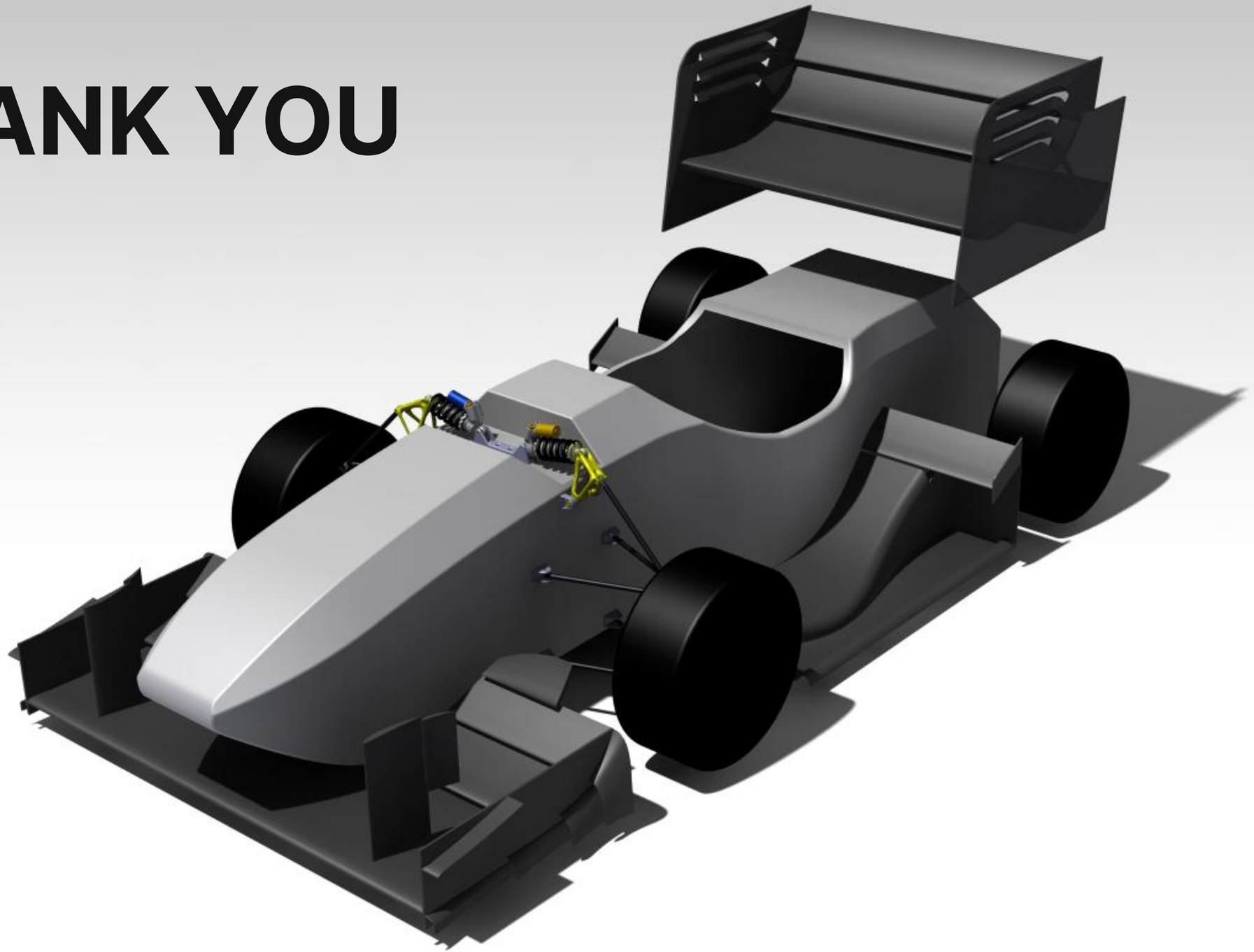
COMPARISON

- HIGHER SAFTY FACTOR
- SATISFYING MAXIMUM DISPLACEMENT CONDITIONS
- 25.5% LIGHTWEIGHT DESIGN

FUTURE IMPROVEMENT

- ADD COMPOSITE VARIABLES (SUCH AS VIBRATION)
- OPTIMIZATION WITH MORE CAE INTERPRETATION (LIGHTWEIGHT)
- LIFECYCLE CALCULATION WITH FATIGUE ANALYSIS

THANK YOU



REFERENCE

- **DESIGN & ANALYSIS OF ROCKER ARM SUSPENSION SYSTEM USED IN FSAE**

  HTTPS://WWW.IJIRSET.COM/UPLOAD/2020/MAY/21_DESIGN_NC.PDF
- **DESIGN AND ANALYSIS OF PUSH ROD ROCKER ARM SUSPENSION USING MONO SPRING**

  HTTPS://WWW.ACADPUBL.EU/JSI/2017-114-7-ICPCIT-2017/ARTICLES/9/41.PDF
- **HTTPS://ISMASUPERS.COM/WP-CONTENT/UPLOADS/2021/11/TECH-01-MOTION-RATIOS-4.PDF**