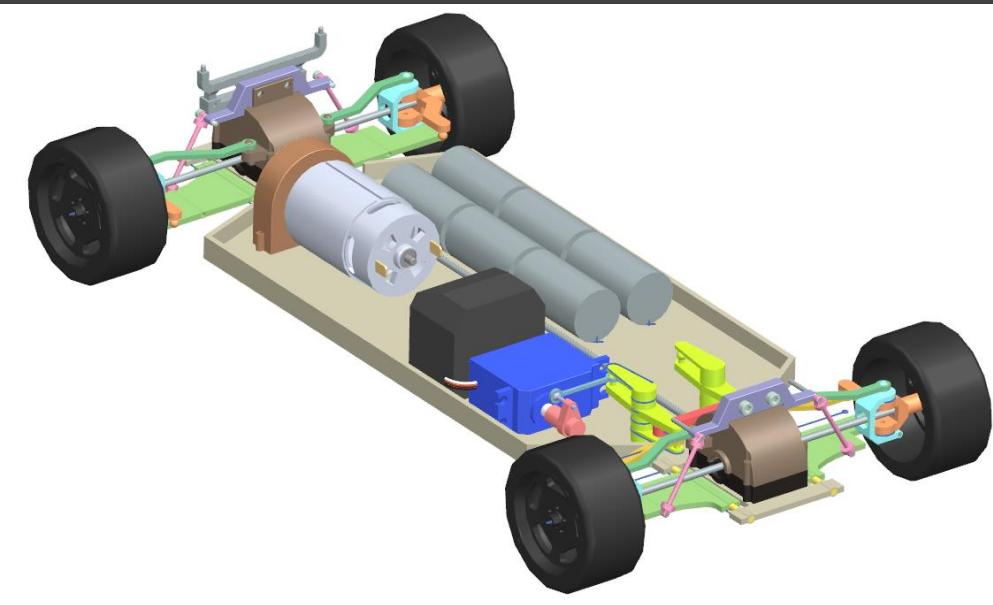


A red 1933 Ford Model T hot rod with a custom front end and large rear fenders, parked in a dark garage.

'33 HOT ROD FINAL DESIGN

Fast and Furious: Cael Fitch, Hailey Fitzsimmons,
Aditya Pimplikar, Thomas Tilford

1. Modeling and Parametrics

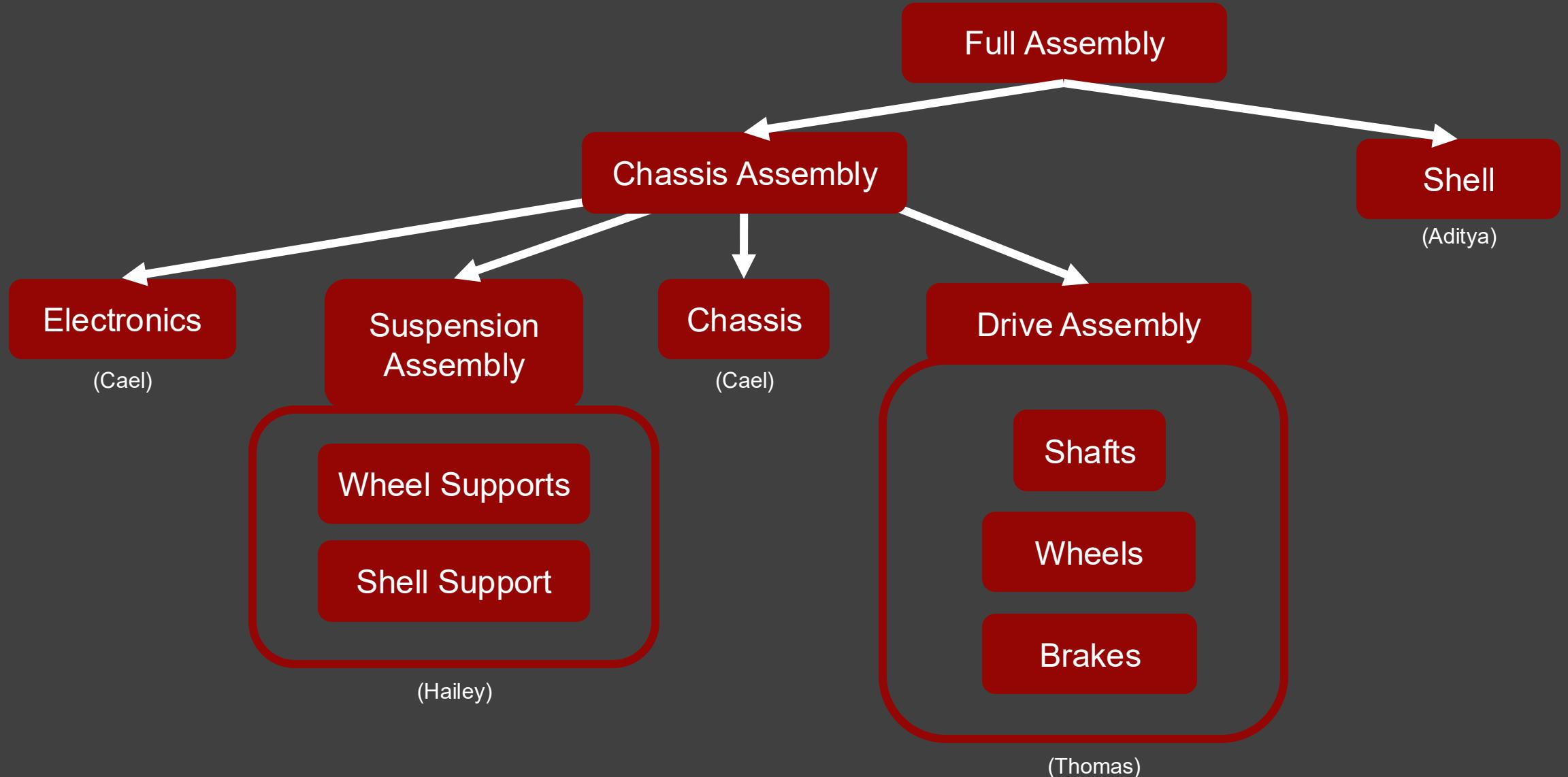


DATA EXCHANGE + COLLABORATION

- Communication through text message
- Semi-weekly meetings
- Individual work out of class
- Files shared through OneDrive
- Team alerted when file pulled out for editing

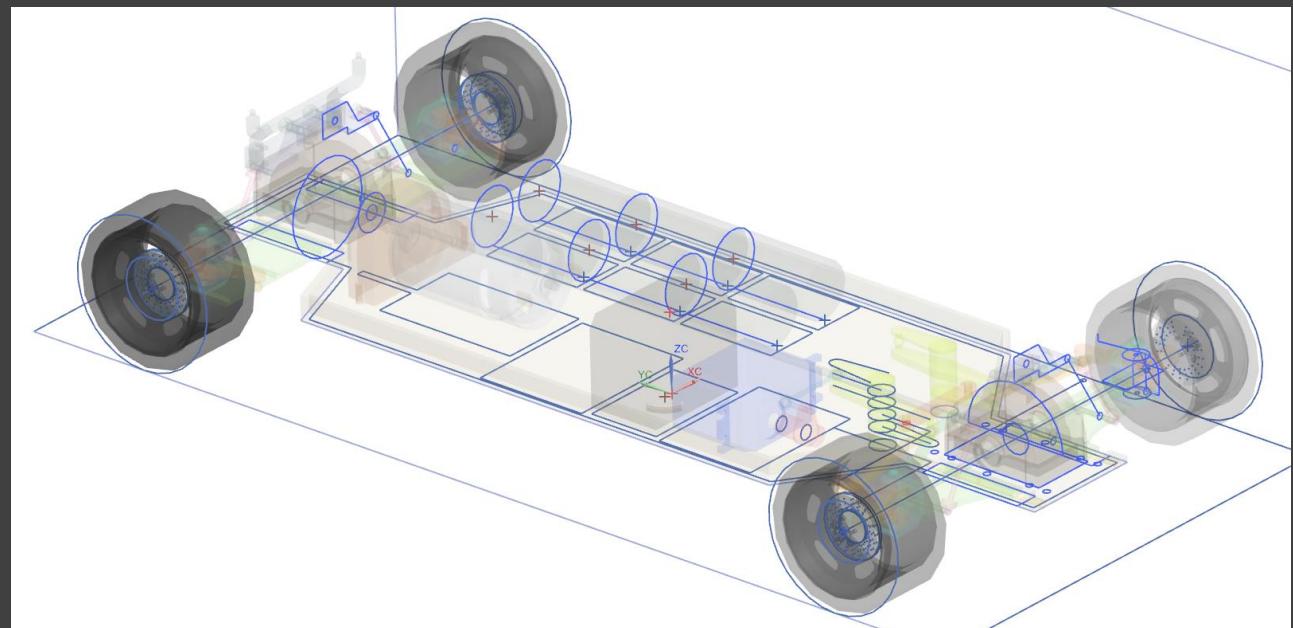
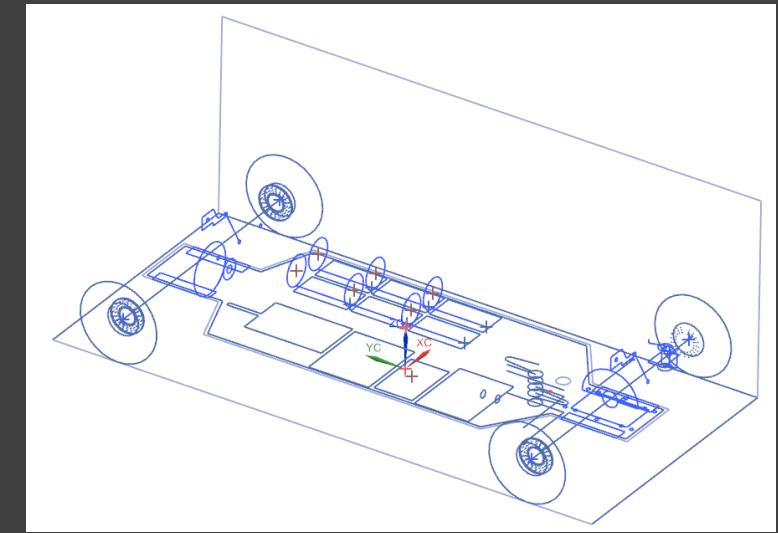
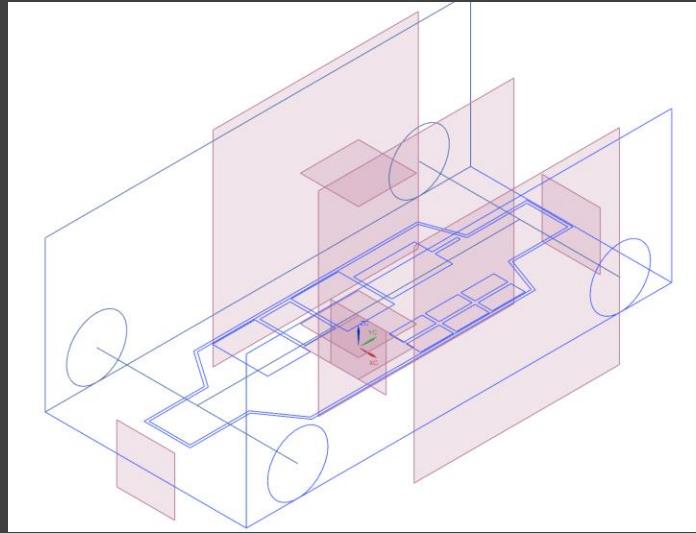
Name	Modified	Modified By	File size	Sharing
Non CAD Files lol	Yesterday at 10:...	Fitzsimmons, Hailey	4 items	Shared
Outdated Parts	5 days ago	Fitzsimmons, Hailey	2 items	Shared
Chassis.prt	Yesterday at 12:...	Tilford, Thomas Ale	385 KB	Shared
Hailey Surface.prt	5 days ago	Fitzsimmons, Hailey	68.1 KB	Shared
HMF Surface.prt	Yesterday at 12:...	Fitzsimmons, Hailey	254 KB	Shared
Main Assembly.prt	Yesterday at 12:...	Tilford, Thomas Ale	291 KB	Shared
starcad.log	Yesterday at 10:...	Fitzsimmons, Hailey	398 bytes	Shared
Titan 550 Motor.STEP	6 days ago	Fitch, Cael Patrick	446 KB	Shared
Traxxas Summit-Radio Gear-Servos-Micro ...	6 days ago	Fitch, Cael Patrick	1.54 MB	Shared
Traxxas XL-5.SLDPRT	July 24, 2011	Fitch, Cael Patrick	906 KB	Shared
Wheels.prt	Yesterday at 12:...	Tilford, Thomas Ale	445 KB	Shared

ASSEMBLY ORGANIZATION



ASSEMBLY SKELETON

- Skeleton geometry for sketches
 - Body bounds
 - Wheel locations/axes
 - Midplanes
 - Chassis
 - Axles
 - Electronics
- Points/curves added to define key points on the shell



PARAMETRICS

- Core Parameters:
 - Car Height (Z)
 - Car Width (X)
 - Car Length (Y)
 - Height of the Ground
 - Wheel Distance Apart
- All skeleton and sub-assembly dimensions related to core parameters
- Sketches also aligned to skeleton geometry

User Expressions	
= BumperLength=0.05*Length	✓
= ChassisHeight=10	✓
= ChassisThickness=2.5	✓
= Height=150	✓
= HeightOffGround=20	✓
= Length=423	✓
= MotorAxeHeight=38/2	✓
= RimDiameter=TireDiameter*76/80	✓
= TireDiameter=(ChassisHeight+HeightOffGround)*2	✓
= TireDistance=Length-TireDiameter-2*BumperLength	✓
= TireWidth=Width/5.5	✓
= Width=200	✓

1	Name	Formula	Value	Units	Dimensionality	Type	Source	Status	Comment	Alert	Checks	Group	Link
1	Default Group			mm	Length	Number						Default Group	
2	p0	width	200	mm	Length	Number	(SKETCH_000-Pr...)	✓				Default Group	
3	p3	chassish... 10	10	mm	Length	Number	(SKETCH_001He...)	✓				Default Group	
4	p5	chasswall 25	25	mm	Length	Number	(SKETCH_002Sk...)	✓				Default Group	
5	p10	Distance... 30	30	mm	Length	Number	(SKETCH_003Sk...)	✓				Default Group	
6	p11	doorwall 20	20	mm	Length	Number	(SKETCH_004Sk...)	✓				Default Group	
7	p12	front_width (Interpart)	200	mm	Length	Number	"Wheels":front_...	?				Default Group	
8	p13	length 500*y_variable	500	mm	Length	Number	(SKETCH_005-Pr...)	✓				Default Group	
9	p14	width 200	200	mm	Length	Number	(SKETCH_006-Pr...)	✓				Default Group	
10	p15	roofheight 152.8539823	152.8539823	mm	Length	Number	(SKETCH_007-Pr...)	✓				Default Group	
11	p16	tre_diameter*y_scale 80	80	mm	Length	Number	(SKETCH_008-Pr...)	✓				Default Group	
12	p17	tre_diameter*y_scale 80	80	mm	Length	Number	(SKETCH_009-Pr...)	✓				Default Group	
13	p18	length*y_scale 500	500	mm	Length	Number	(SKETCH_010-Pr...)	✓				Default Group	
14	p19	wheel_center2center*y_scale 371.25	371.25	mm	Length	Number	(SKETCH_011-Pr...)	✓				Default Group	
15	p20	TiptoFrontWheel*y_scale 50	50	mm	Length	Number	(SKETCH_012-Pr...)	✓				Default Group	
16	p21	(tre_diameter/2)*z_scale 40	40	mm	Length	Number	(SKETCH_013-Pr...)	✓				Default Group	
17	p22	(tre_diameter/2)*z_scale 40	40	mm	Length	Number	(SKETCH_014-Pr...)	✓				Default Group	
18	p23	DistanceOffTheGround 30	30	mm	Length	Number	(Height off groun...	?				Default Group	
19	p24	chassish... 25	25	mm	Length	Number	(Chassis Wall[0])	?				Default Group	
20	p25	doorwall 20	20	mm	Length	Number	(Door Wall[10] D...	?				Default Group	
21	p26	doorwall 20	20	mm	Length	Number	(Datum Plane[11])	?				Default Group	
22	p27	chassish... 25	25	mm	Length	Number	(Datum Plane[12])	?				Default Group	
23	p28	roofheight*77*z_scale 106.9977876	106.9977876	mm	Length	Number	(SKETCH_003-Sk...)	✓				Default Group	
24	p29	roofheight*77*z_scale 106.9977876	106.9977876	mm	Length	Number	(SKETCH_003-Sk...)	✓				Default Group	
25	p30	length*.45*y_scale 225	225	mm	Length	Number	(SKETCH_003-Sk...)	✓				Default Group	
26	p31	length*.77*y_scale 350	350	mm	Length	Number	(SKETCH_003-Sk...)	✓				Default Group	
27	p32	rear_width 200*y_variable 200	200	mm	Length	Number	(SKETCH_003-Sk...)	✓				Default Group	
28	p33	roofheight 152.85398230085*y_variable 152.8539823	152.8539823	mm	Length	Number	(SKETCH_003-Sk...)	✓				Default Group	
29	p34	TiptoFront... 50	50	mm	Length	Number	(SKETCH_004-Pr...)	✓				Default Group	
30	p35	tire_diam... (chassisheight+DistanceOffTheGround)*80 80	80	mm	Length	Number	(SKETCH_005-Pr...)	✓				Default Group	
31	p36	wheel_cen... (length-TiptoFrontWheel)*.825 371.25	371.25	mm	Length	Number	(SKETCH_006-Pr...)	✓				Default Group	
32	p37	wheel_da... tre_diameter-4 76	76	mm	Length	Number	(SKETCH_007-Pr...)	✓				Default Group	
33	p38	wheel_width 25	25	mm	Length	Number	(SKETCH_008-Pr...)	✓				Default Group	
34	p39	width 200*x_variable 200	200	mm	Length	Number	(SKETCH_009-Pr...)	✓				Default Group	
35	p40	x_scale 1	1	mm	Length	Number	(SKETCH_010-Pr...)	✓				Default Group	
36	p41	x_variable (Interpart) 1	1	mm	Length	Number	"Tophat_Surface..."	?				Default Group	
37	p42	y_scale 1	1	mm	Length	Number	(SKETCH_011-Pr...)	✓				Default Group	
38	p43	y_variable (Interpart) 1	1	mm	Length	Number	"Tophat_Surface..."	?				Default Group	
39	p44	z_scale 1	1	mm	Length	Number	(SKETCH_012-Pr...)	✓				Default Group	
40	p45	z_variable (Interpart) 1	1	mm	Length	Number	"Tophat_Surface..."	?				Default Group	

1	Name	Formula	Value	Units	Dimensionality	Type	Source	Status	Comment	Alert	Checks	Group	Link
9	p0	width	200	mm	Length	Number	(SKETCH_000-Pr...)	✓				Default Group	
10	p3	roofheight	152.8539823	mm	Length	Number	(SKETCH_001He...)	✓				Default Group	
11	p4	tre_diameter*y_scale	80	mm	Length	Number	(SKETCH_002Sk...)	✓				Default Group	
12	p6	tre_diameter*y_scale	80	mm	Length	Number	(SKETCH_003Sk...)	✓				Default Group	
13	p10	length*y_scale	500	mm	Length	Number	(SKETCH_004-Pr...)	✓				Default Group	
14	p11	wheel_center2center*y_scale	371.25	mm	Length	Number	(SKETCH_005-Pr...)	✓				Default Group	
15	p12	TiptoFrontWheel*y_scale	50	mm	Length	Number	(SKETCH_006-Pr...)	✓				Default Group	
16	p13	(tre_diameter/2)*z_scale	40	mm	Length	Number	(SKETCH_007-Pr...)	✓				Default Group	
17	p14	(tre_diameter/2)*z_scale	40	mm	Length	Number	(SKETCH_008-Pr...)	✓				Default Group	
18	p20	DistanceOffTheGround	30	mm	Length	Number	(Height off groun...	?				Default Group	
19	p25	chassish... 25	25	mm	Length	Number	(Chassis Wall[0])	?				Default Group	
20	p30	doorwall 20	20	mm	Length	Number	(Door Wall[10] D...	?				Default Group	
21	p35	doorwall 20	20	mm	Length	Number	(Datum Plane[11])	?				Default Group	
22	p41	chassish... 25	25	mm	Length	Number	(Datum Plane[12])	?				Default Group	
23	p42	roofheight*77*z_scale	106.9977876	mm	Length	Number	(SKETCH_003-Sk...)	✓				Default Group	
24	p45	roofheight*77*z_scale	106.9977876	mm	Length	Number	(SKETCH_003-Sk...)	✓				Default Group	
25	p46	length*.45*y_scale	225	mm	Length	Number	(SKETCH_003-Sk...)	✓				Default Group	
26	p47	length*.77*y_scale	350	mm	Length	Number	(SKETCH_003-Sk...)	✓				Default Group	
27	p48	rear_width 200*x_variable	200	mm	Length	Number	(SKETCH_003-Sk...)	✓				Default Group	
28	p49	roofheight 152.85398230085*y_variable	152.8539823	mm	Length	Number	(SKETCH_003-Sk...)	✓				Default Group	
29	p50	TiptoFront... 50	50	mm	Length	Number	(SKETCH_004-Pr...)	✓				Default Group	
30	p51	tire_diam... (chassisheight+DistanceOffTheGround)*80 80	80	mm	Length	Number	(SKETCH_005-Pr...)	✓				Default Group	
31	p52	wheel_cen... (length-TiptoFrontWheel)*.825 371.25	371.25	mm	Length	Number	(SKETCH_006-Pr...)	✓				Default Group	
32	p53	wheel_da... tre_diameter-4 76	76	mm	Length	Number	(SKETCH_007-Pr...)	✓				Default Group	
33	p54	wheel_width 25	25	mm	Length	Number	(SKETCH_008-Pr...)	✓				Default Group	
34	p55	width 200*x_variable	200	mm	Length	Number	(SKETCH_009-Pr...)	✓				Default Group	
35	p56	x_scale 1	1	mm	Length	Number	(SKETCH_010-Pr...)	✓				Default Group	
36	p57	x_variable (Interpart) 1	1	mm	Length	Number	"Tophat_Surface..."	?				Default Group	
37	p58	y_scale 1	1	mm	Length	Number	(SKETCH_011-Pr...)	✓				Default Group	
38	p59	z_scale (Interpart) 1	1	mm	Length	Number	"Tophat_Surface..."	?				Default Group	
39	p60	z_variable (Interpart) 1	1	mm	Length	Number	"Tophat_Surface..."	?				Default Group	

PARAMETRICS – SCENARIOS

Original

Thinner Track

(Width Scale)

Low Clearance Bridge

(Height Scale)

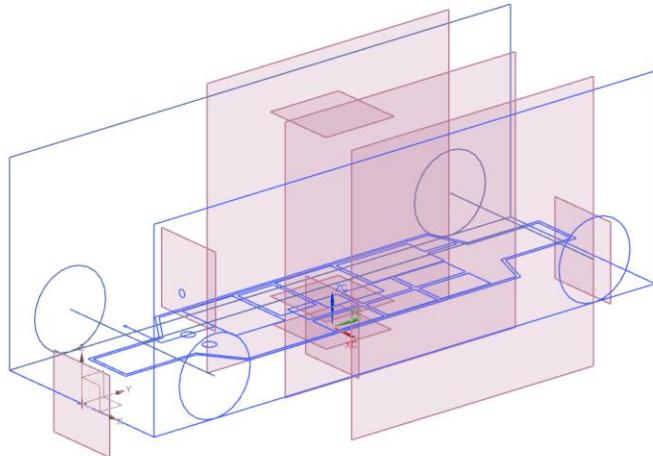
Small Parking Spot

(Length Scale)

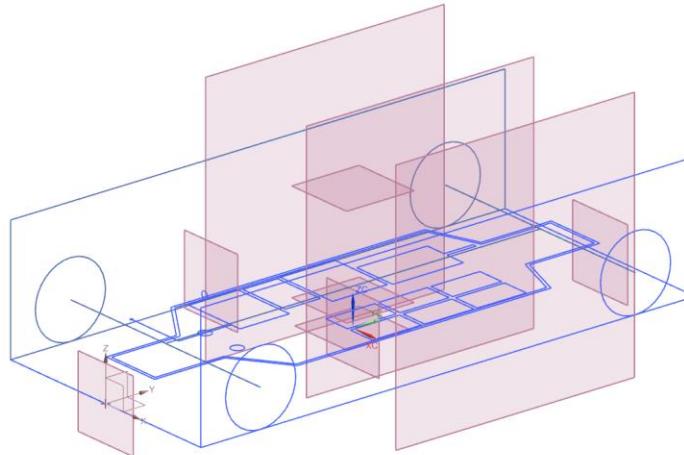
Default parametrics are the minimum bounds to still fit “hardcoded” components like electronics.

PARAMETRICS - SKELETON

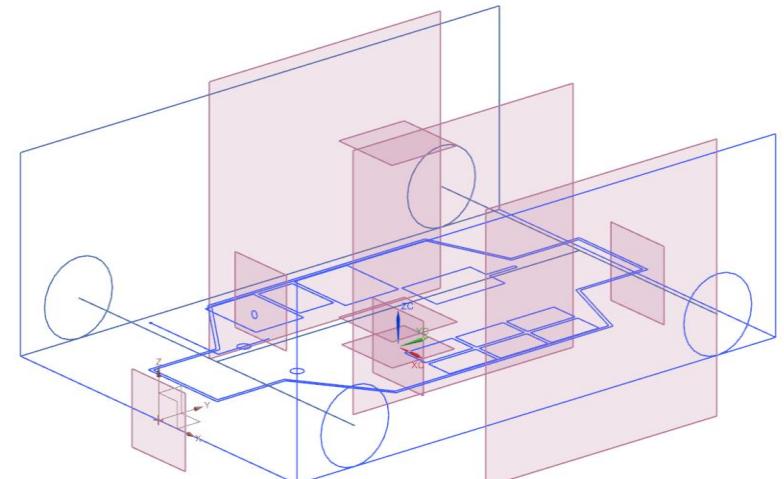
Thinner Track



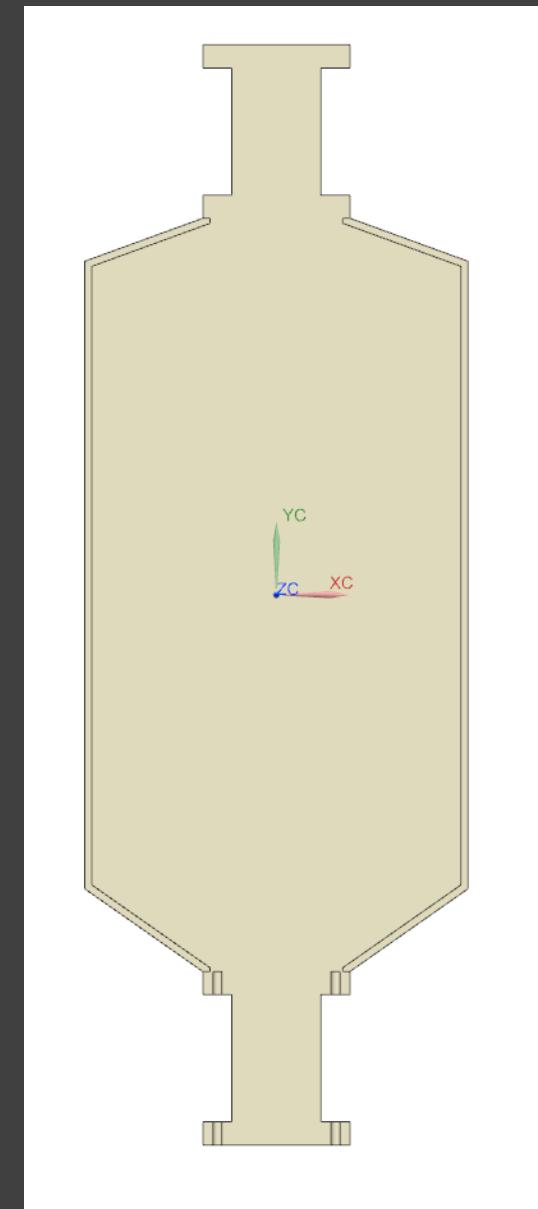
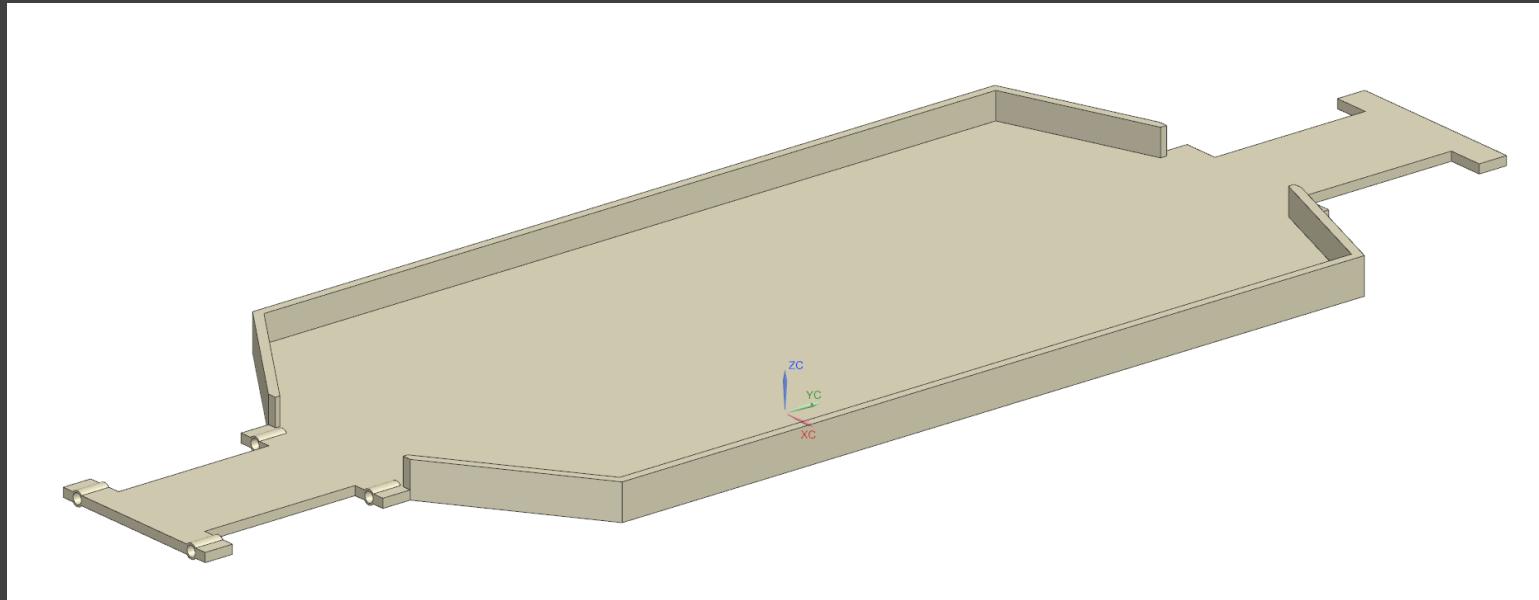
Low Clearance Bridge



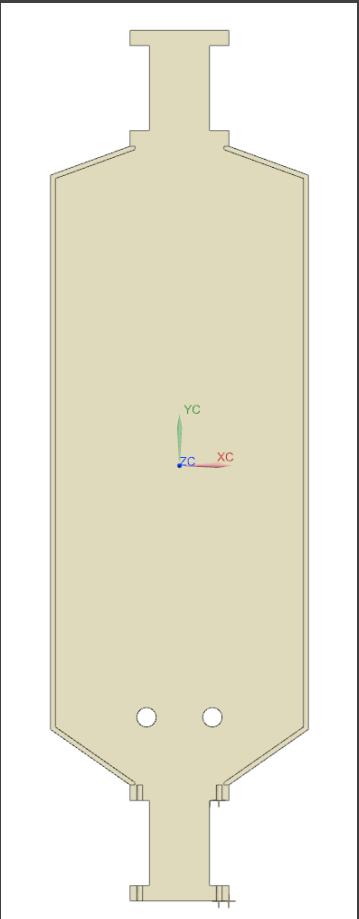
Small Parking Spot



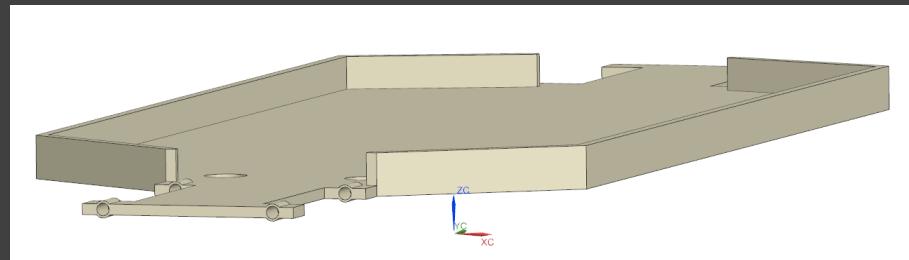
CHASSIS - MODEL



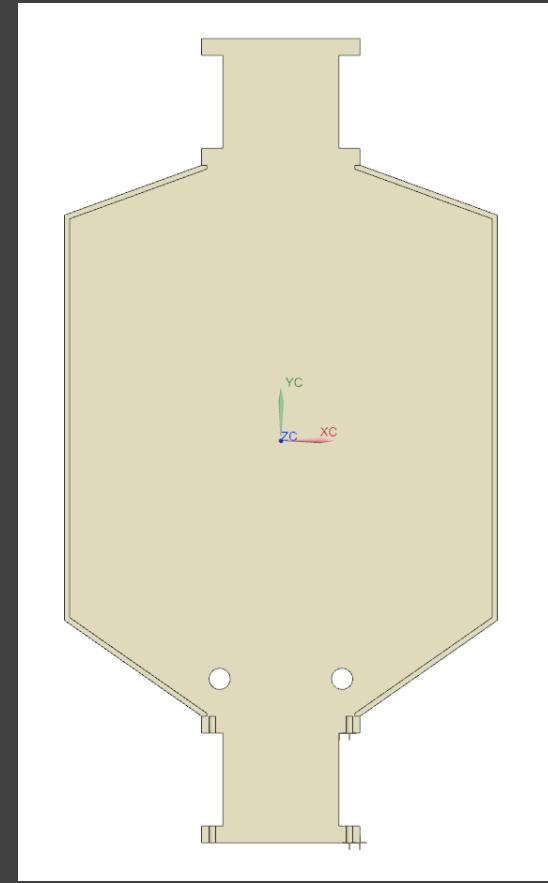
CHASSIS - PARAMETRICS



Thinner Track

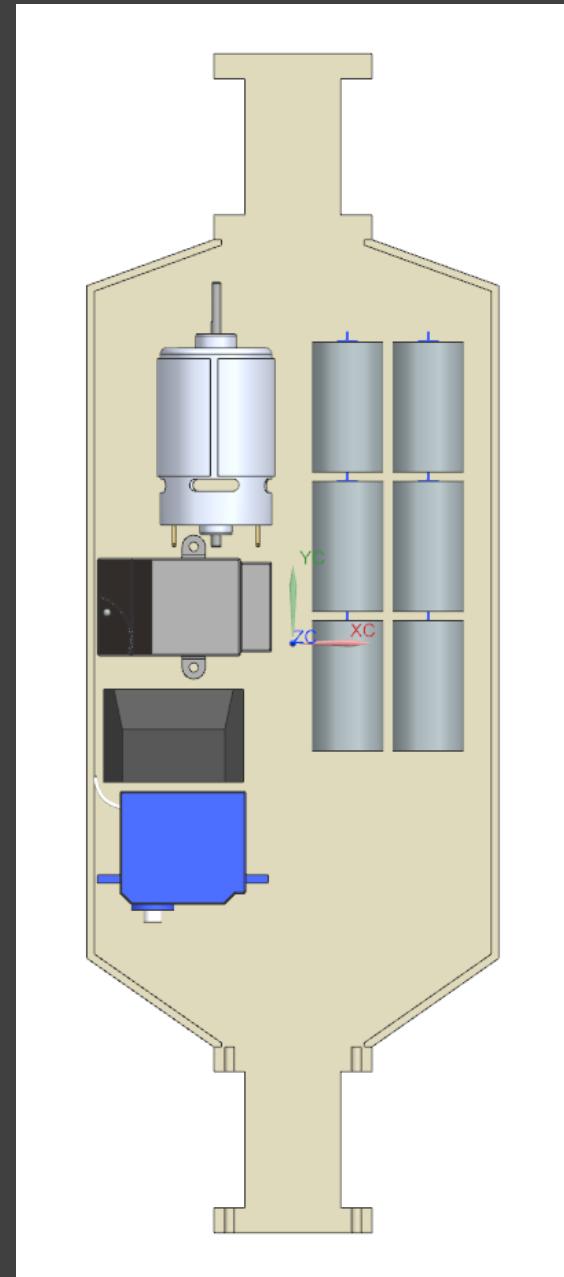
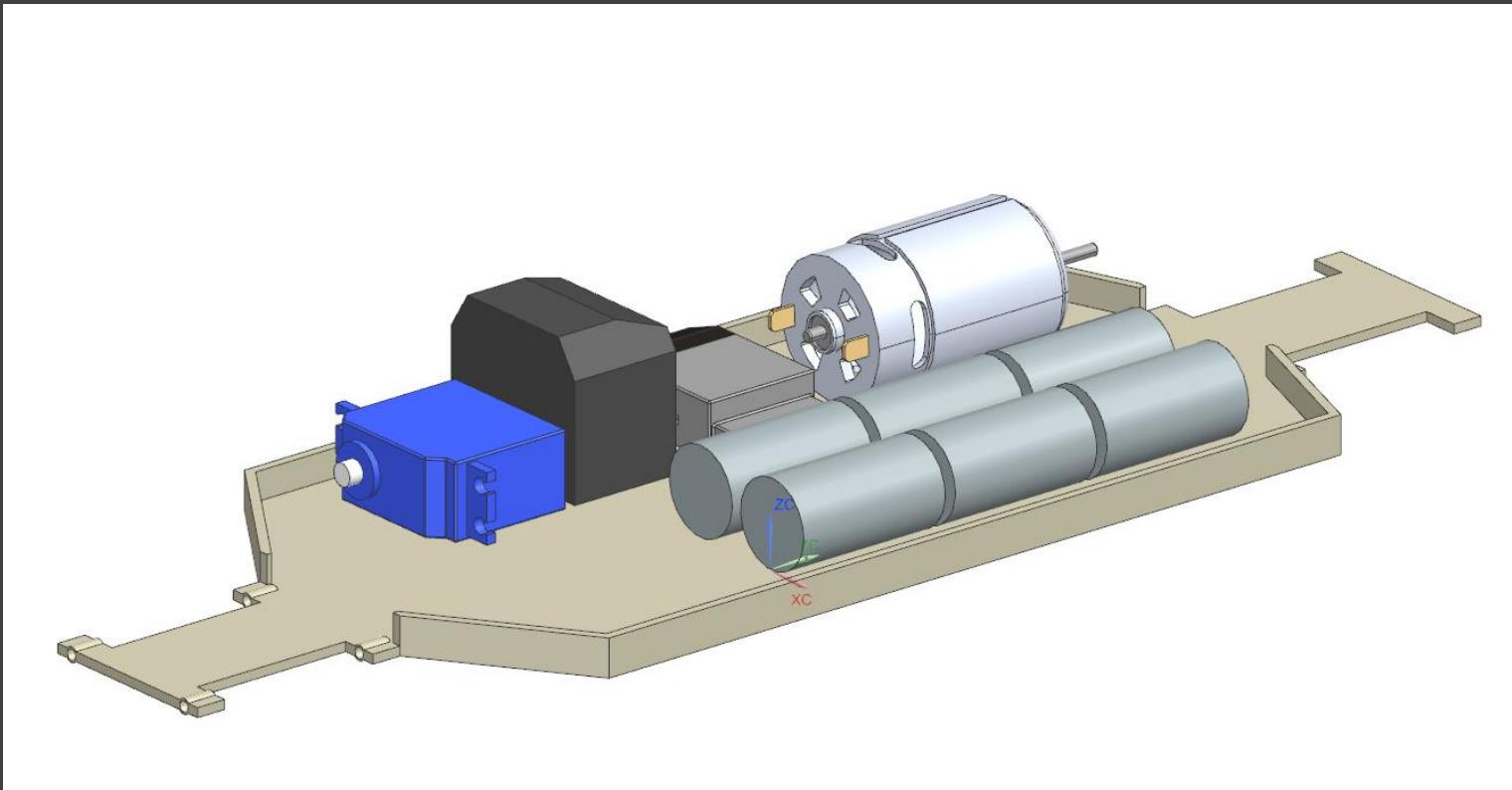


Low Clearance Bridge

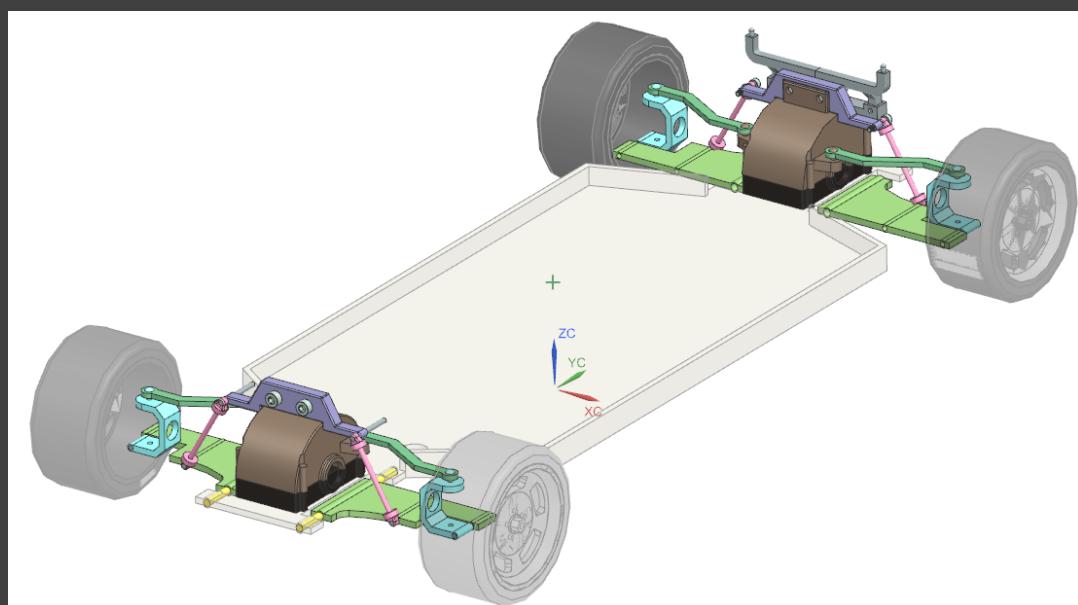
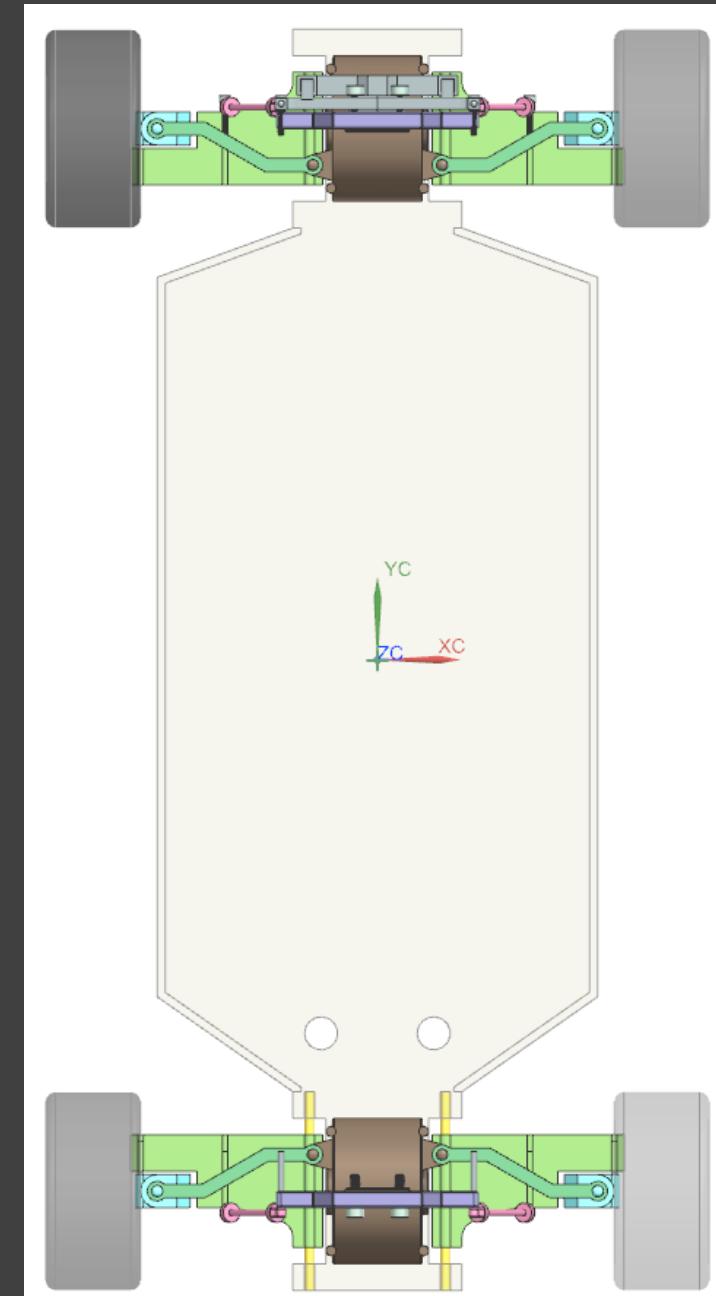
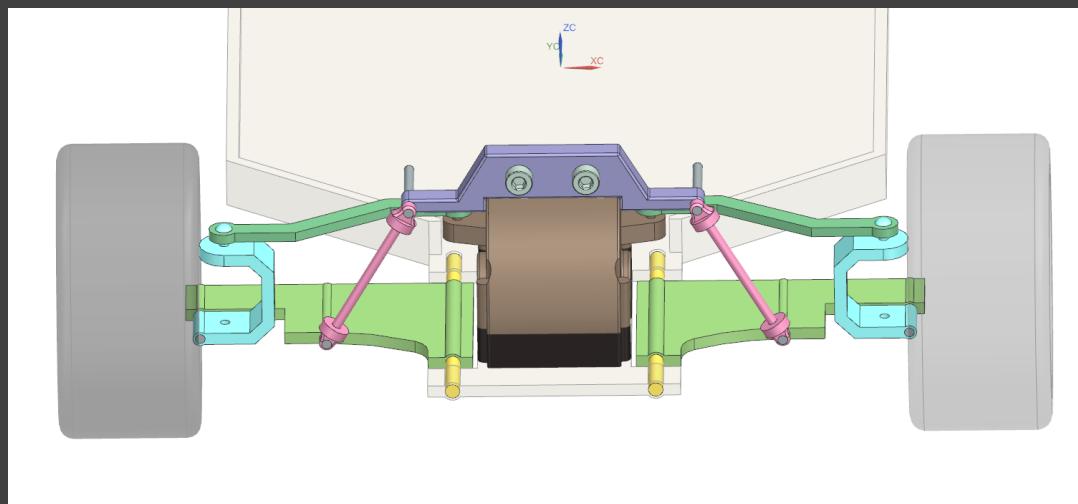


Small Parking Spot

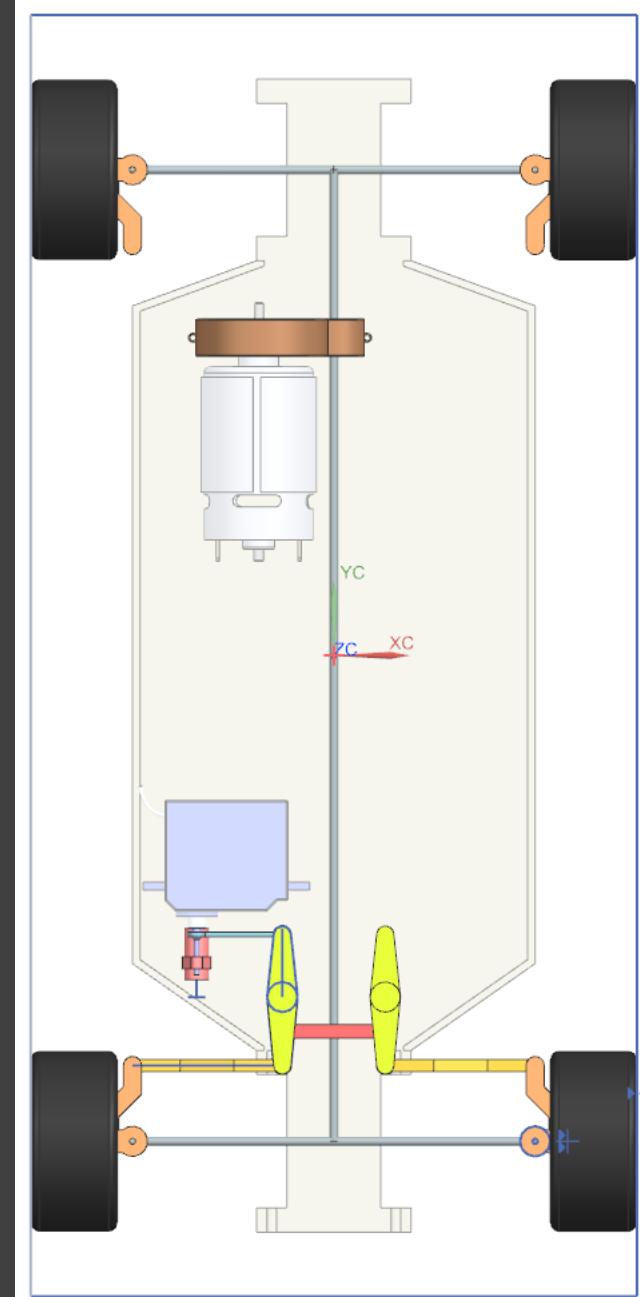
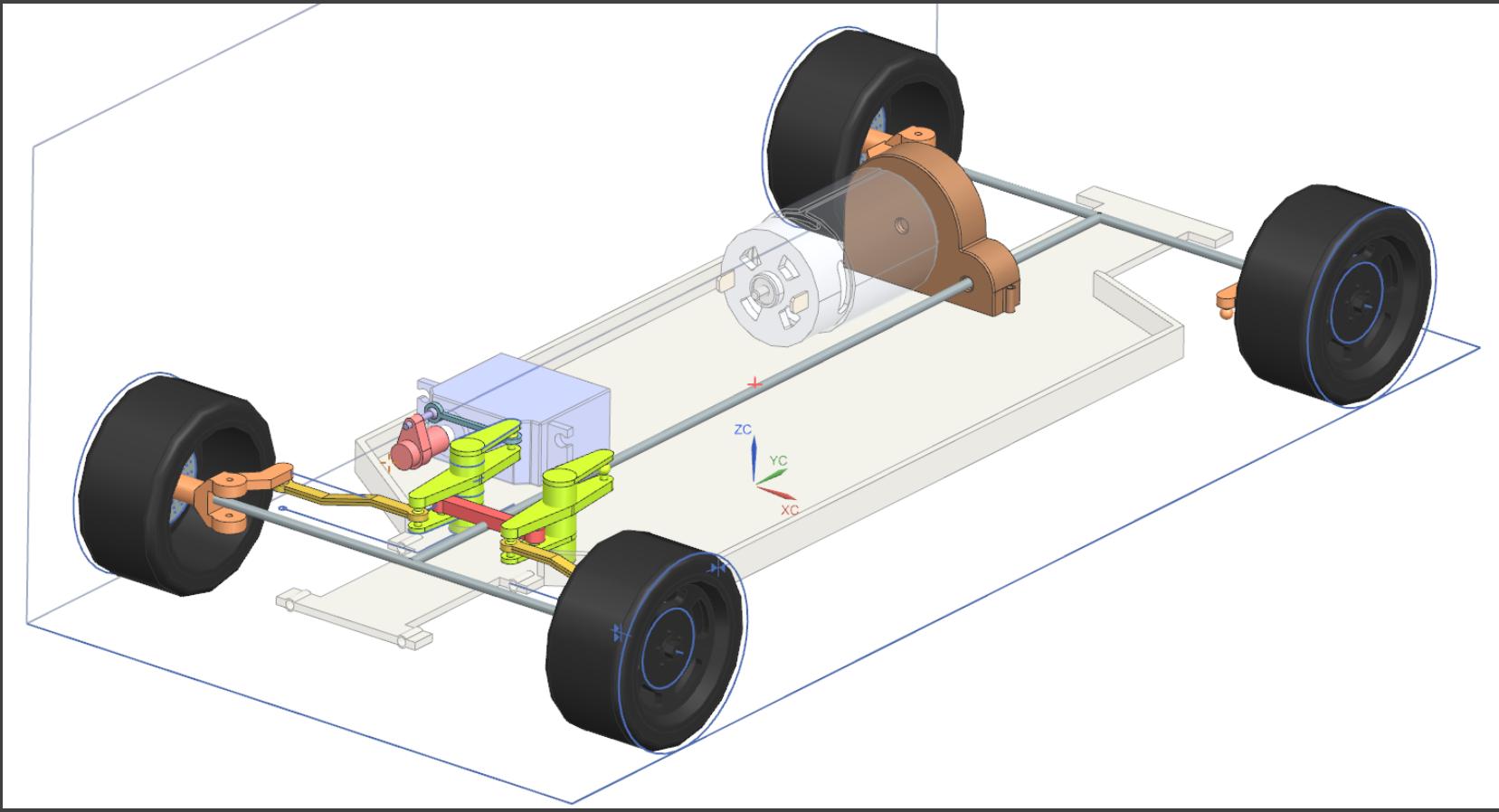
ELECTRONICS - MODEL



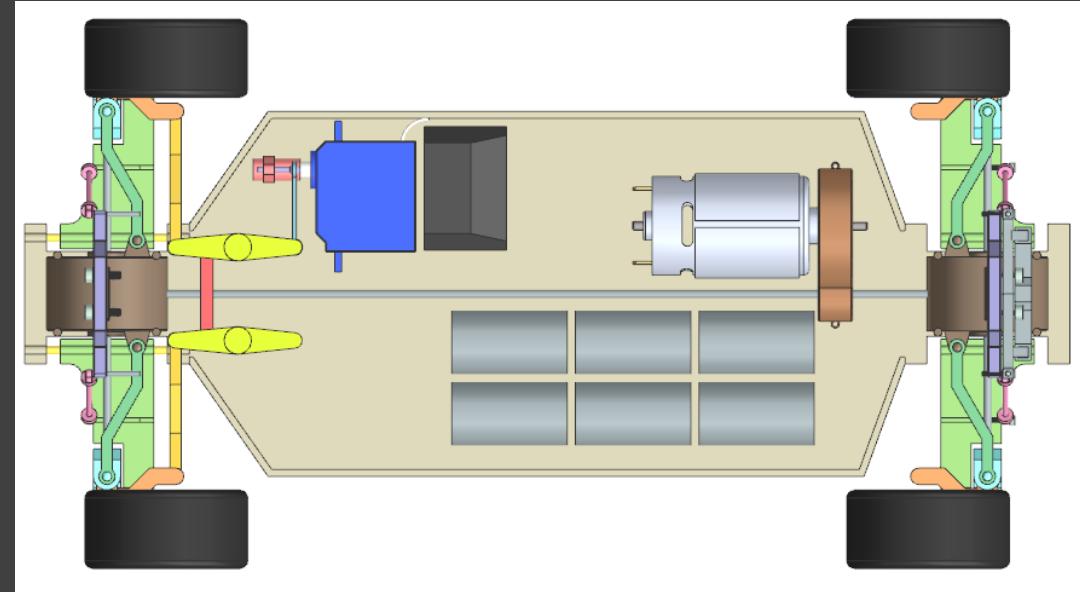
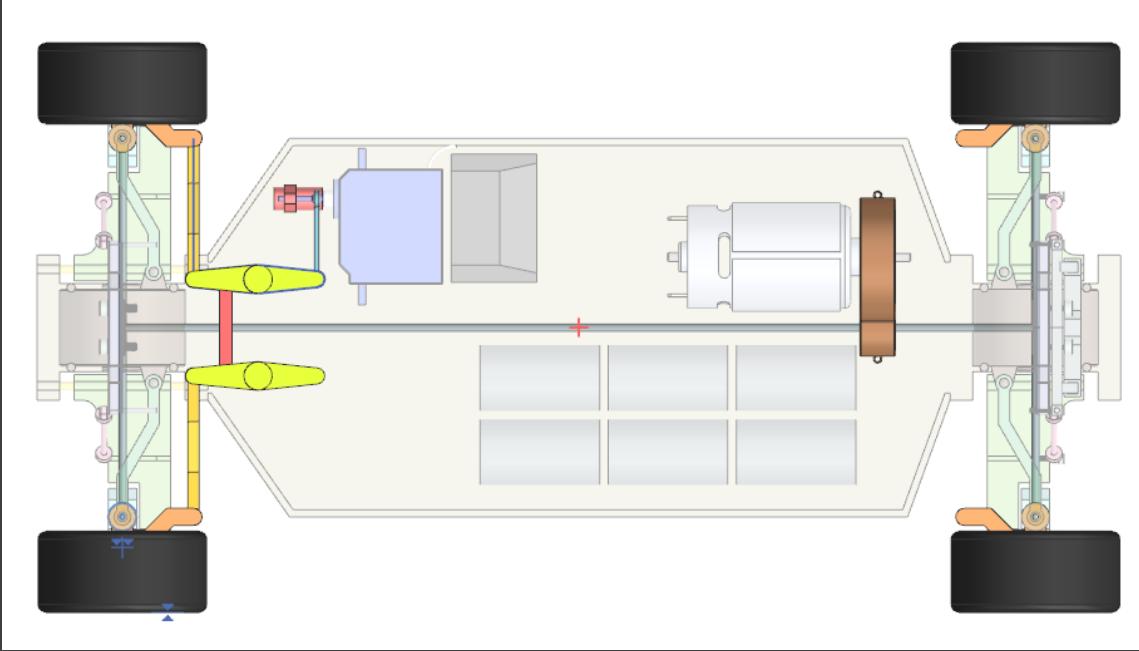
SUSPENSION - MODEL



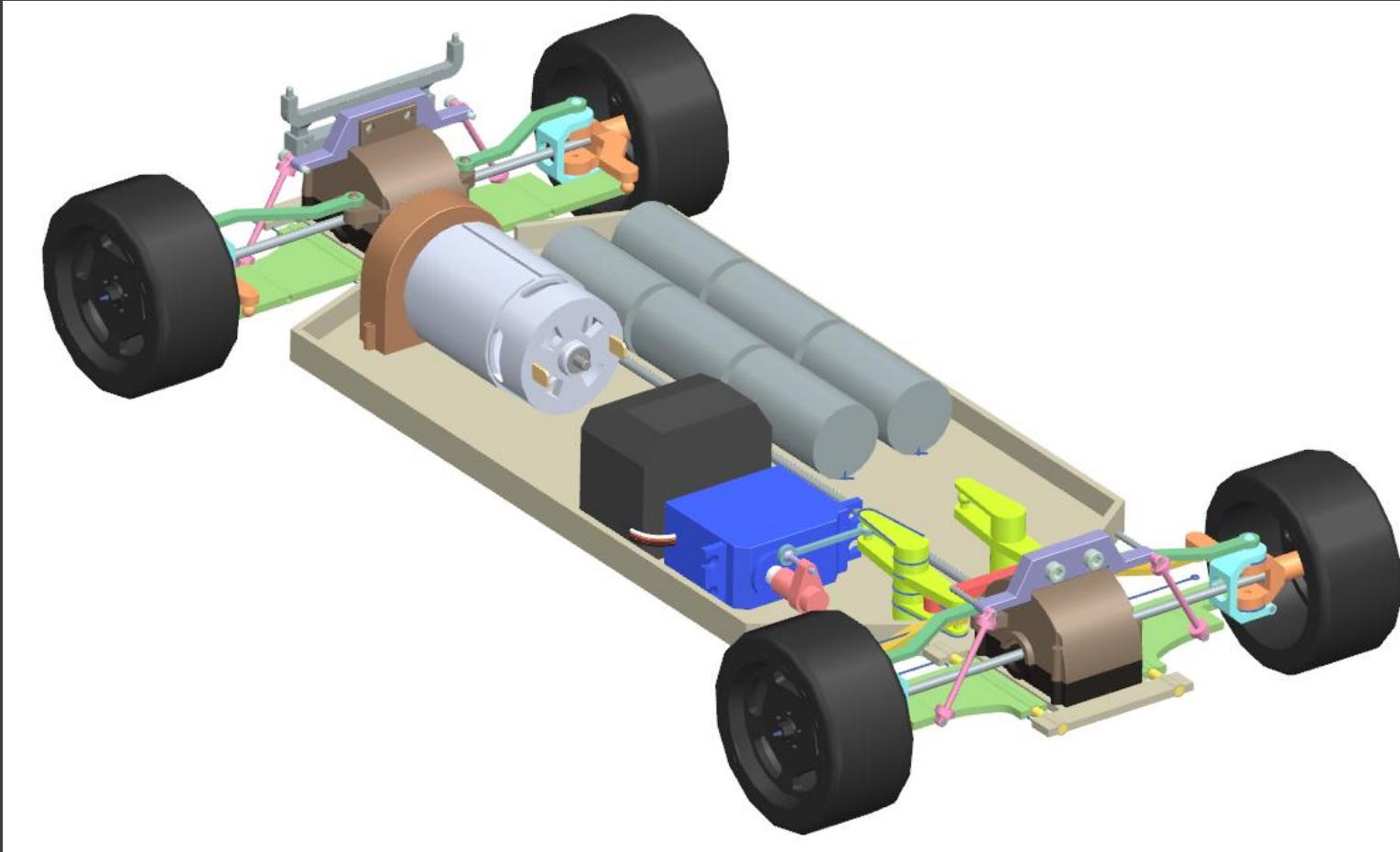
DRIVE TRAIN - MODEL



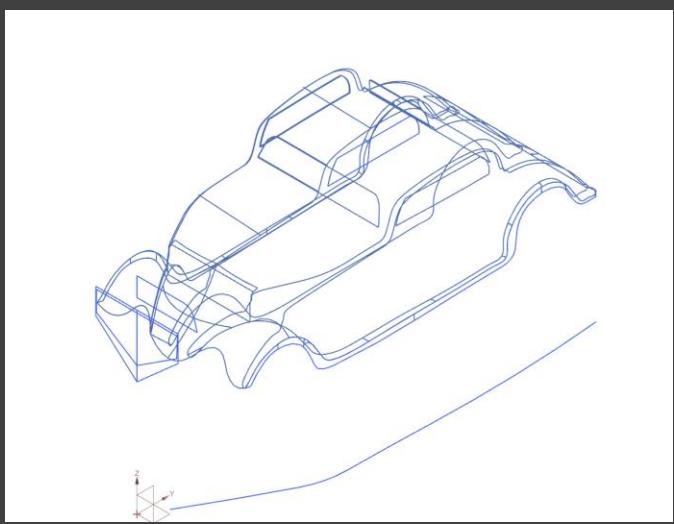
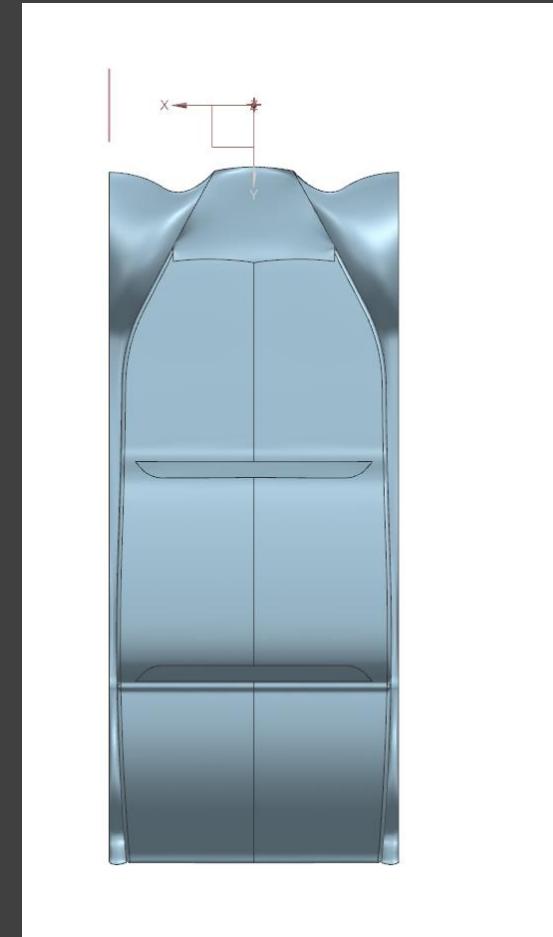
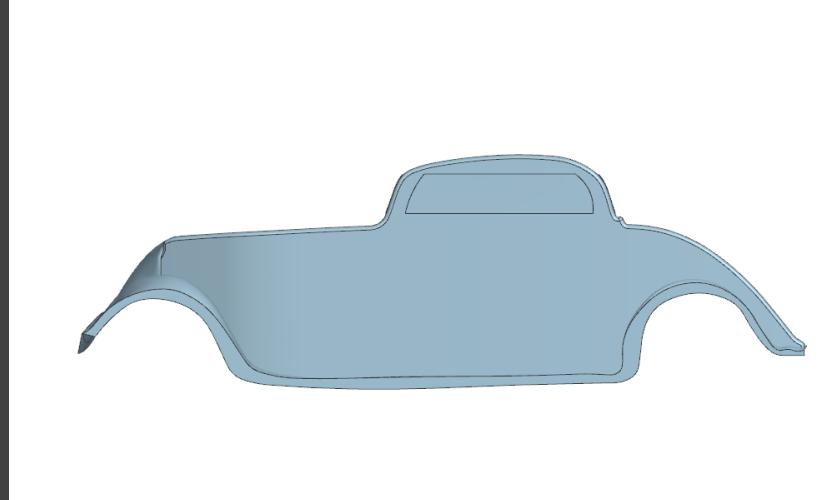
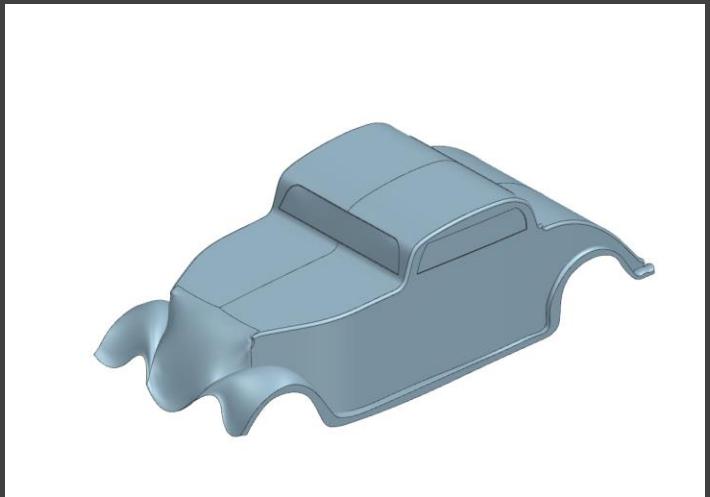
DRIVE TRAIN - PARAMETRICS



FULL INTERNALS

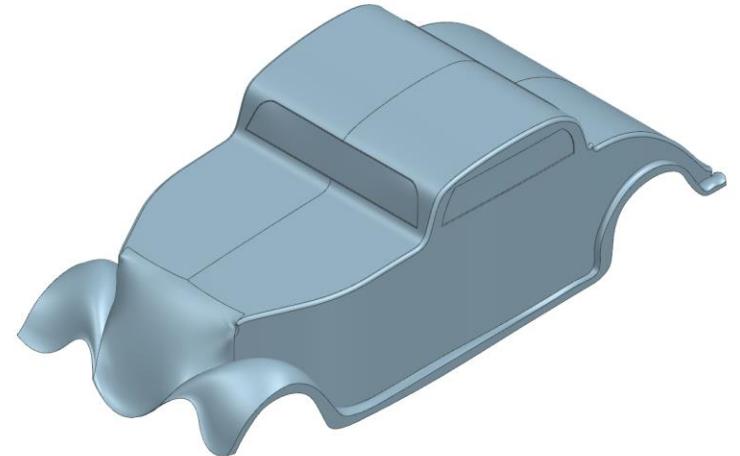


PRIMARY SHELL SURFACES

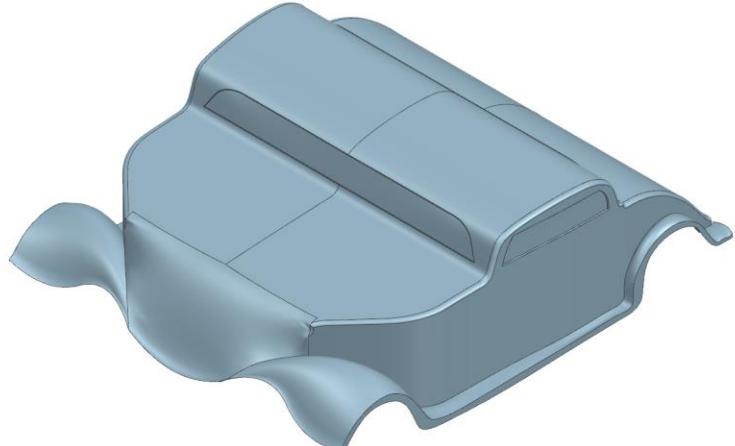


SHELL - PARAMETRICS

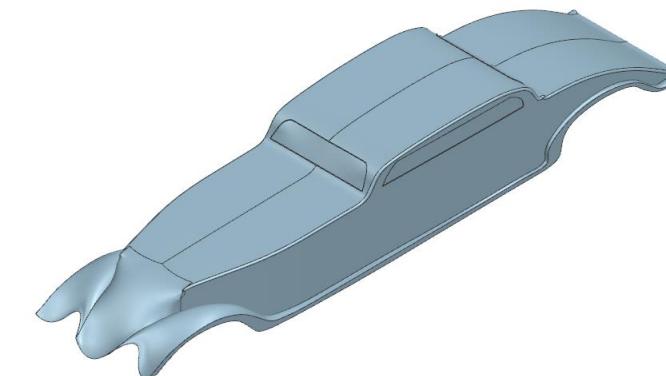
Original



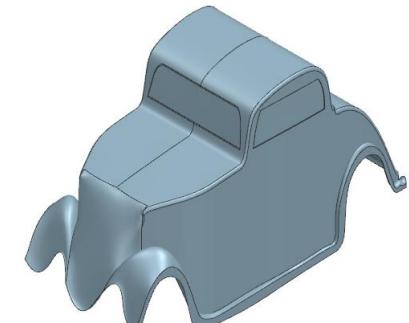
2x X-Scale



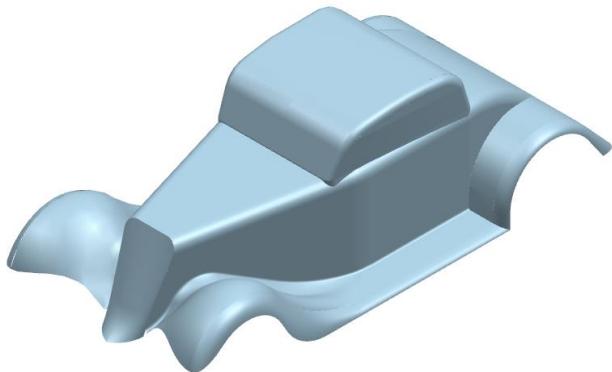
2x Y-Scale



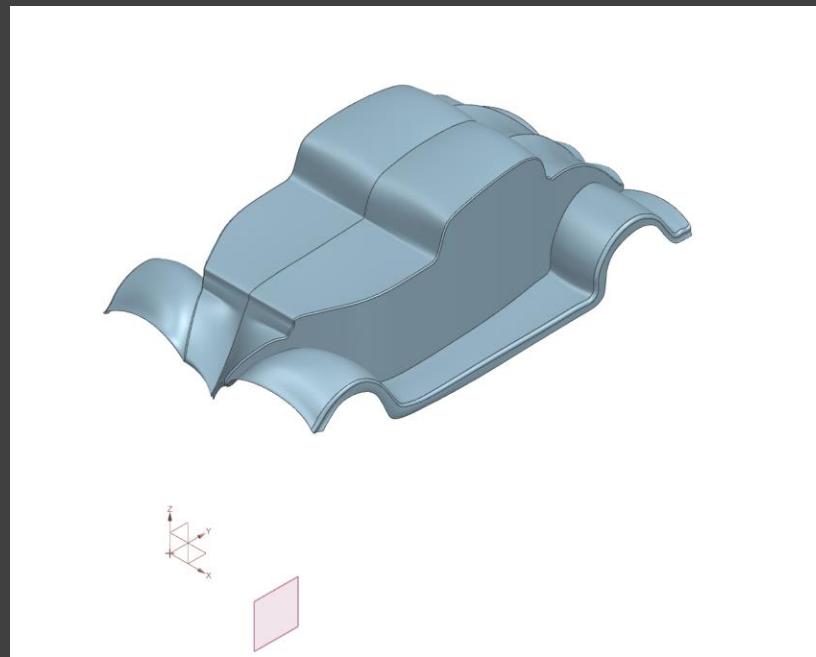
2x Z-Scale



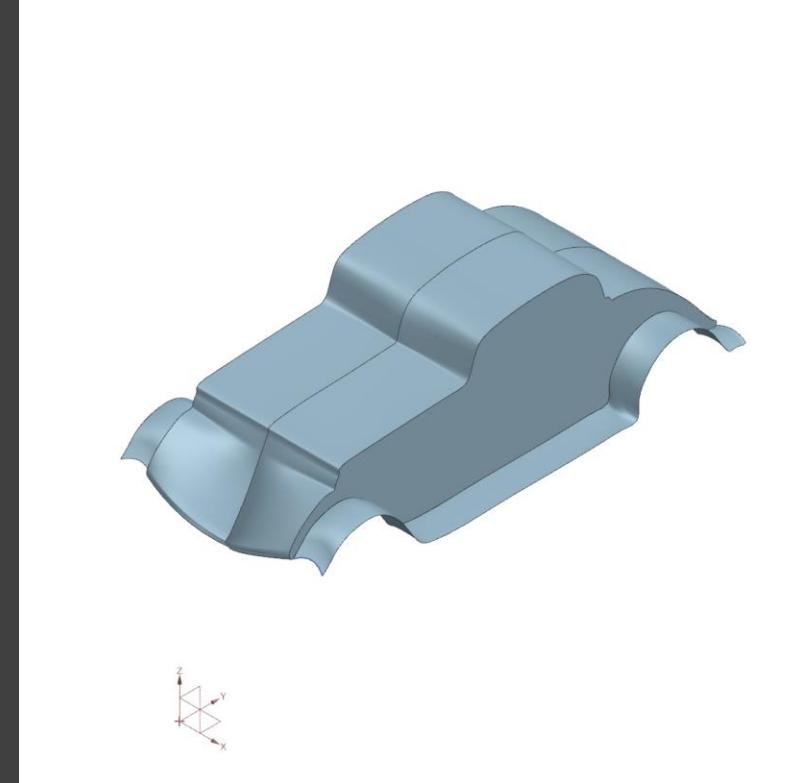
ALTERNATE SHELL SURFACES



(Cael's Surface)

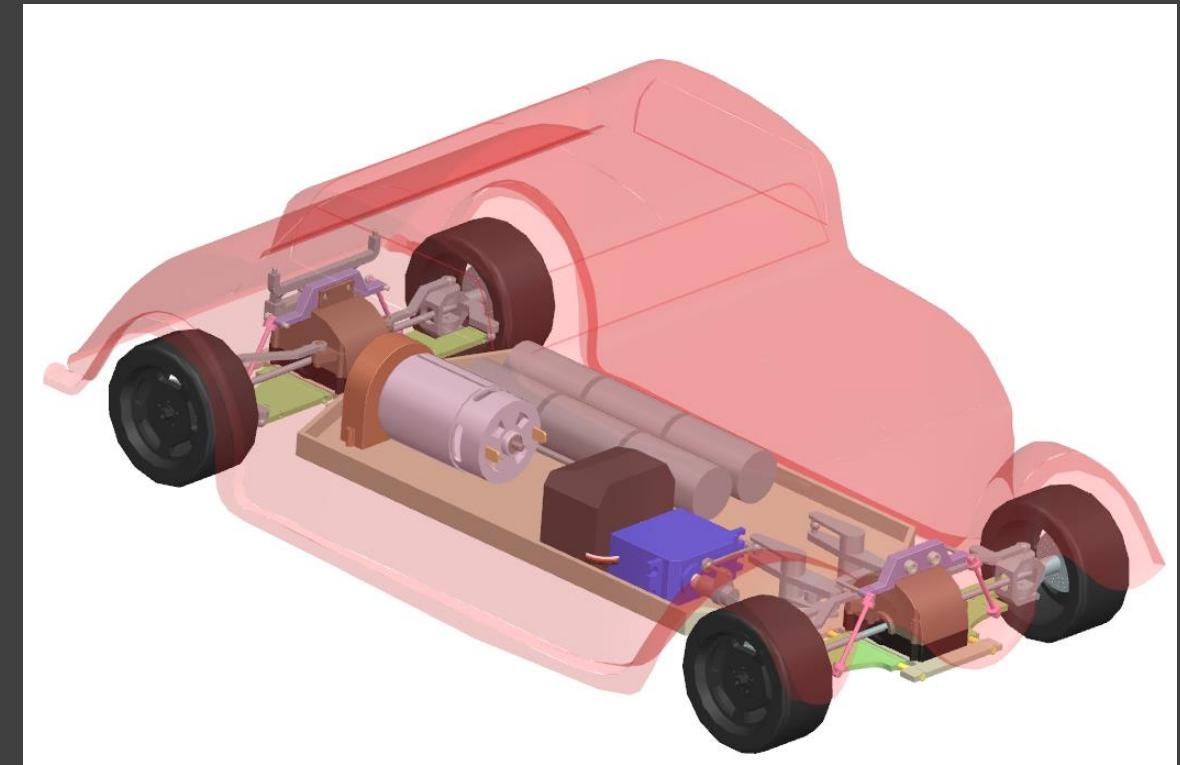
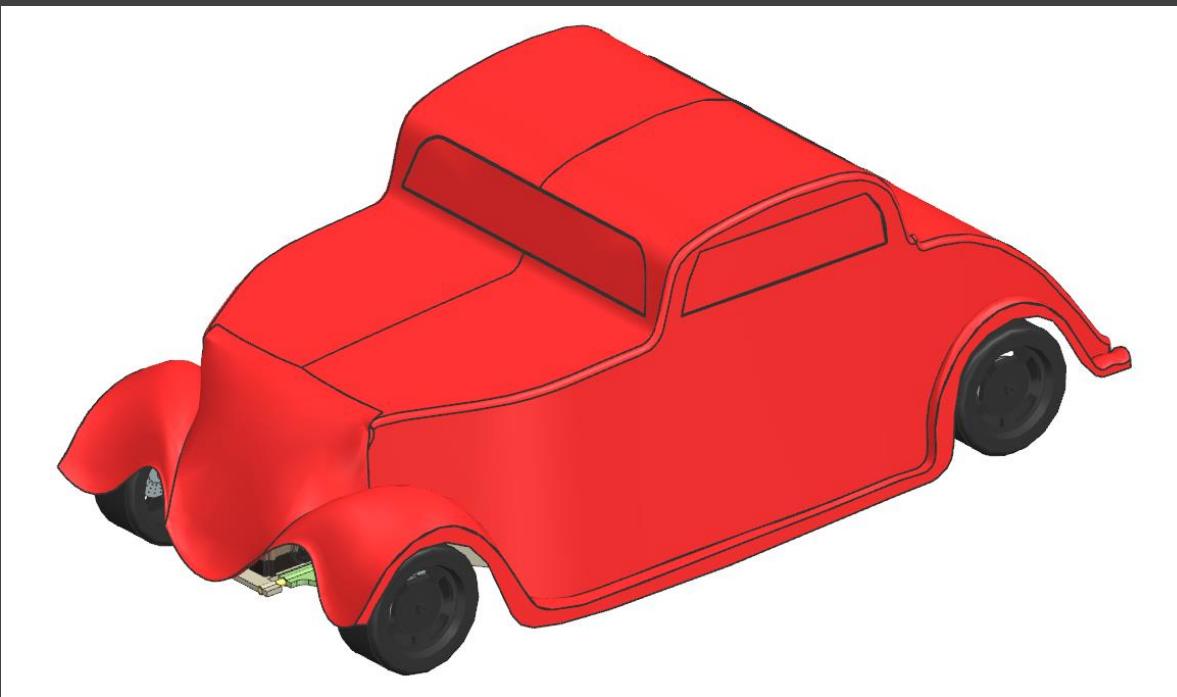


(Hailey's Surface)



(Thomas' Surface)

FULL MODEL



MATERIALS + MASS PROPERTIES

Assembly:

- Estimated Mass: 1.266 kg
- Real Mass: 1.919 kg
- Percent Error: 34.03 %

Component	Material
Chassis	Polymer
Shell	Plastic (Polyethylene)
Wheels	Plastic (Polycarbonate)
Tires	Rubber
Suspension	Plastic (Polycarbonate)
Axles	Aluminum

Shell:

- Estimated Mass: .1951 kg
- Real Mass: .166 kg
- Percent Error: 17.53 %

2. Design Improvements



Topology Optimization

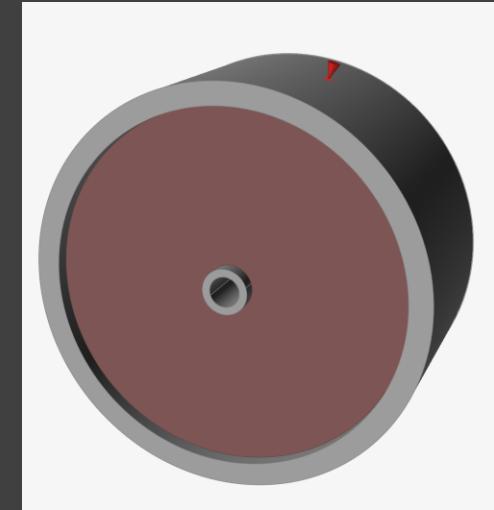
Goal: Reduce mass of RC Car while still maintaining structural integrity for optimization

WHEEL – STATIC CASE

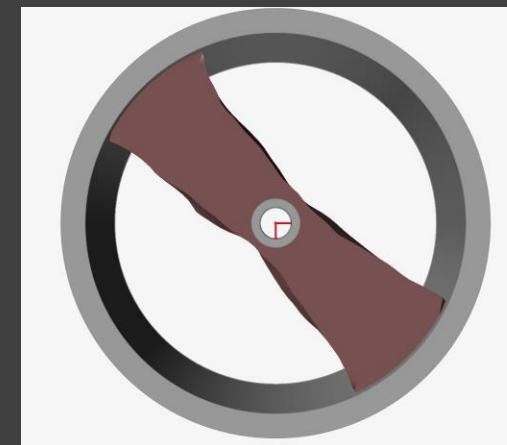
- Outer rim and center hub not considered design space
- Inner rim is area of focus
- Fixed constraint on outside rim face
- 20 N force in +Y and -Z on the center axial
- Material: Plastic (ABS)
- Model Mass- 20.429 g
- Optimized Mass- 14.258 kg



Current Design



Loading with
preserved faces and
design space



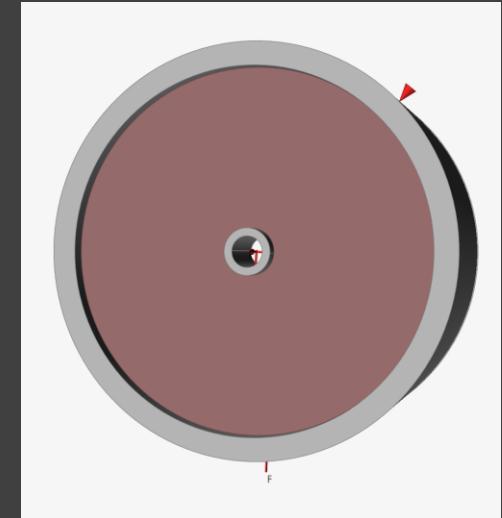
Optimized Part

WHEEL – “ROLLING” CASE

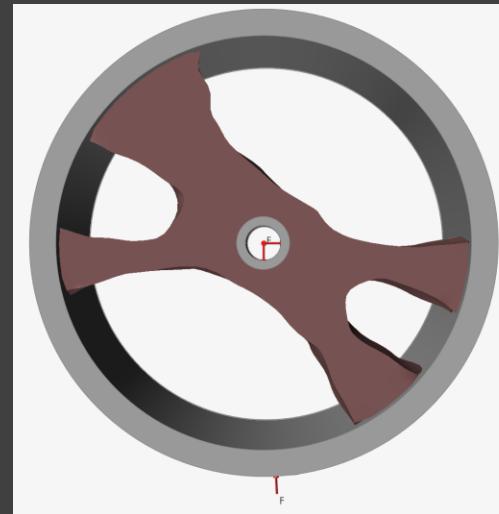
- Outer rim and center hub not considered design space
- Inner rim is area of focus
- Fixed constraint on outside rim face
- 20 N force in +Y, -Z and +X on the center axial
- Added a 20 N force on outer rim for basic “motion” force simulation
- Material – Plastic (ABS)
- Model Mass- 20.429 g
- Optimized Mass- 14.64 g



Current Design



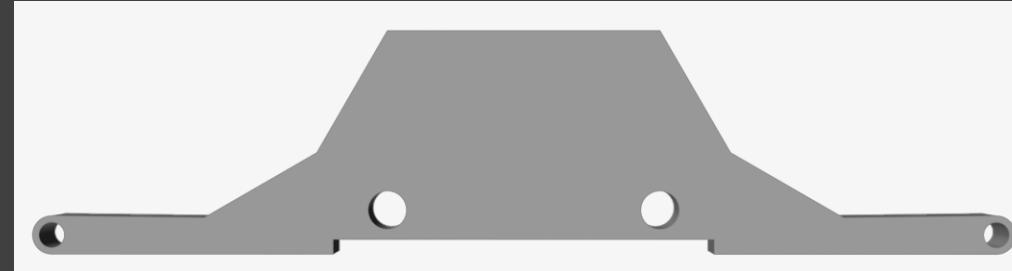
Loading with
preserved faces and
design space



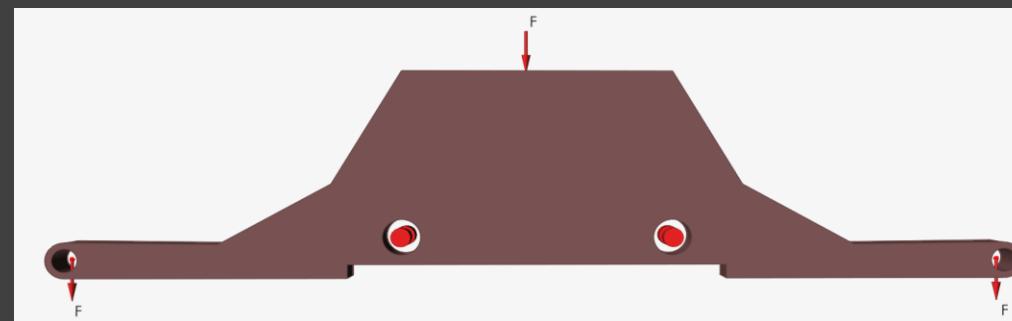
Optimized Part

SUSPENSION SPRING ARM – MASS REDUCTION

- 8 N force applied to outer holes in the –Z direction
- 5 N force on top face to simulate shell
- Fixed constraint on two inner holes
- Reduce Mass Safety Factor set to 2
- Material – Polypropylene
- Model Mass- 22.778 g
- Optimized Mass- 10.225 g



Current Design



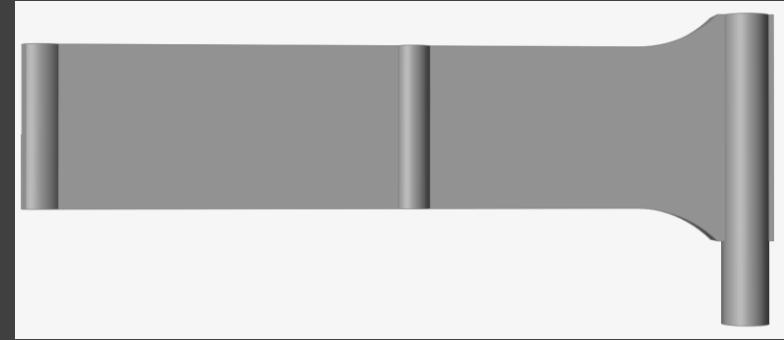
Loading with preserved faces and design space



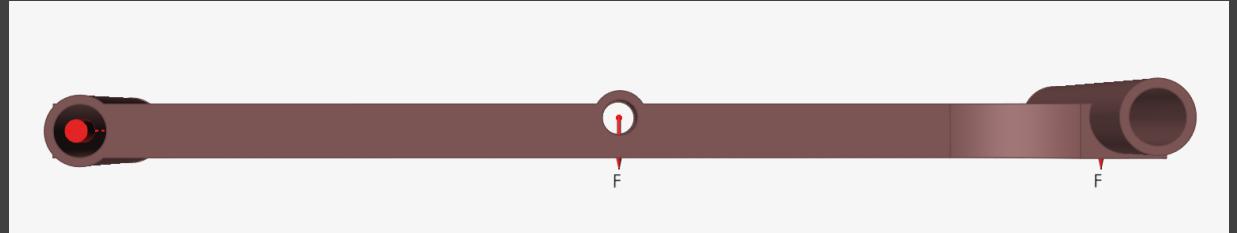
Optimized Part

WHEEL WING – MASS REDUCTION

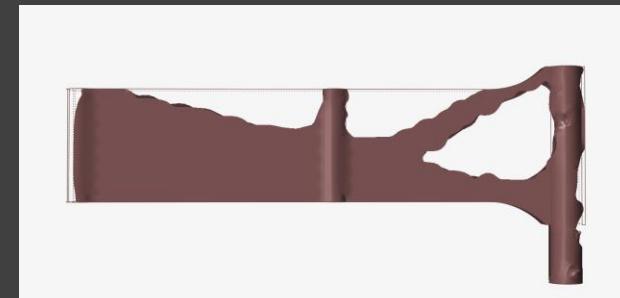
- 8 N force applied holes in the –Z direction
- Fixed constraint on left side hole
- Reduce Mass Safety Factor set to 2
- Material – Polypropylene
- Model Mass- 20.07 g
- Optimized Mass- 12.95 g



Current Design



Loading with preserved faces and design space



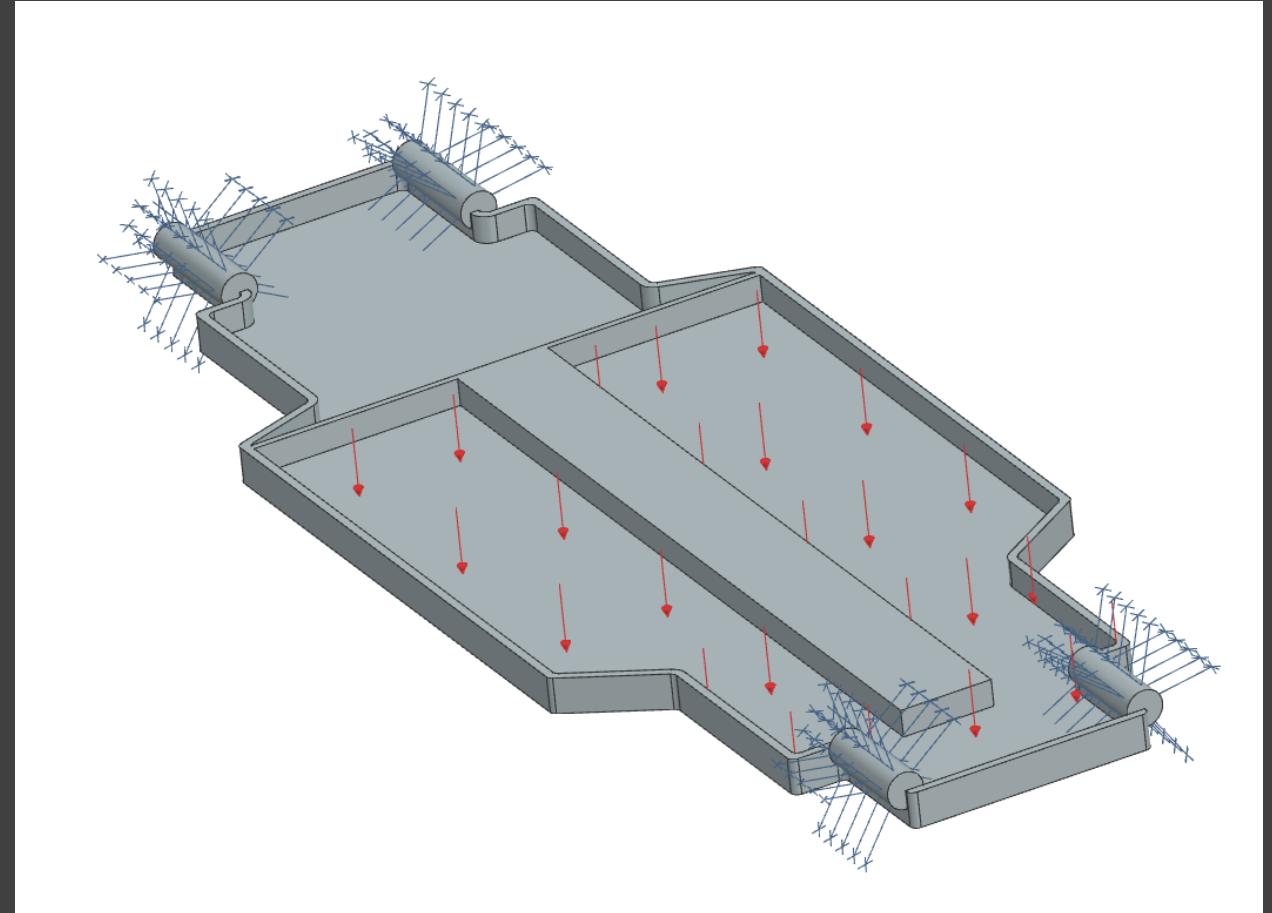
Optimized Part

Finite Element Analysis

Goal: Analyze the different forces and load conditions to **confirm the design** of the selected component

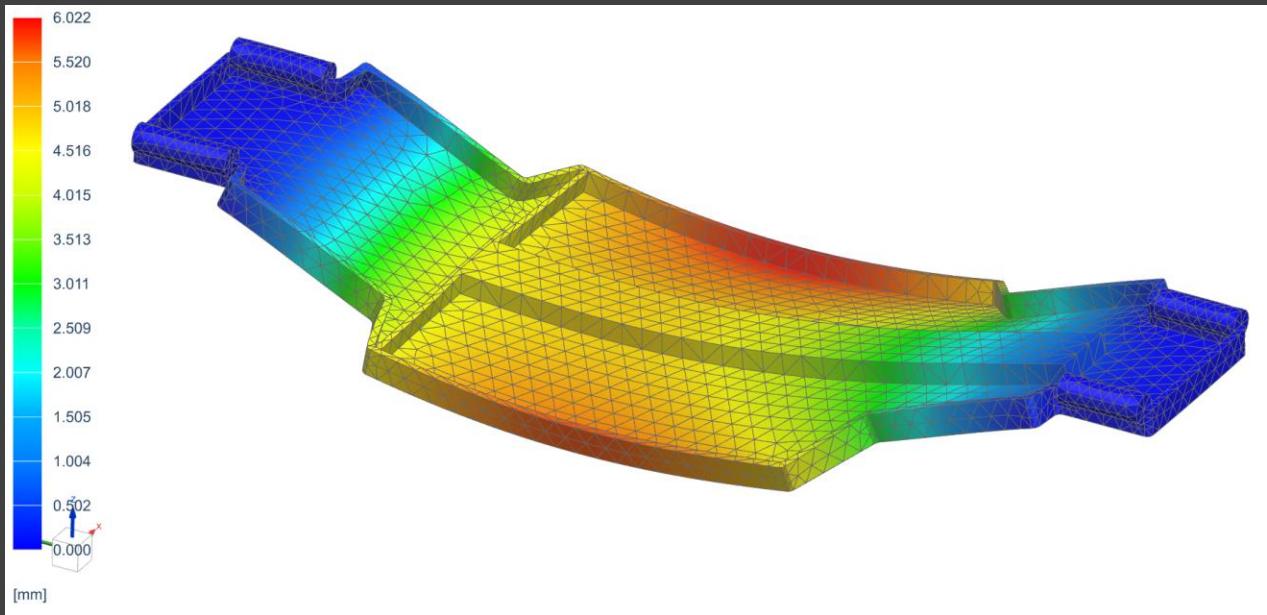
CHASSIS (PART) - SETUP

- To study the overall form and the impact of ribbing
- 20N distributed across floor to simulate electronics weight



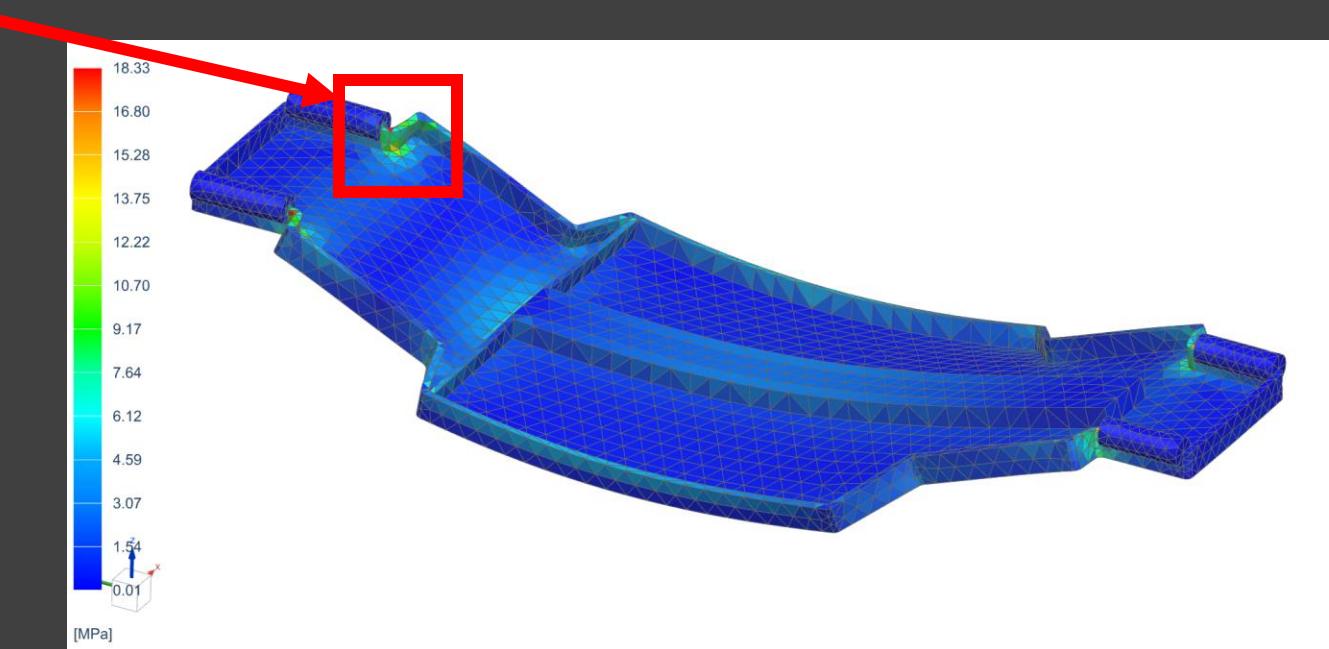
CHASSIS - RESULTS

Displacement



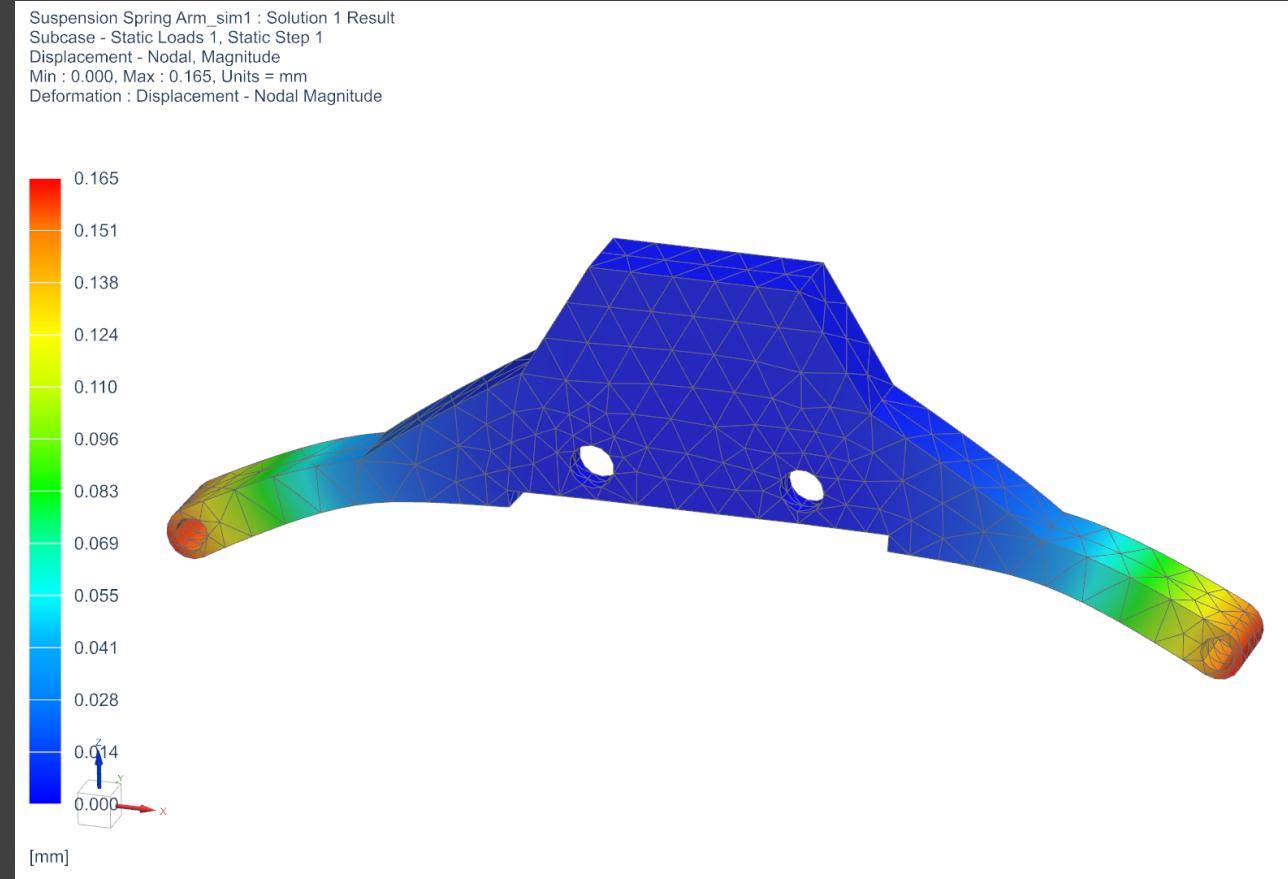
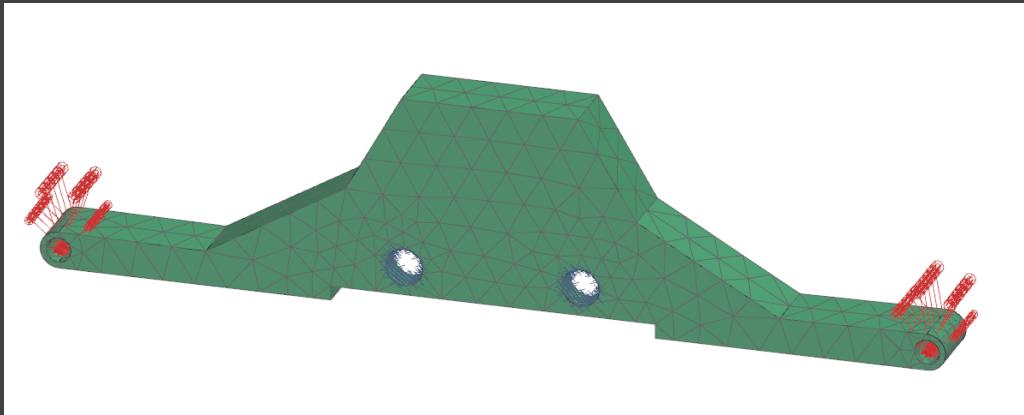
Von Mises

Stress
Concentration



SUSPENSION SPRING ARM (PART)

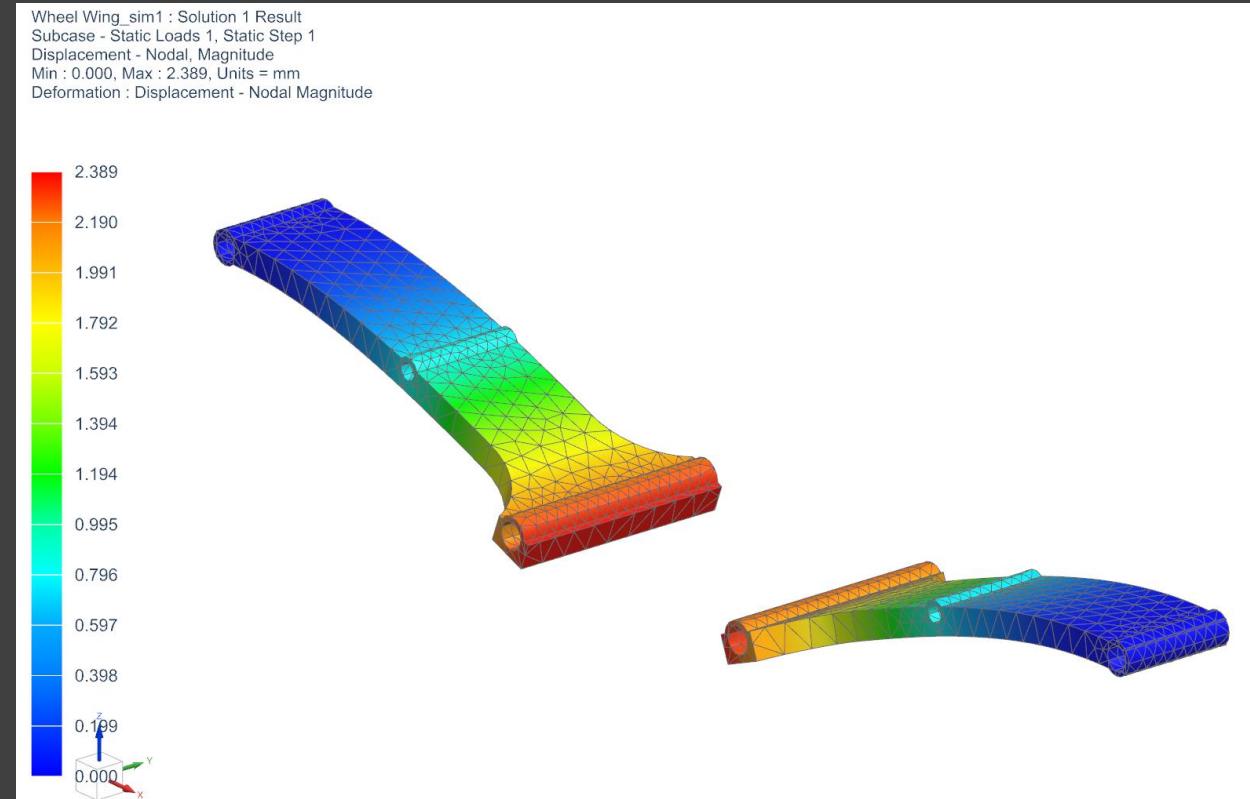
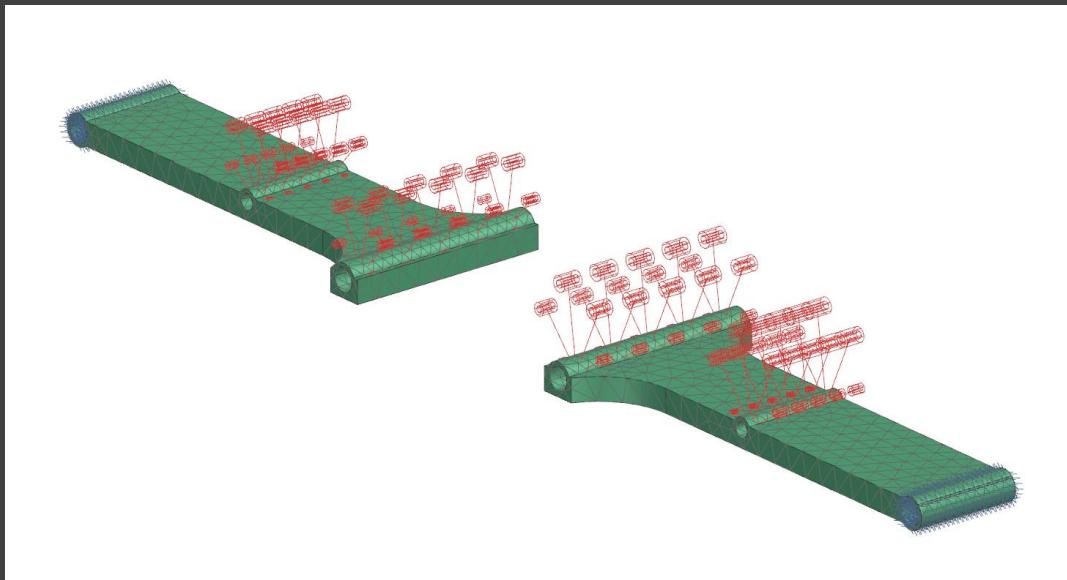
- Key component of suspension supporting forces from wheels
- 5N on each arm, fixed bolt holes
- Max Deflection of **0.165 mm** (acceptable)



(Displacement)

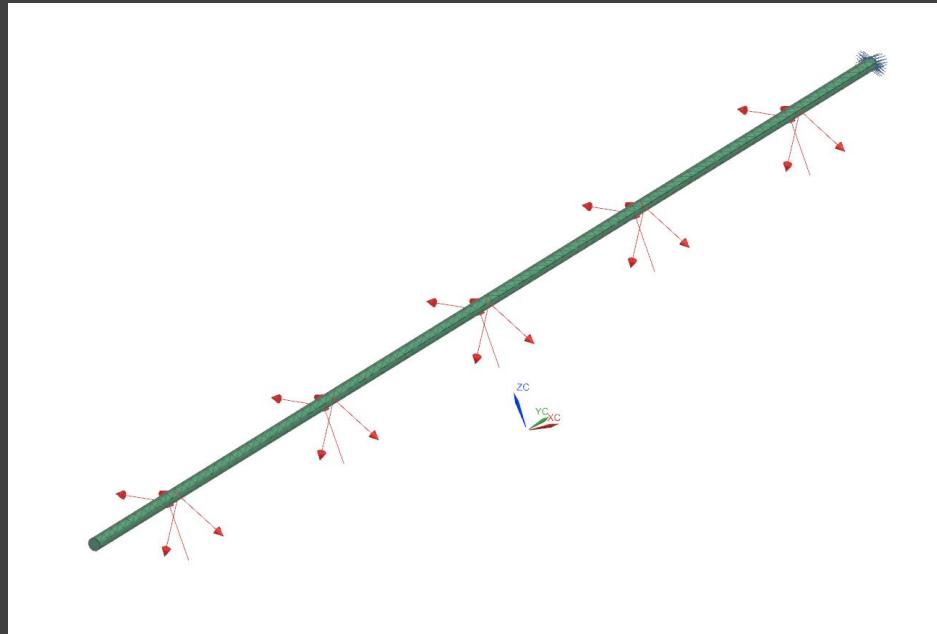
WHEEL WING (PART)

- Flexible element of suspension
- 5N on inner and middle holes
- Fixed outer hole
- Max Deflection of **2.4 mm** (acceptable)

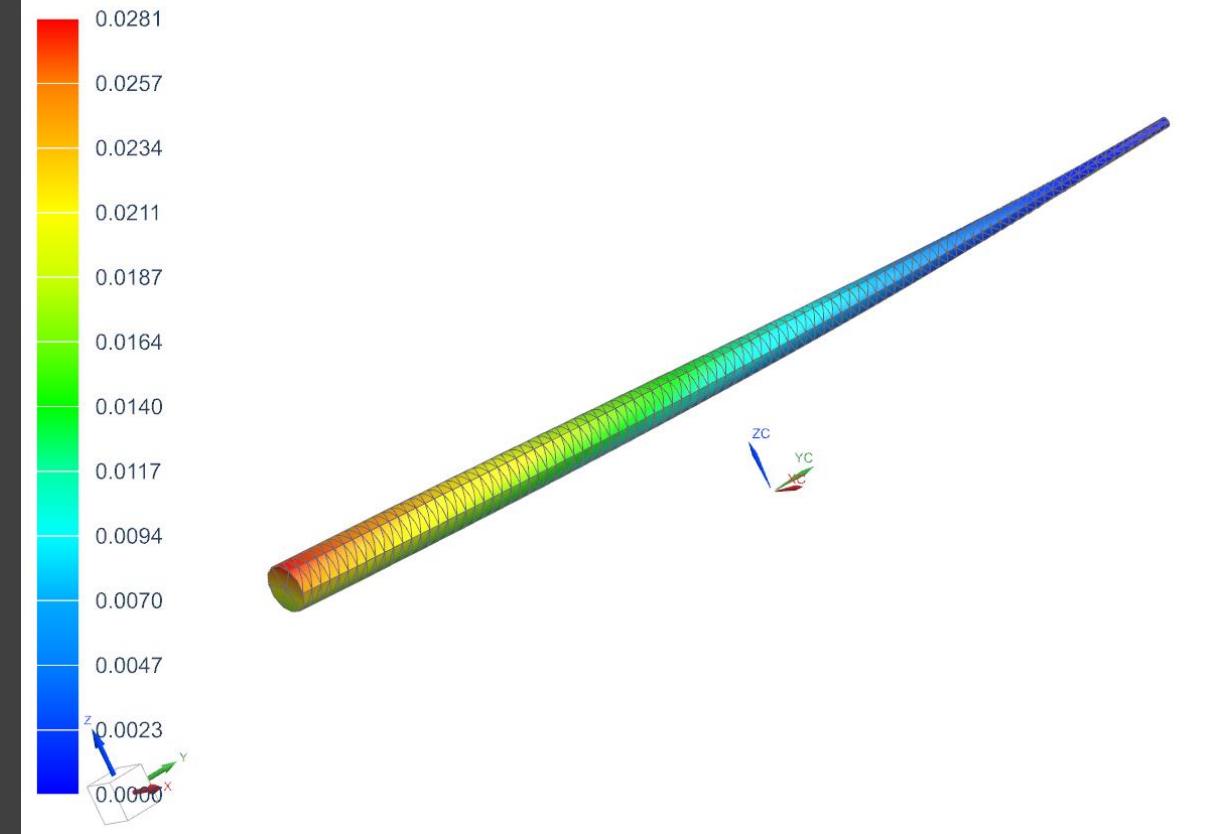


DRIVE SHAFT (PART)

- Important torque bearing component for steering
- Max Deflection of **0.03 mm** (acceptable)

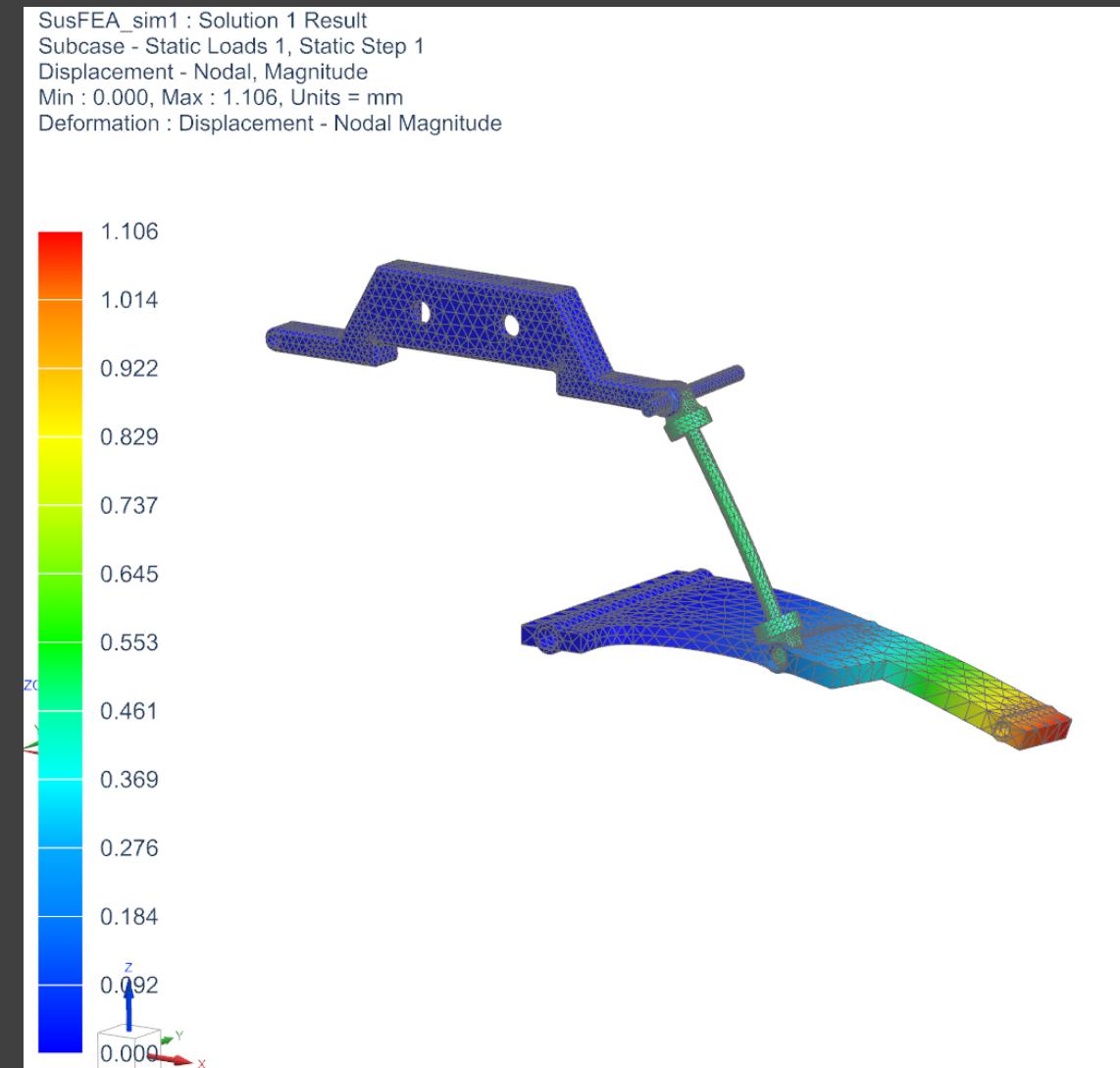
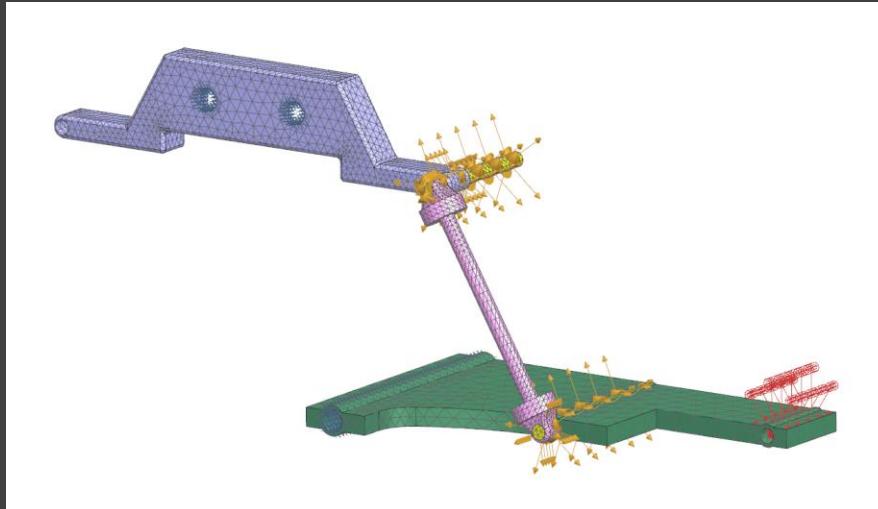


Drive Shaft_sim1 : Solution 1 Result
Subcase - Static Loads 1, Static Step 1
Displacement - Nodal, Magnitude
Min : 0.0000, Max : 0.0281, Units = mm
Deformation : Displacement - Nodal Magnitude



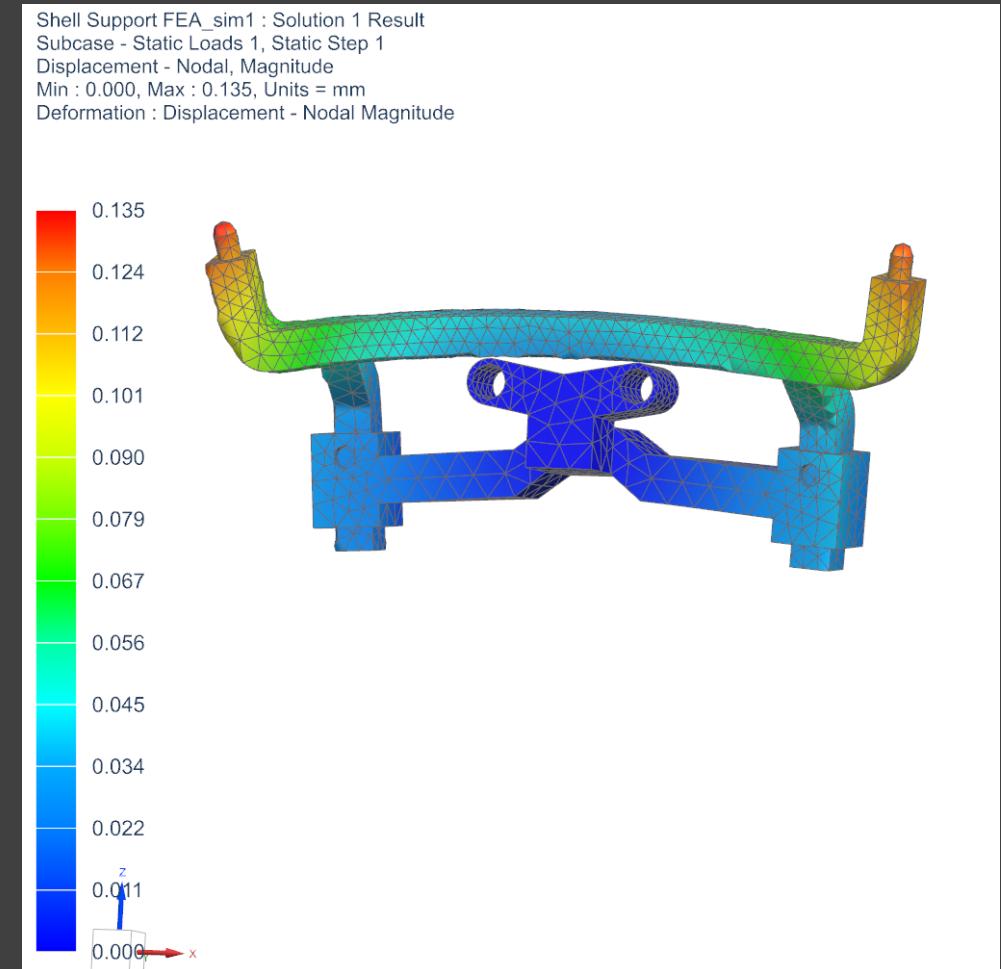
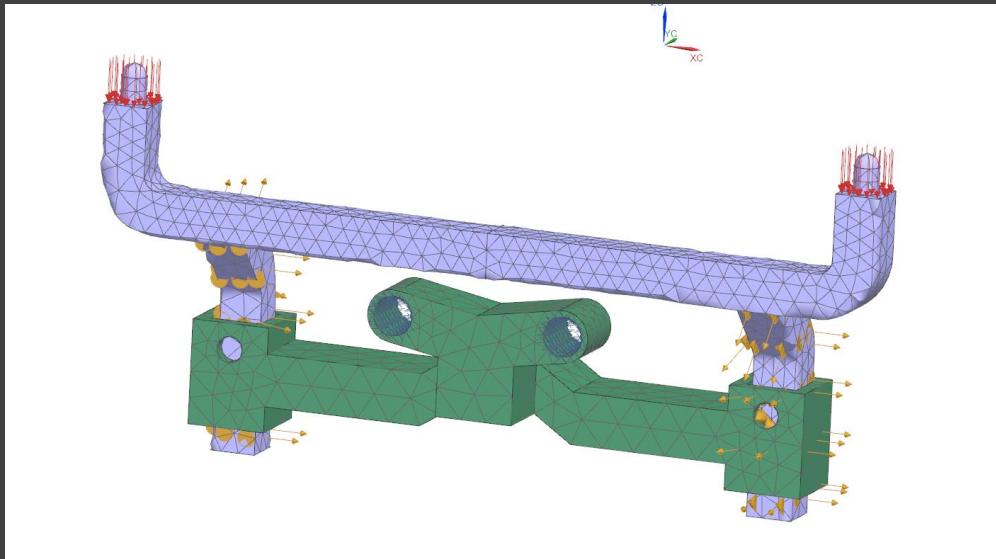
SUSPENSION ASSEMBLY

- To check if loads can be properly supported with selected materials
- 5N force to simulate quarter of car's weight
- Utilizing symmetry for simplification
- Max deflection of 1.1 mm in wheel wing (acceptable)



SHELL SUPPORT ASSEMBLY

- To check if shell can be supported
- 2N applied
- Max deflection of 0.135 mm
(acceptable)



CFD

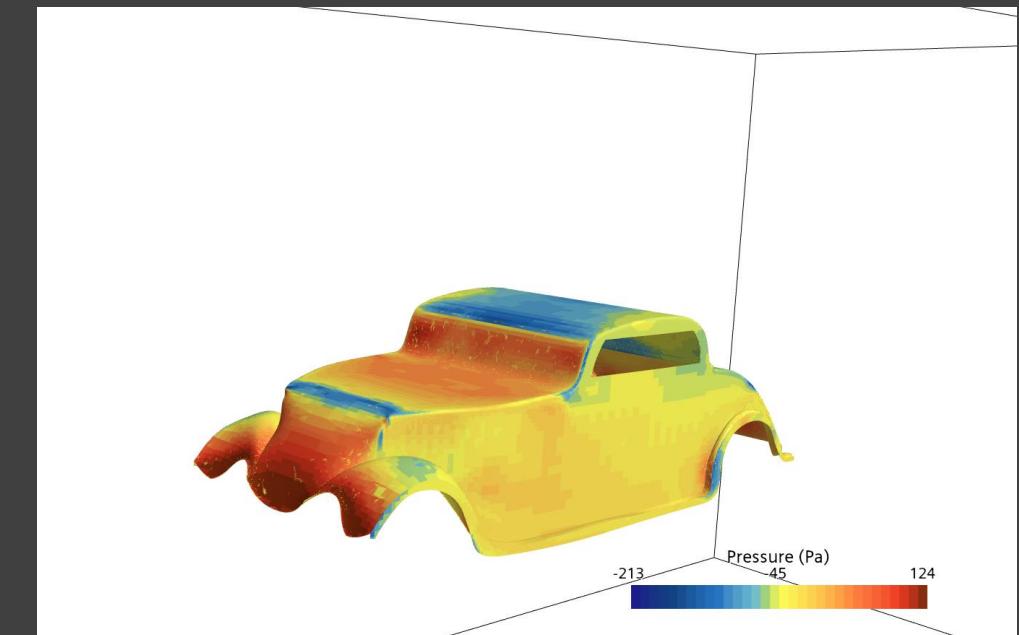
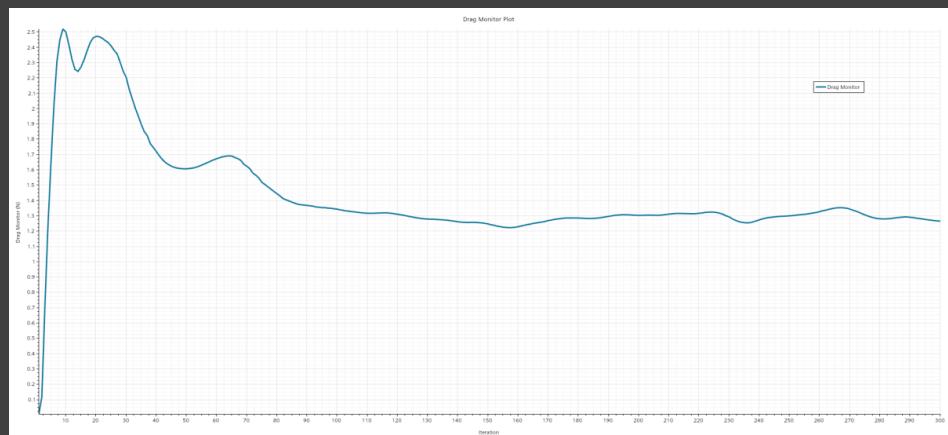
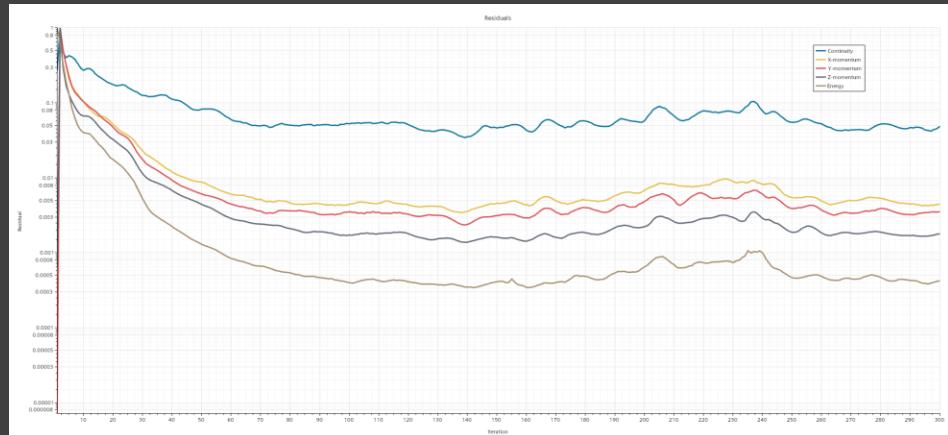
Goal: Reduce the drag force while still maintaining the visual design of the Hot Rod

CFD (MAIN SHELL)

Measured: Drag force

Speed: 30 MPH

Drag Force: 1.3 N

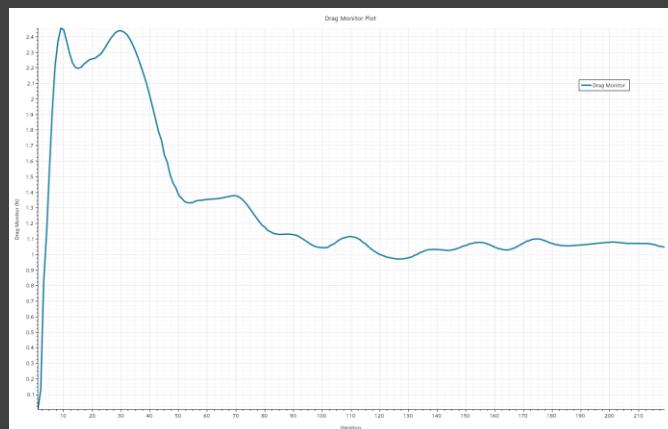
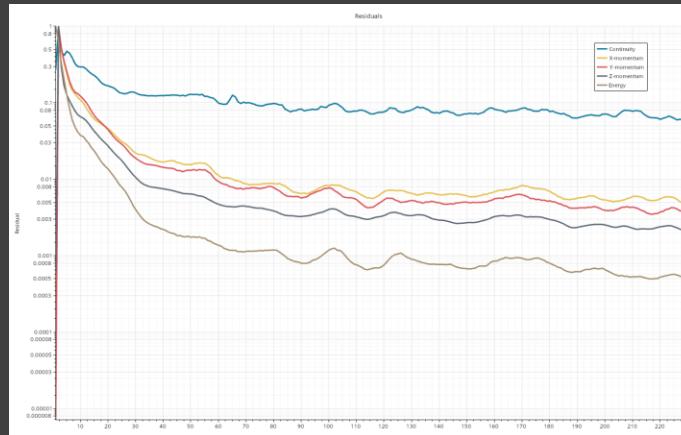


CFD (SECOND SHELL)

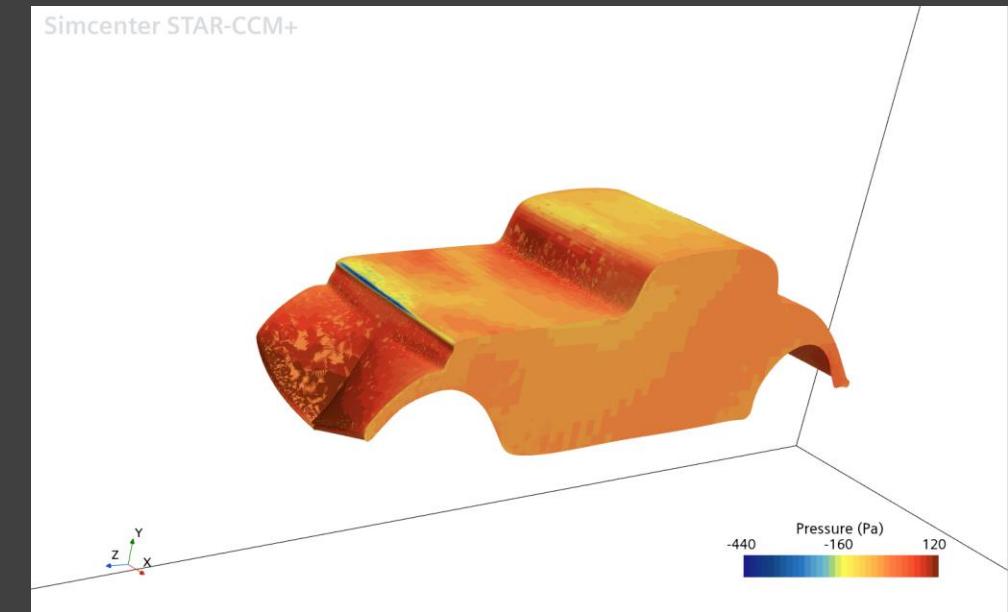
Measured: Drag force

Speed: 30 MPH

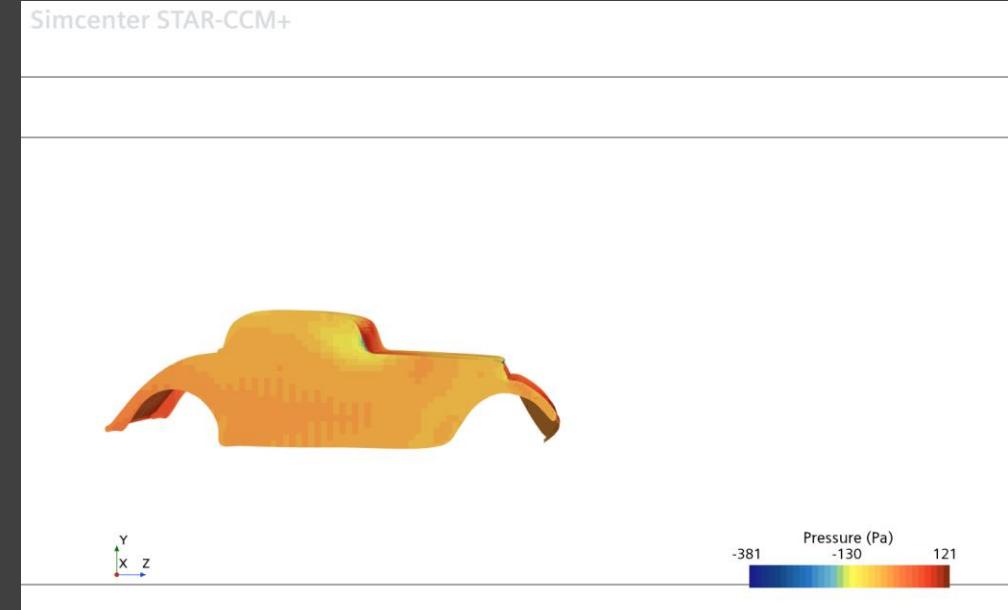
Drag force: 1.4 N



Simcenter STAR-CCM+



Simcenter STAR-CCM+

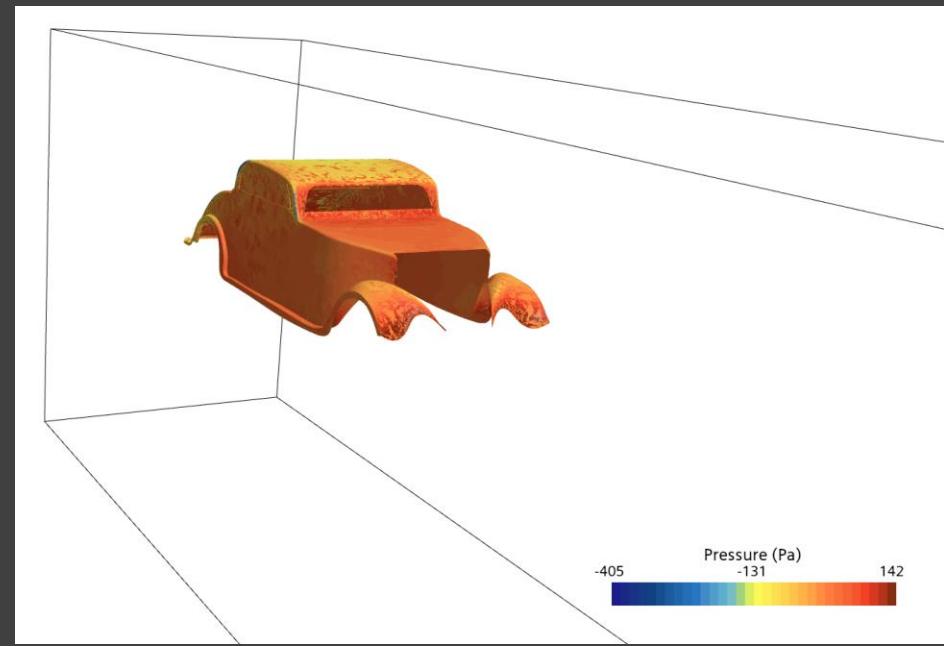
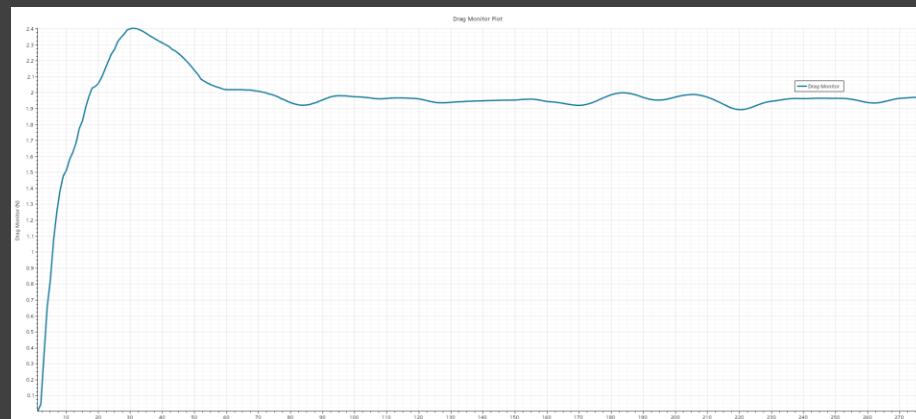
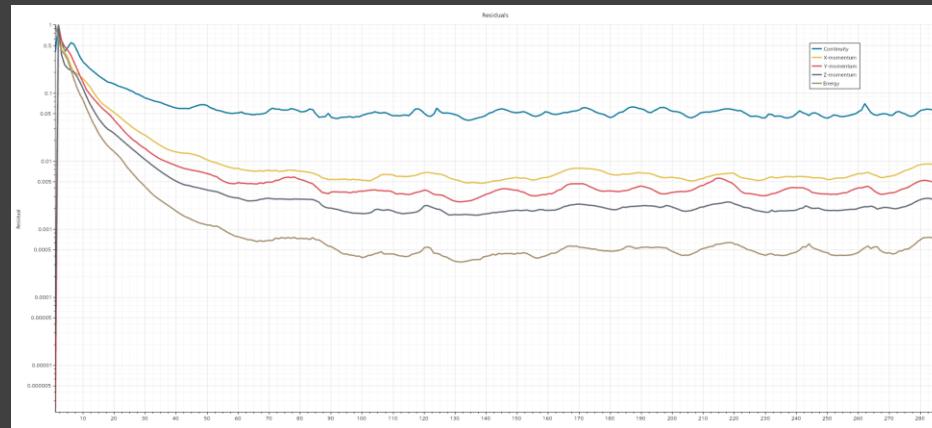


CFD (MODIFIED SHELL)

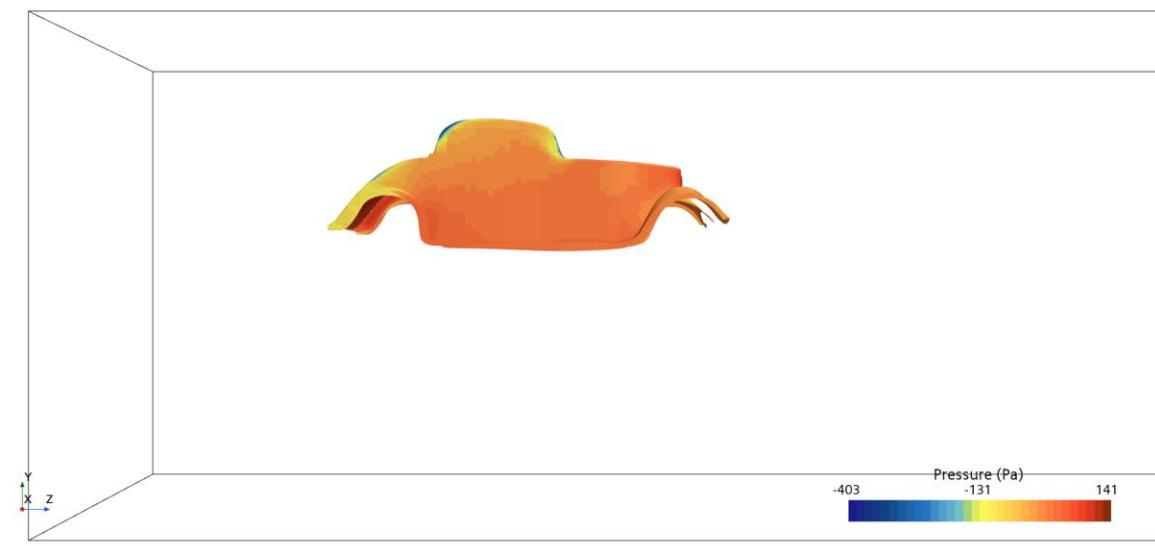
Altered Shell w/o Grill and Windshield

Measured: Drag force [2.0 N]

Speed: 30 MPH



Simcenter STAR-CCM+

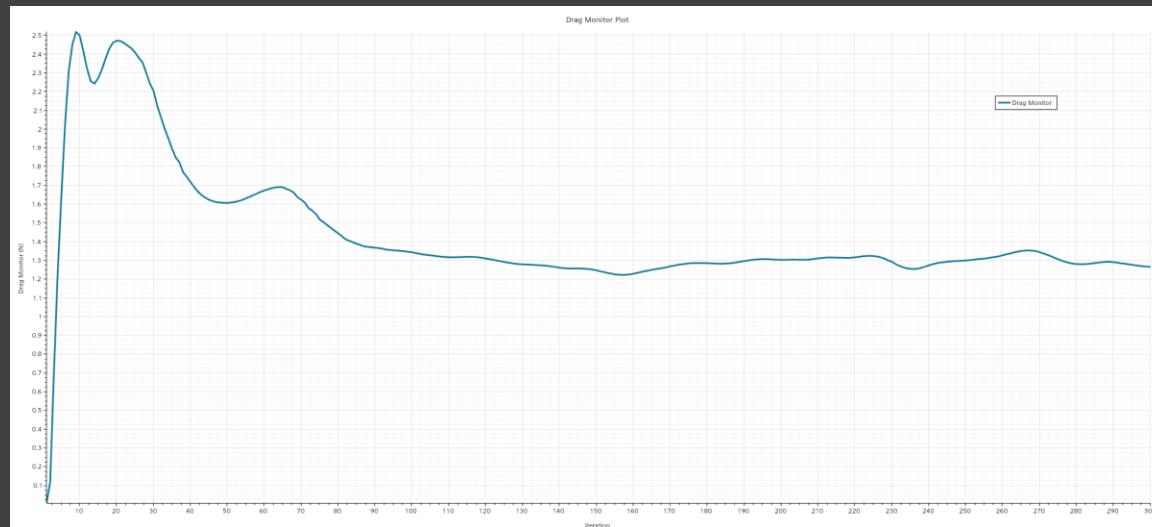


CFD - IMPACT

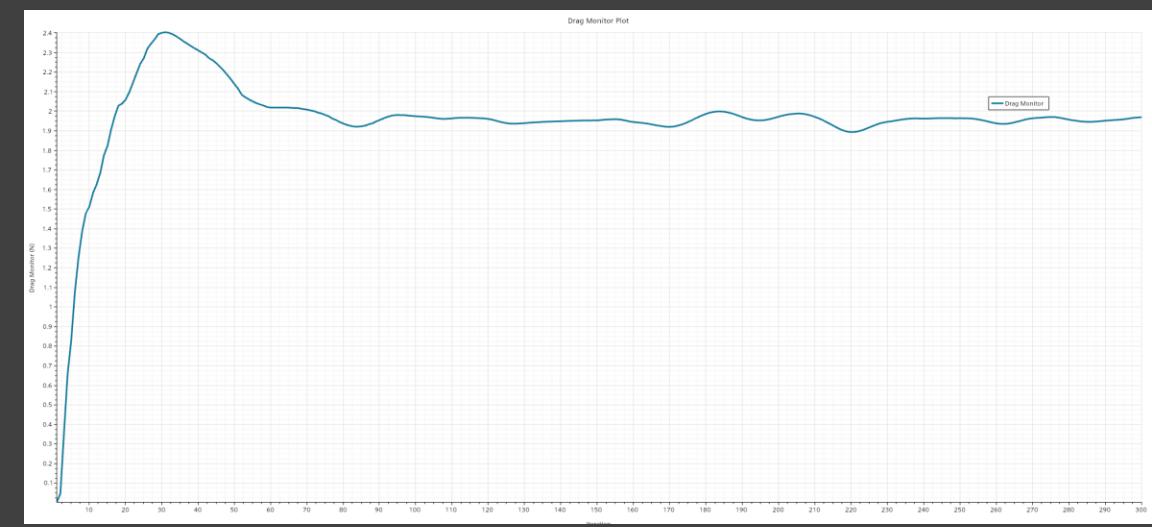
Designed Grill is better for drag force

Drag force: 1.3 Newtons

Removing the grill and windshield results in weight savings but
drastically increase the drag force from 1.3 Newtons to 2.0
Newtons



Designed Shell

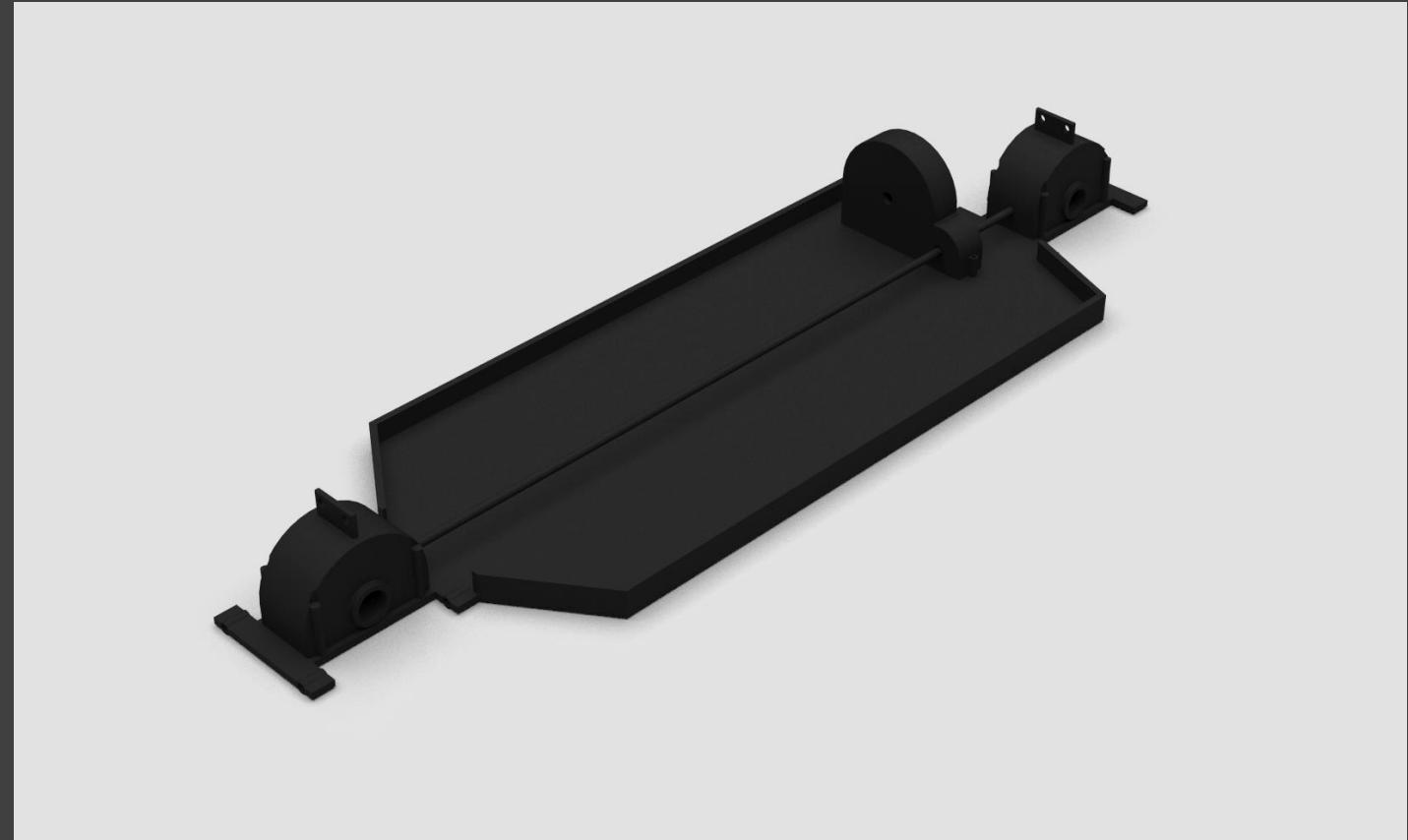


Modified (No grill) Shell

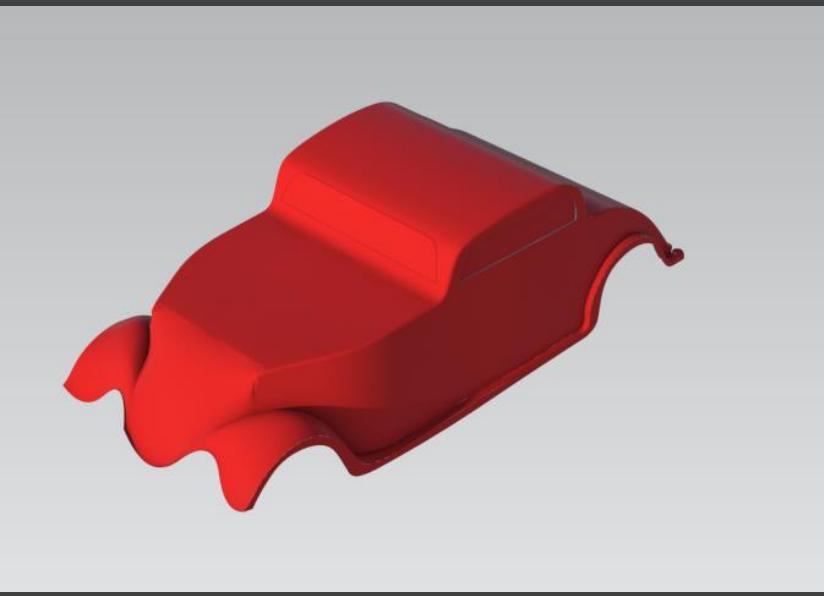
3. Visualization



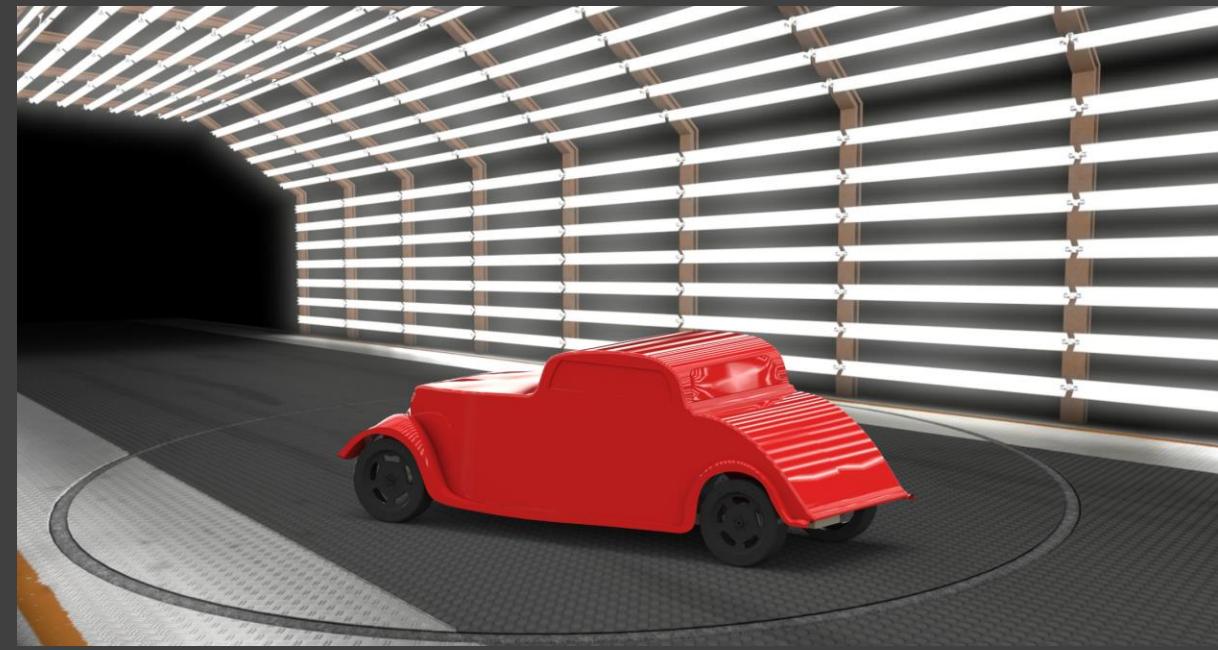
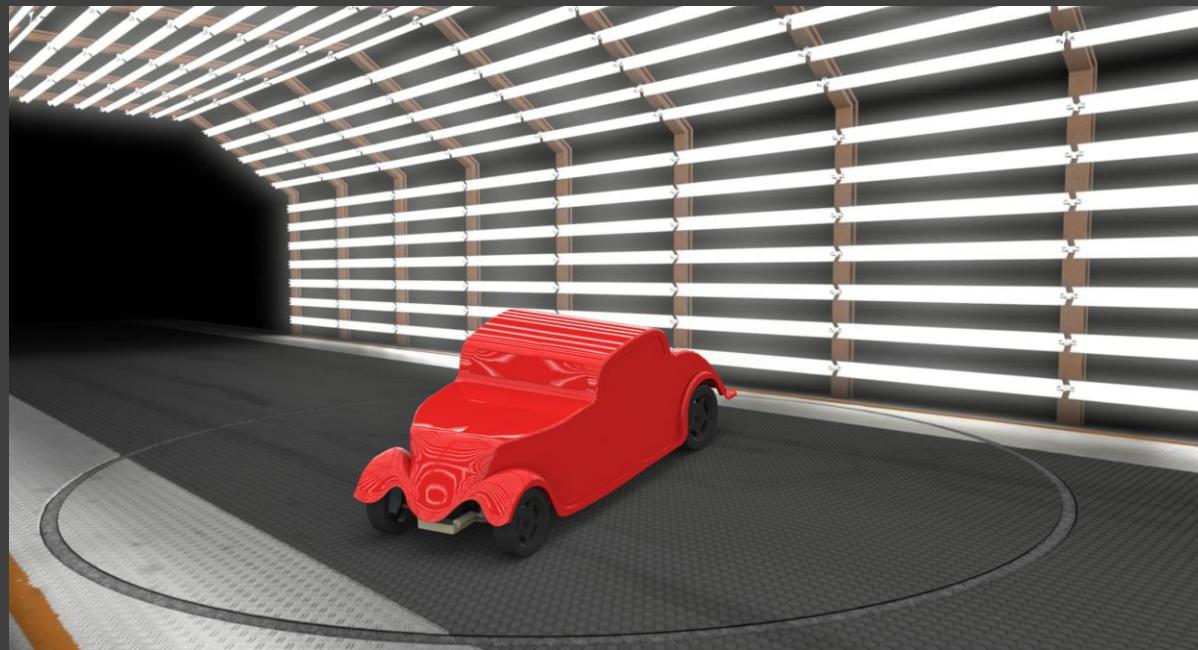
PART VISUALIZATIONS



SHELL VISUALIZATION



FULL CAR VISUALIZATION



FULL CAR VISUALIZATION



FULL CAR VISUALIZATION



ACCOMPLISHMENTS AND DIFFICULTIES

Accomplishments:

- Experience with complex CAD modeling
- Successful simulations (Optimization, CFD, FEA)
- Reducing mass on certain parts
- Reverse engineering

Difficulties:

- Time constraint
- Suspension and drivetrain modeling and parametrization
- Unknown fatal CAD errors



A side-profile view of a shiny red classic hot rod car, possibly a 1932 Ford, parked in a dark, atmospheric garage. The car features a custom body with a prominent front grille, round headlights, and a long hood. The background is dimly lit, showing various garage equipment and a red sign with a white star.

THANK YOU!