TRAXXAS SLASH 4X4 VXL

ME49601 TOOLS/METHODS FOR ITERATIVE PRODUCT DESIGN & ANALYSES

Team Trophy Truck

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Outline

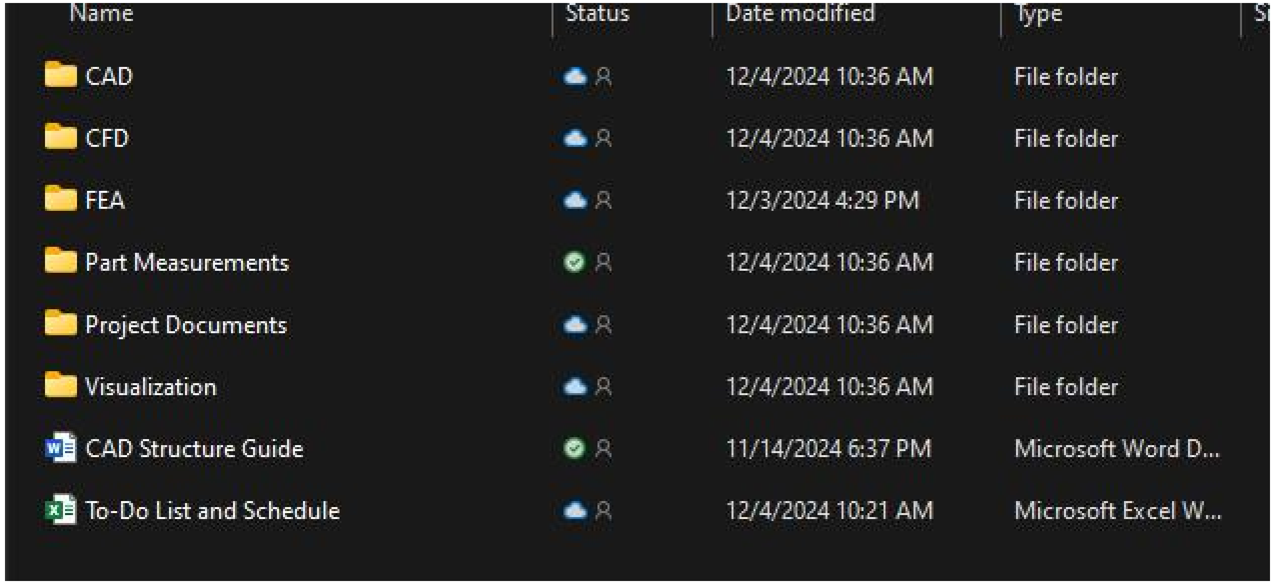
- Team Organization and Collaboration
  - File Structures
  - Team organization
  - Roles and Responsibilities
- CAD Overview
  - CAD structure
  - Wireframe and Shared Parameters
  - Surface and Solid Modeling
  - Mass Properties
- Analysis
  - Component and Assembly FEA
  - Topology Optimization
  - CFD
- Visualization

TEAM ORGANIZATION AND COMMUNICATION

Team Organization and Communication

File Structures

- OneDrive Shared folder with all files
- Files transfer to other softwares:
  - FEA → STEP files
  - CFD → Parasolid Files



Name	Status	Date modified	Type
CAD		12/4/2024 10:36 AM	File folder
CFD		12/4/2024 10:36 AM	File folder
FEA		12/3/2024 4:29 PM	File folder
Part Measurements		12/4/2024 10:36 AM	File folder
Project Documents		12/4/2024 10:36 AM	File folder
Visualization		12/4/2024 10:36 AM	File folder
CAD Structure Guide		11/14/2024 6:37 PM	Microsoft Word D...
To-Do List and Schedule		12/4/2024 10:21 AM	Microsoft Excel W...

Team Organization and Communication

Team Organization

- Item Checklist
  - Helped with accountability and progress tracking
- Schedule to keep all deadlines and relevant information in one place
- Text Group chat for easy communication
- **Parts List and BOM:**
  - Helps keep track of parts and also ensures the team doesn't overlook parts during CAD and Analysis
  - Not all hardware is included in BOM, but instructions on where to keep hardware are provided
- **Team Standards:**
  - Standardization of units, naming conventions
  - Text Group chat with reminders

To Do Item	Due Date	Assigned to	Started	Completed	Checked Off
Create To Do list	10/28/2024	Connor	Y	Y	SG
Update Schedule	10/28/2024	Connor	Y	Y	SG
Initial Shell CAD	11/6/2024	Sidh	Y	Y	CD
Shell CFD	11/9/2024	Sidh	Y	Y	CD
Initial Chassis CAD	11/6/2024	Jackson	Y	Y	CD
Chassis Torsion FEA	11/9/2024	Jackson	Y	Y	CD
Drivetrain CAD	11/6/2024	Connor	Y	Y	CD
~~MOI / Torque Analysis for bigger tires~~	~~11/9/2024~~	~~Connor~~	~~N~~	~~N~~	
Initial Suspension CAD	11/6/2024	William	Y	Y	CD
~~Suspension Motion Study~~	~~11/9/2024~~	~~William~~	~~N~~	~~N~~	
Weigh Components and Parts List	11/1/2024	Connor	Y	Y	WS
Prelim Render/Visualization	11/10/2024	Sidh	Y	Y	CD
Main Assm Skeleton Sketch	11/12/2024	Sidh	Y	Y	CD
Driveshaft Torque FEA	11/18/2024	Connor	Y	Y	SG
Differential Cases Modeling	11/21/2024	Connor	Y	Y	JJ
Final Chassis CAD	11/21/2024	Jackson	Y	Y	CD
Final Shell CAD	11/21/2024	Sidh	Y	Y	CD
Gear Torque Topology Optimization	11/17/2024	Connor	Y	Y	CD
Rear Suspenion modeling	12/4/2024	William	Y	Y	CD
Full assembly visualization	12/4/2024	All	Y	Y	CD
Optimization screenshots	12/4/2024	Connor	Y	Y	SG
FEA/CFD files and screenshots	12/4/2024	Connor	Y	Y	SG
All screenshots in presentation	12/4/2024	All	Y	Y	CD
Finish presentation	12/4/2024	All	Y	Y	CD
Final Chassis Top Optimization	12/4/2024	Connor	Y	Y	JJ
Final Chassis FEA	12/4/2024	Connor	Y	Y	JJ
FEA of bottom support and Top rod	12/4/2024	William	Y	Y	CD
Tire Tread	12/4/2024	William	Y	Y	CD
Custom Livery	12/4/2024	Sidh	Y	Y	CD
Front Bumper FEA	12/4/2024	Connor	Y	Y	WS
Rear Byumper FEA	12/4/2024	Connor	Y	Y	WS
Control Arm Topology Optimization	12/4/2024	Connor	Y	Y	WS
Presentation and Flash Drive Submission	12/4/2024	All	Y	N	

Assignment	Due Date	Notes
RC Car Progress Presentation 1	11/11/2024	RC Car Vehicle Project Design Review #1.docx
Full Parametric Car CAD	11/16/2024	Linked CAD
Car Parts List	11/1/2024	Track all parts. VIDEO teardown
Car Component Weight	11/1/2024	weights in BOM
RC Car Progress Presentation 2	11/18/2024	Will link doc when posted
RC Car Progress Presentation 3	11/25/2024	Will link doc when posted
Semester Project Presentation	12/4/2024	Final Project Description - F22.docx
Turn In USB drive of shared files	12/4/2024	

Team Organization and Communication

Roles and Responsibilities

Name	Responsibility
Jonathan Jackson	Chassis
Connor Day	Drivetrain/FEA & Topology
Sidh Gurnani	Primary Shell Surface/CFD
William Snyder	Front/Rear Suspension

CAD OVERVIEW

CAD Overview

CAD Structure

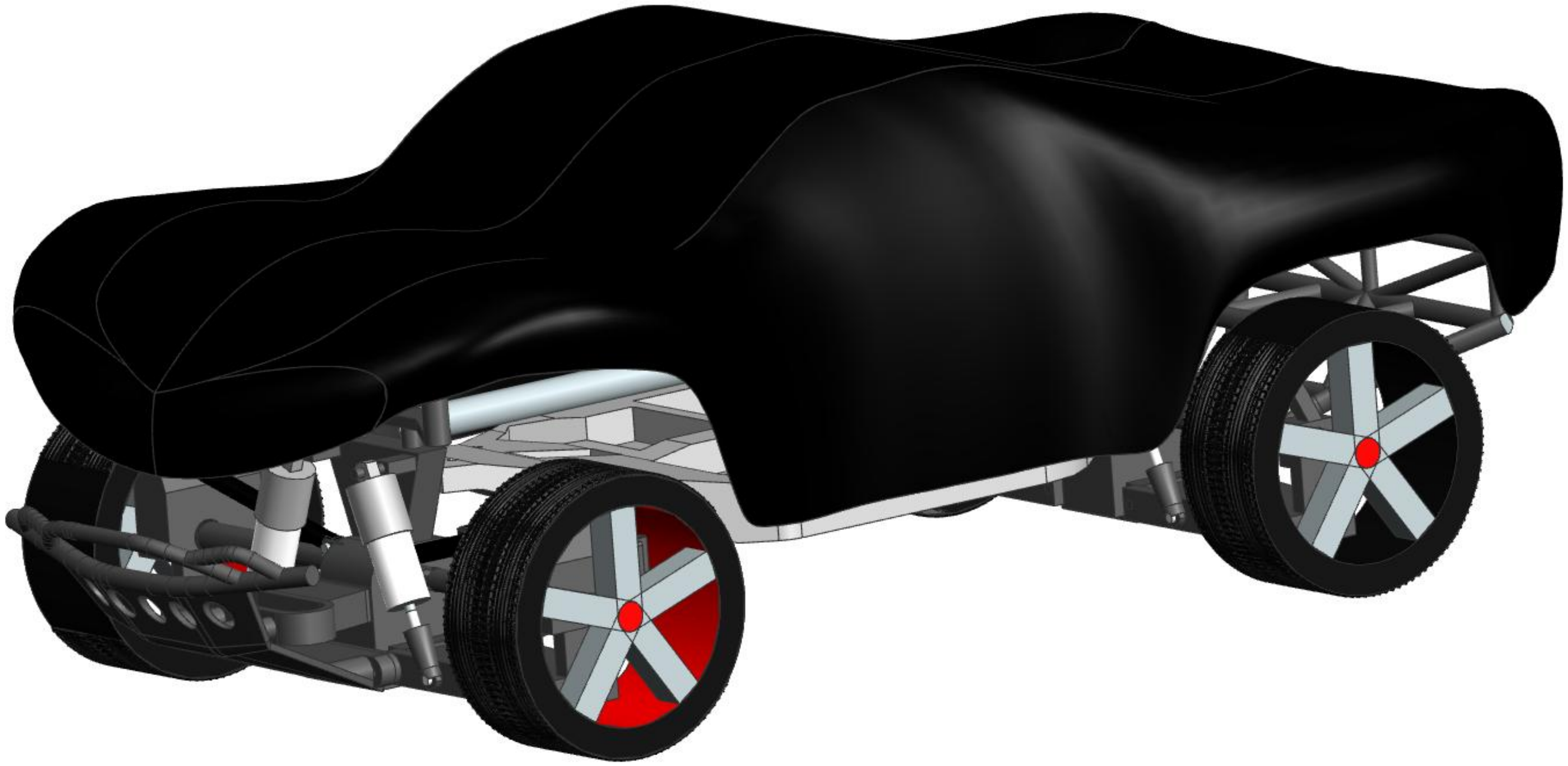
Top-Down Skeleton

- Overall System Geometry
- Expressions

Subsystems

- Shell
- Drivetrain
- Chassis
- Suspension

Overall CAD



Wireframe and Shared Parameters

- Global Scale Factor
- Accurate Datum Planes/Wireframe model for sub-assembly references
  - Relevant geometry from skeleton and wireframes wavelinked into parts and assemblies as needed
  - Linked parameters were also used to share dimensions

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1	Default Group					
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4	p5	12*SCALE	12	in	Length	Number
5	p8	3.5*SCALE	3.5	in	Length	Number
6	p11	3.5*SCALE	3.5	in	Length	Number
7	p14	0.65*SCALE	0.65	in	Length	Number
8	p17	0.65*SCALE	0.65	in	Length	Number
9	p20	11.7/2*SCALE	5.85	in	Length	Number
10	p23	11.7/2*SCALE	5.85	in	Length	Number
11	p26	0.6*SCALE	0.6	in	Length	Number
12	p29	0.6*SCALE	0.6	in	Length	Number
13	p32	0	0	in	Length	Number
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18	p94	4.08*SCALE	4.08	in	Length	Number
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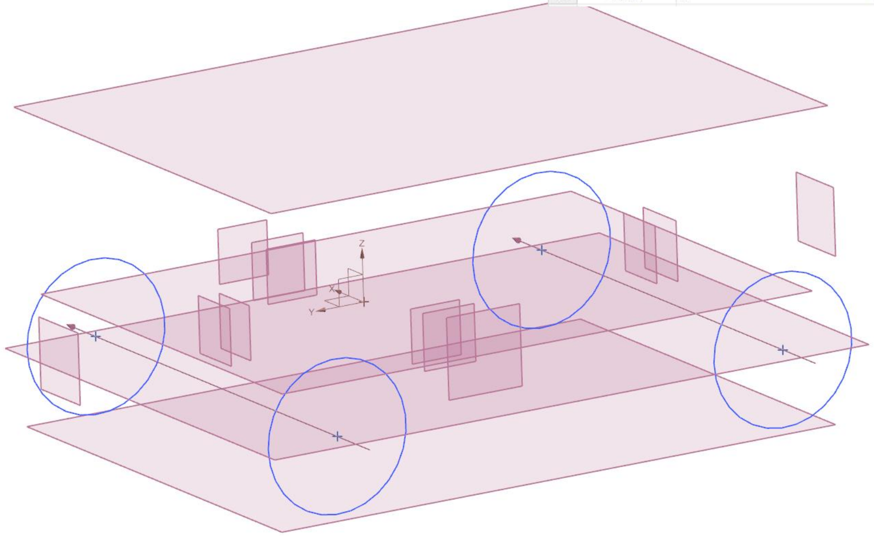


CAD Overview

Primary Surface Modeling

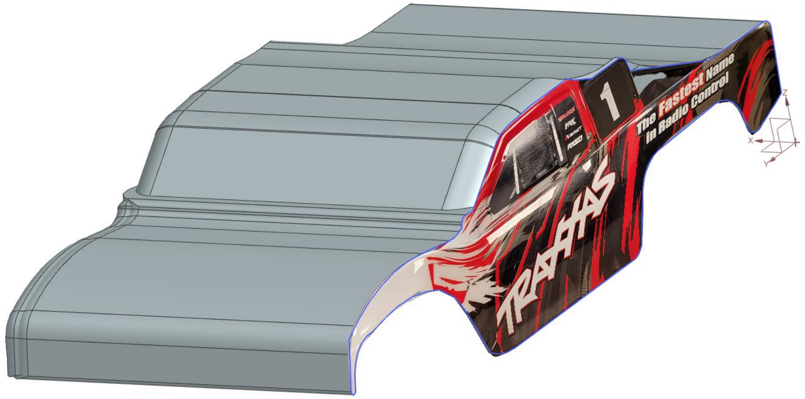
CAD Overview

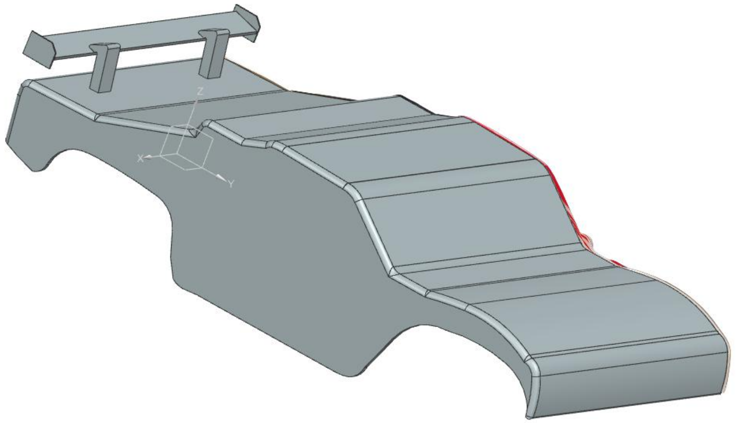
Primary Surface Modeling

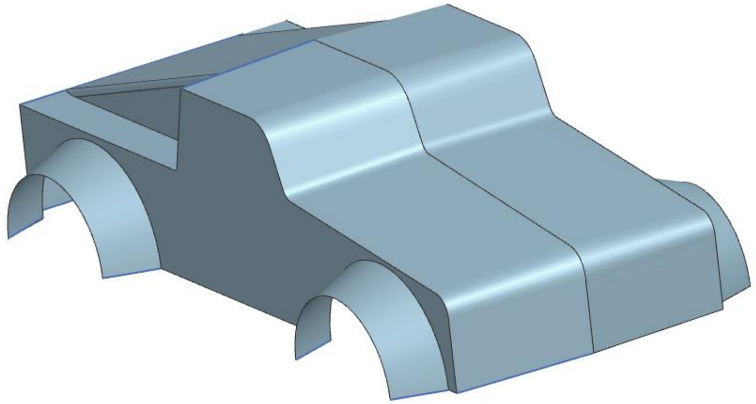
- Slightly modified from Traxxas's
  - Overall tighter packaging and reduction of sharp corners throughout surface
  - Creates smoother surface overall

CAD Overview

Secondary Surface Modeling



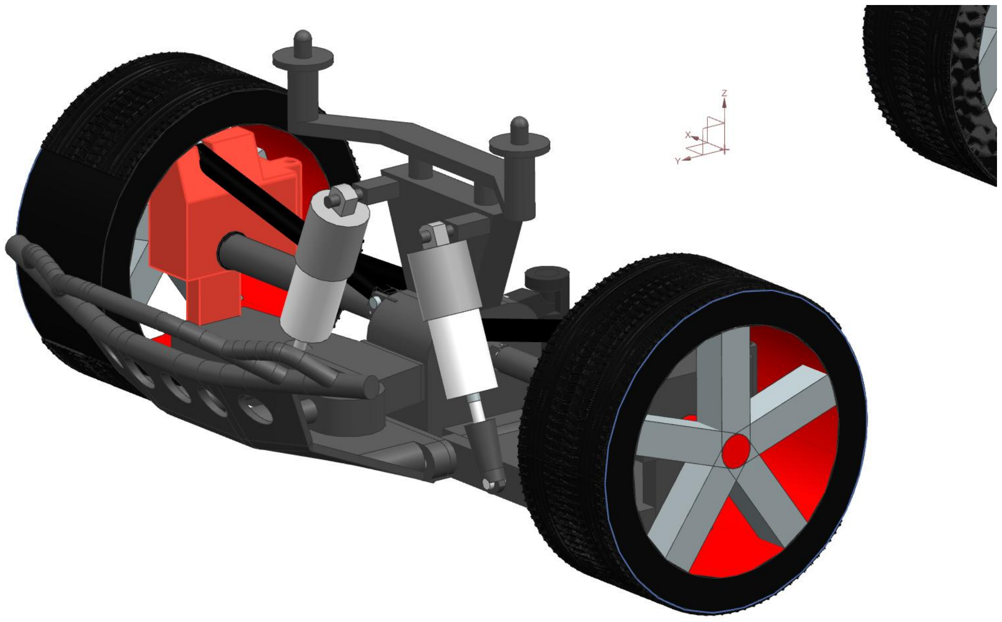


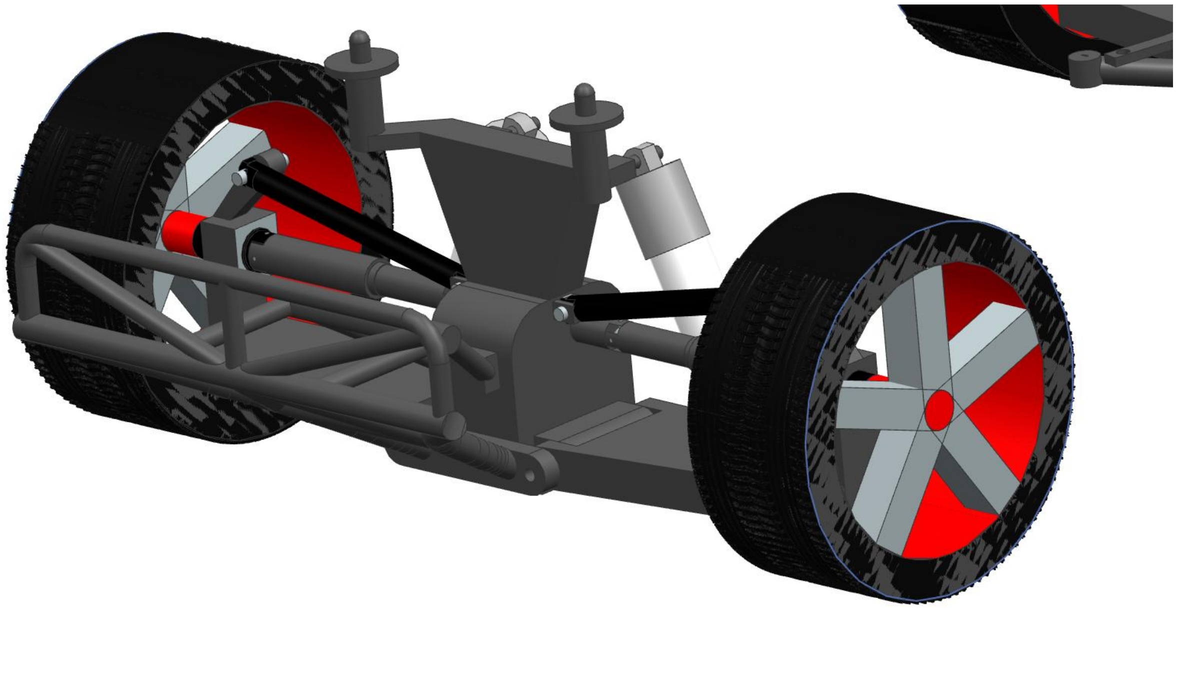


CAD Overview

Solid Modeling: Suspension Subassemblies

- Select parts were modeled with Optimization in mind

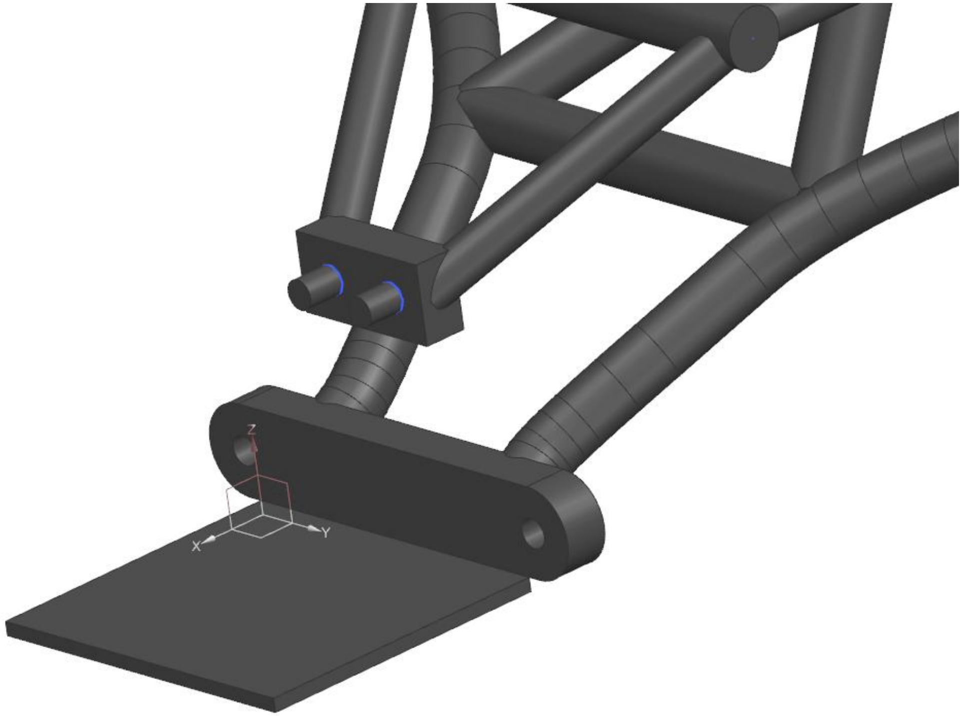


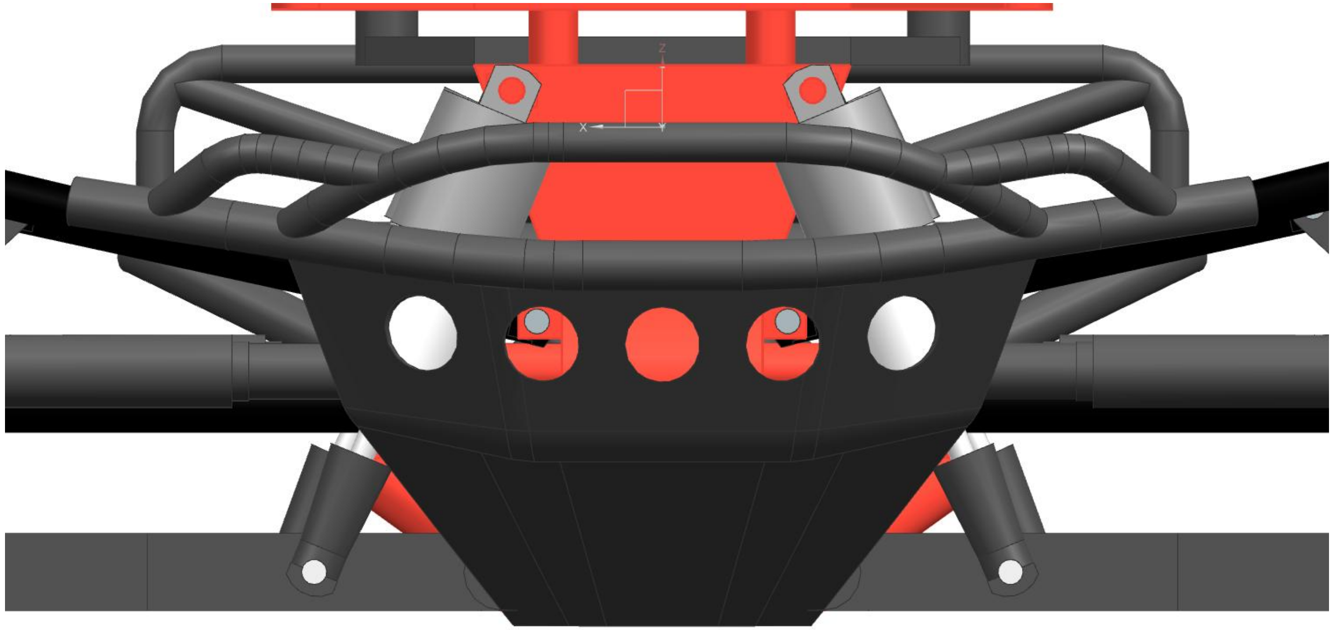


CAD Overview

Solid Modeling: Suspension Re-Engineering

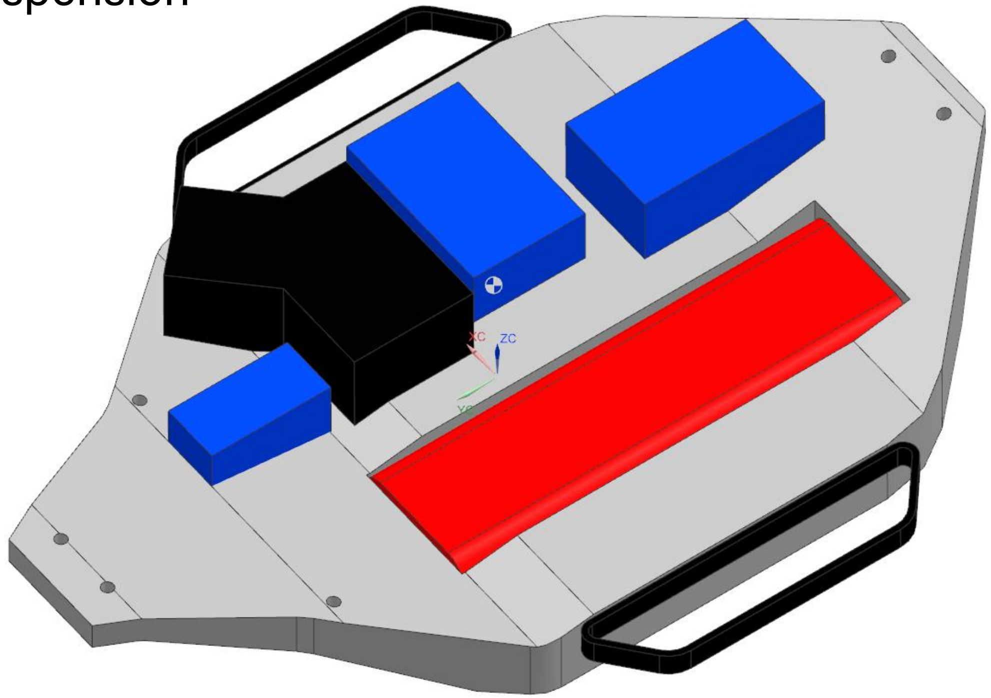
- Rear suspension had no upper supports
- Rear suspension location change

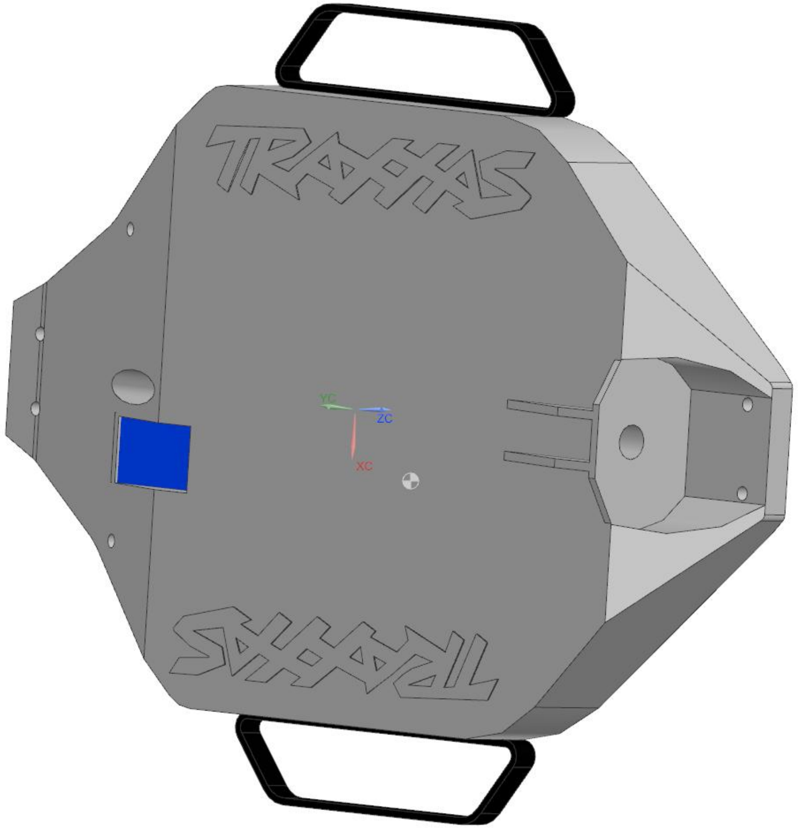




Solid Modeling: Chassis

- Modeled with optimization in mind
- More time for finer details
- Integrate with front & rear suspension





CAD Overview

Mass Properties

- Mostly ABS Plastic (high impact in Ansys)
  - Shell is Polycarbonate
- Yield Strength: 40 ksi
- Differs in CAD because of lack of optimized parts and design improvements

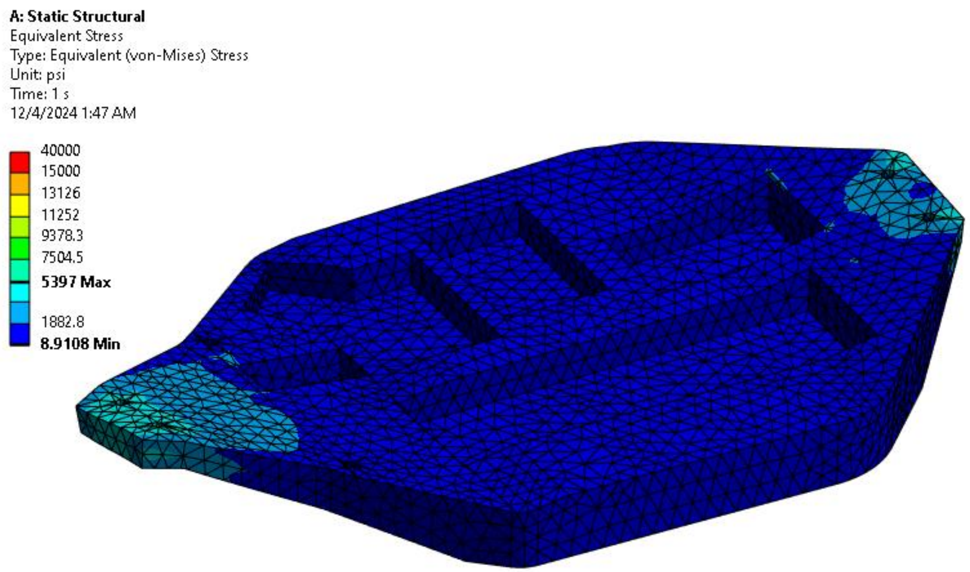
Part Description	Qty	Mass (g)	CAD Mass (g)	Difference	NOTES
Chassis	1	1165	1390	-225	Chassis left blank for optimization
Front Suspension	1	645	860	-215	Differs because topology optimization not considered/no cutouts, solid shocks, etc.
Rear Suspension	1	636	680	-44	^^See above
Shell	1	198	79	119	Optimized shell thickness
Total		2644	3009	-365	

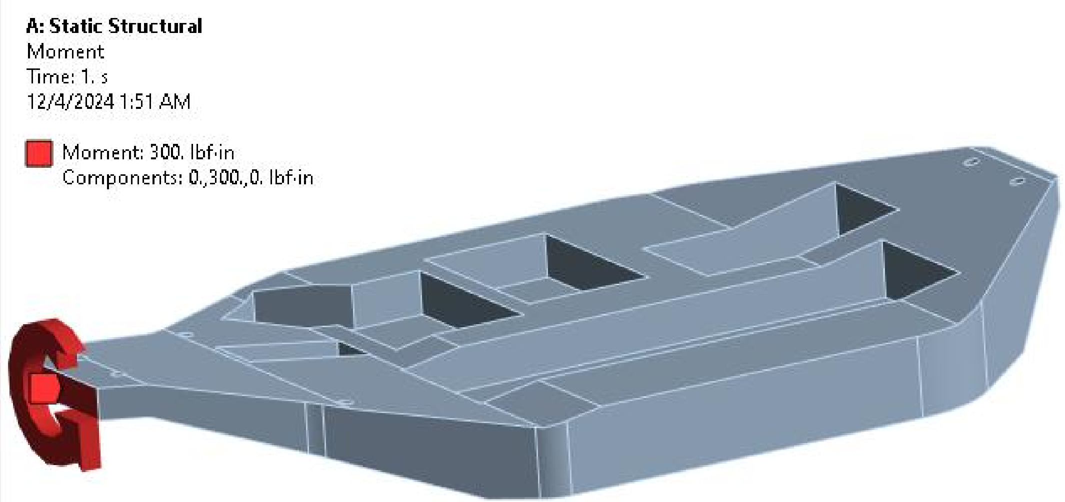
ANALYSIS AND OPTIMIZATION

Chassis Torsion and Impact FEA

- Fixed back plane
- Cylindrical Supports at bolt holes
- Tetrahedral Mesh size: .25"
- Moment applied at front face

- Torsional stiffness provides basis for future assembly FEA and validates rigid constraints. Low deflection shows this is strong enough to assume this.

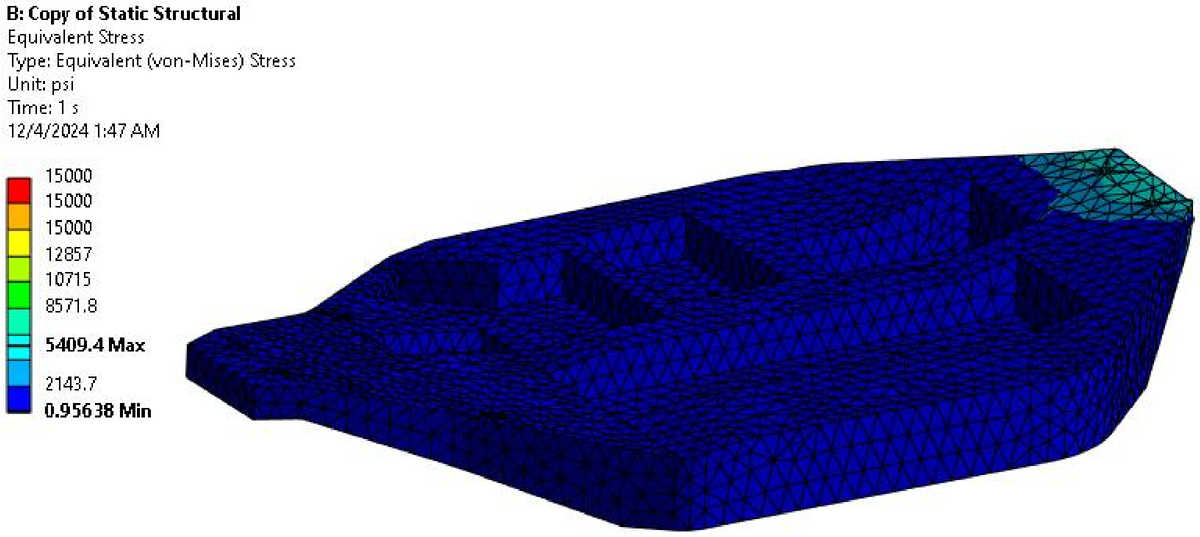


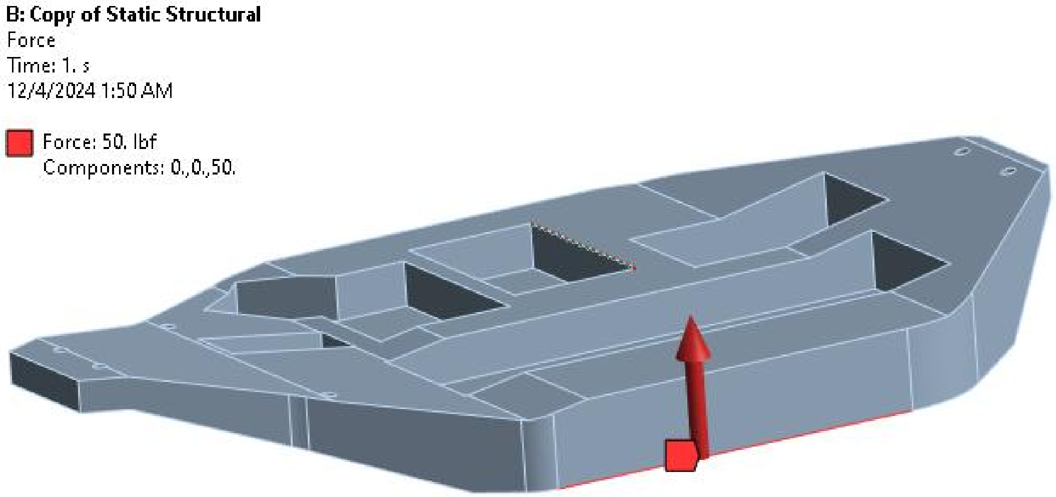


Chassis Side Impact FEA

- Same setup as previous
- 50lbs on leftmost edge upward

- Stress is high but not close to 2.0 FOS



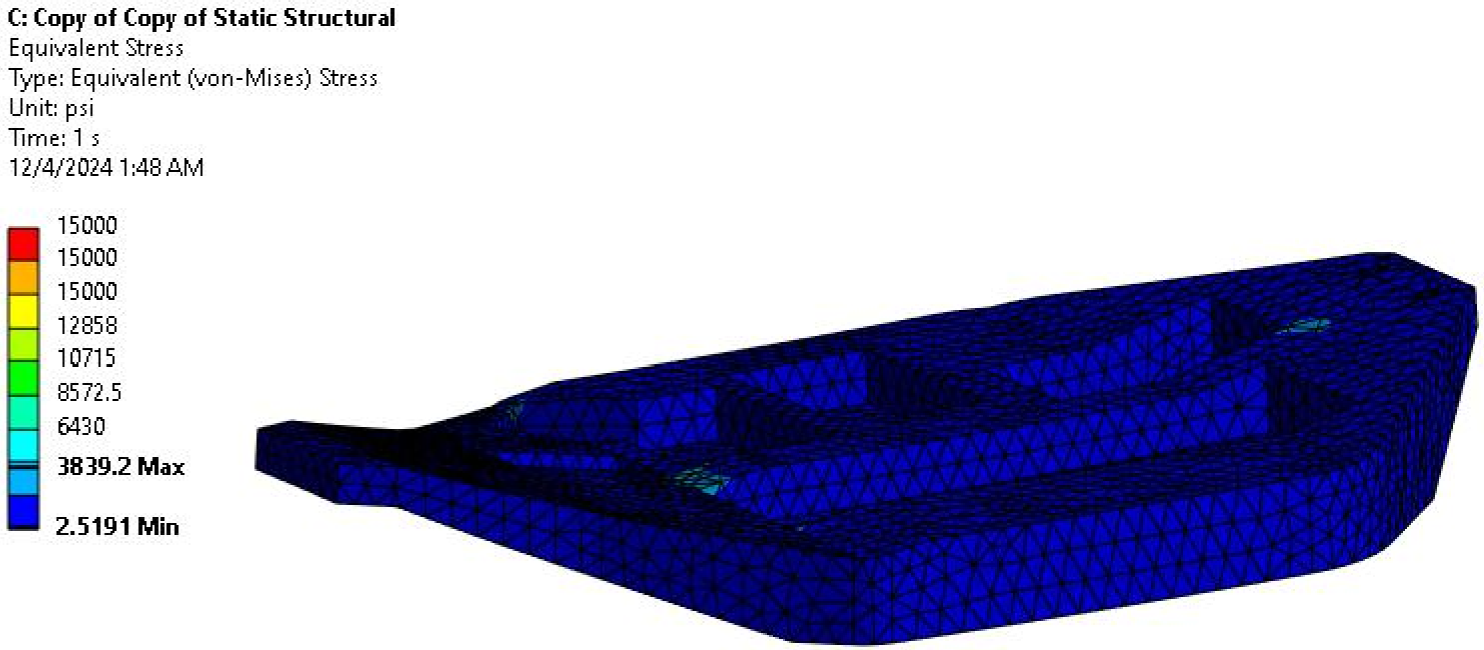


Analysis and Optimization

Chassis Front Impact FEA

- Same Fixed Geometry
- 500lbf applied at front face

- Low stress allows for much material removal



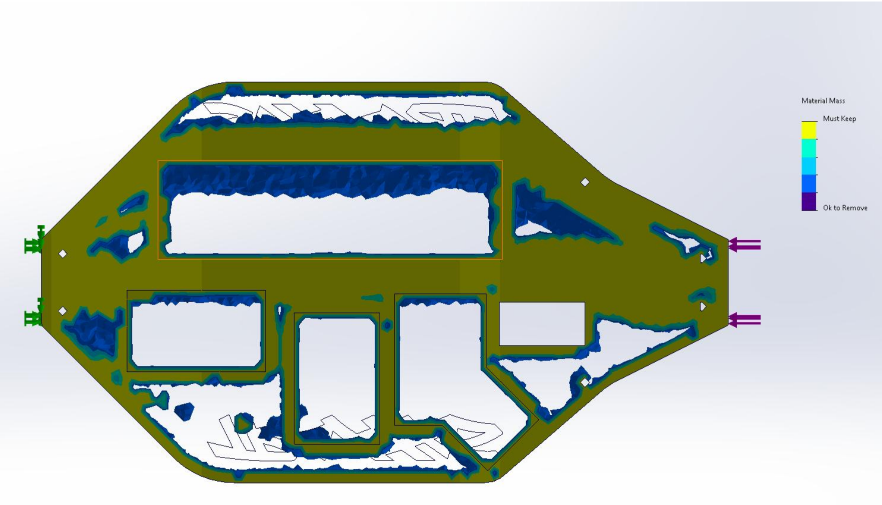
Analysis and Optimization

Chassis Topology Optimization

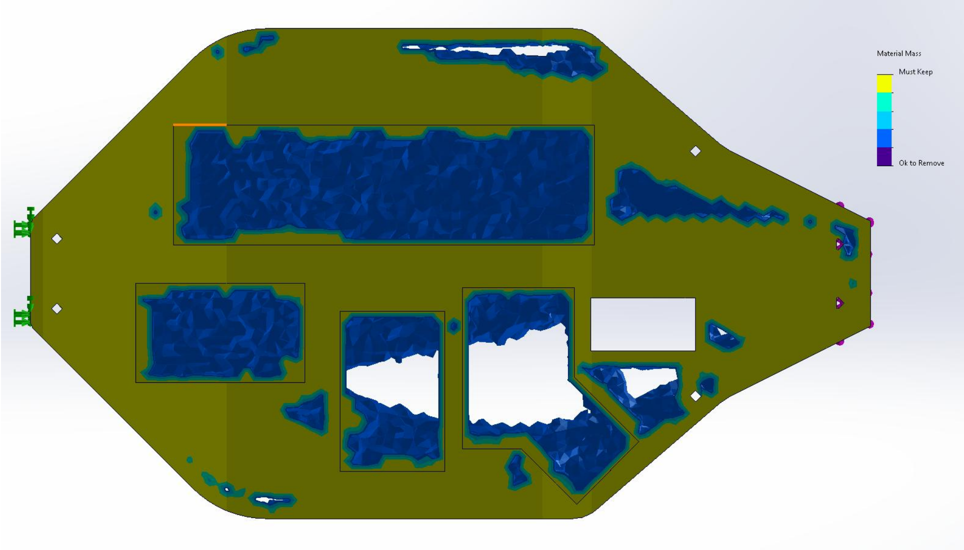
- Kept outside geometry
- Fixed back face
- 20% weight reduction and 1.3 stiffness factor
- Force applied at front edge to simulate front impact, putting chassis in bending

- Significant amount of material can be removed

Study 1



Study 2



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Analysis and Optimization

Drivetrain FEA Torque Calcs

Motor Data:

Titan 12T

Max Torque Output: 1.5-2Nm

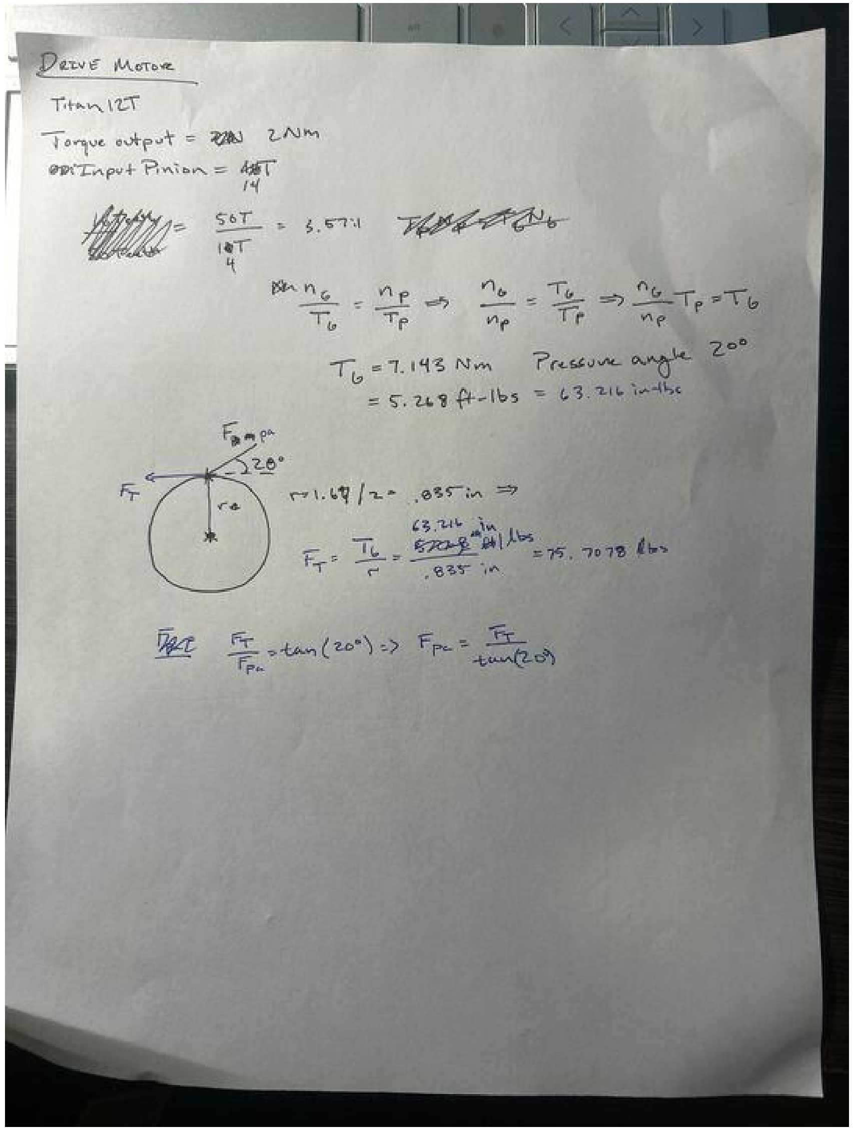
Gear Ratio: 3.57:1

Pressure Angle: 20 deg.

Torque at Gear: 63.216 in-lbs

Equivalent Force Tangent = 75.708 lbs

Equivalent Force at Pressure angle: 208.005 lbs



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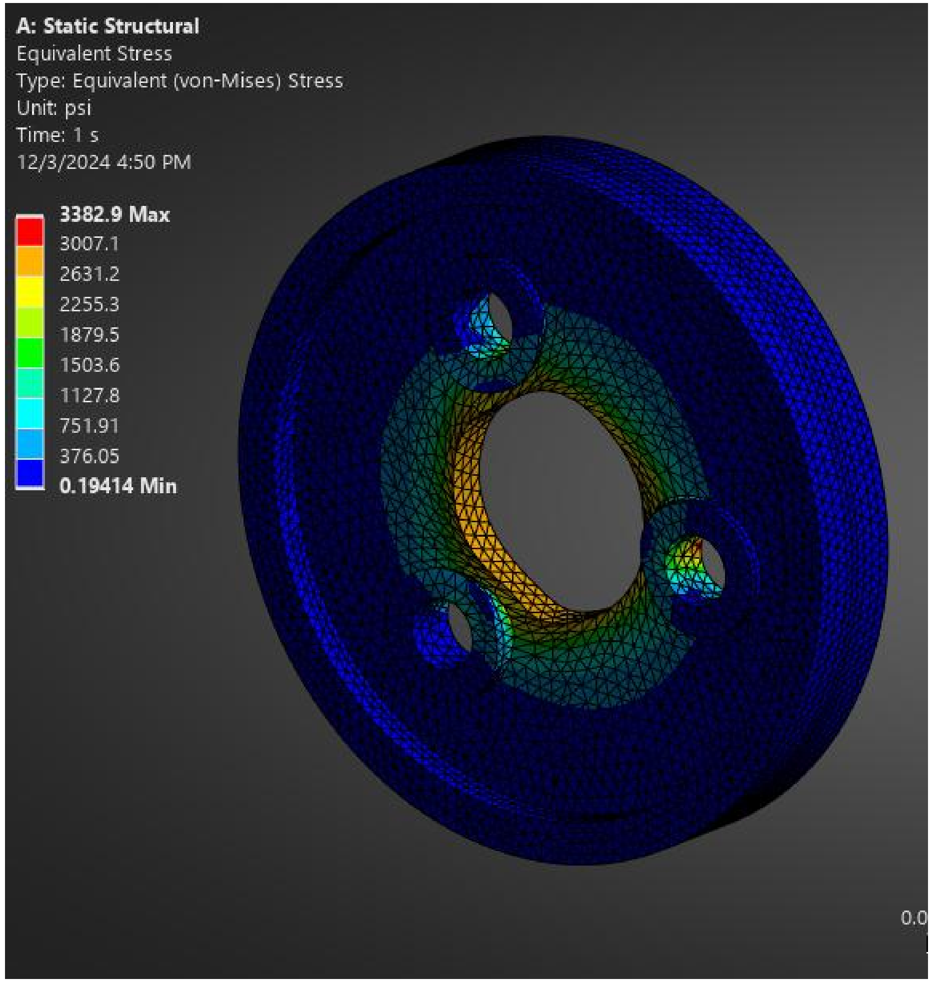
Analysis and Optimization

Drive Gear FEA

- Tetrahedral Mesh (size .035 in)
- ABS plastic (high impact)
- Torque applied from calculation: 63.2 in-lbs at center cylinder
- Fixed cylindrical supports at bolts and at edge
- Material Yield: 36 ksi



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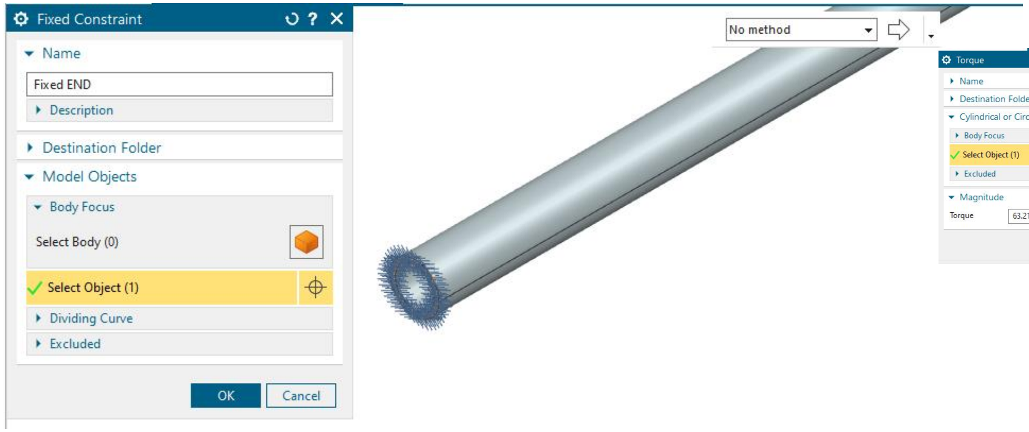
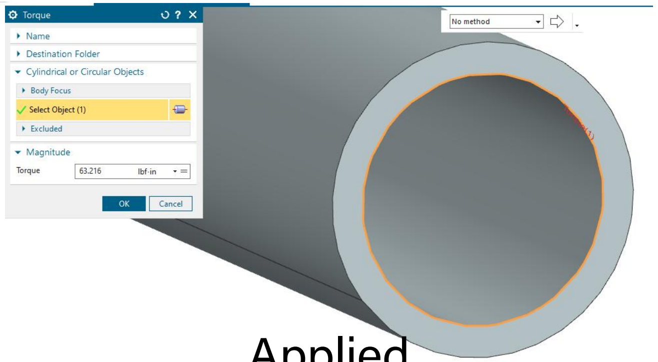
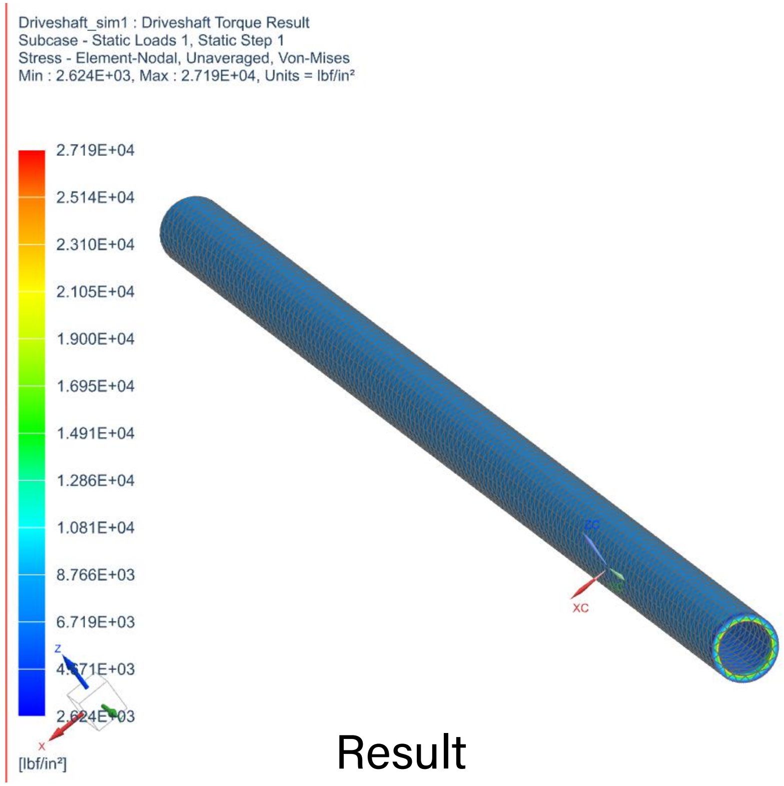
Analysis and Optimization



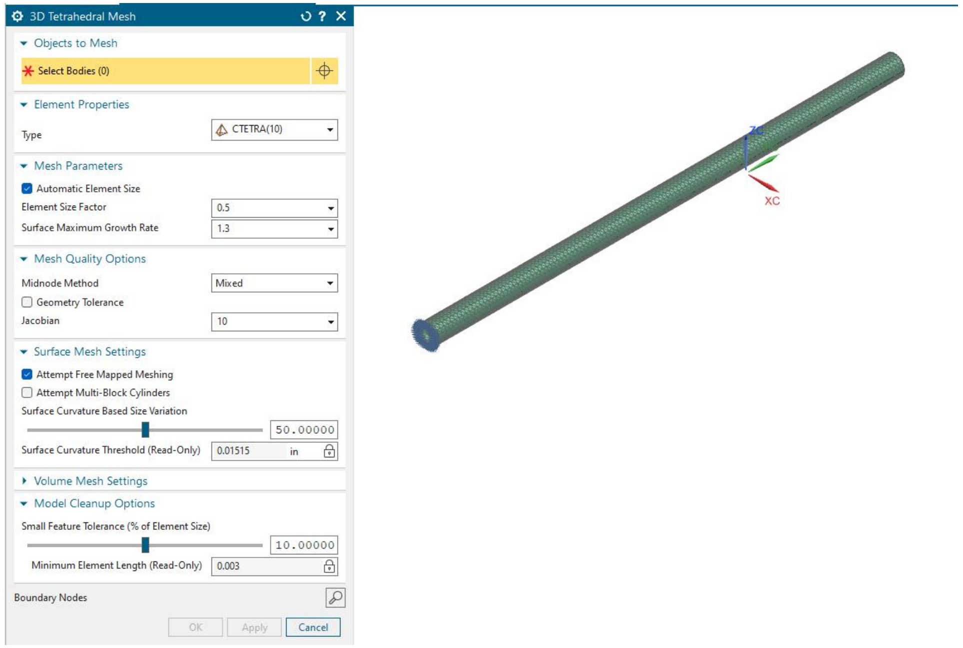
Fixed Constraint



Applied Torque



Result

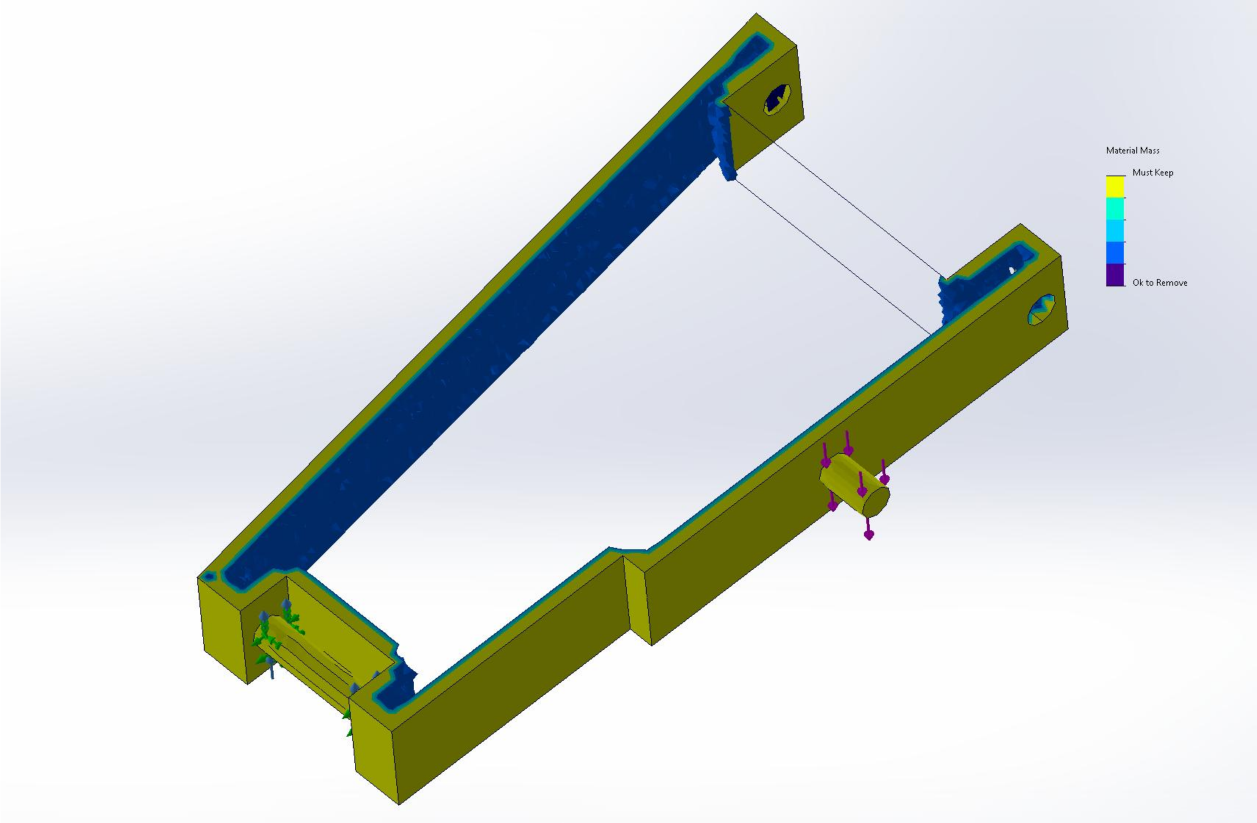


3D Tet Mesh

Analysis and Optimization

Bottom Support Topology Optimization

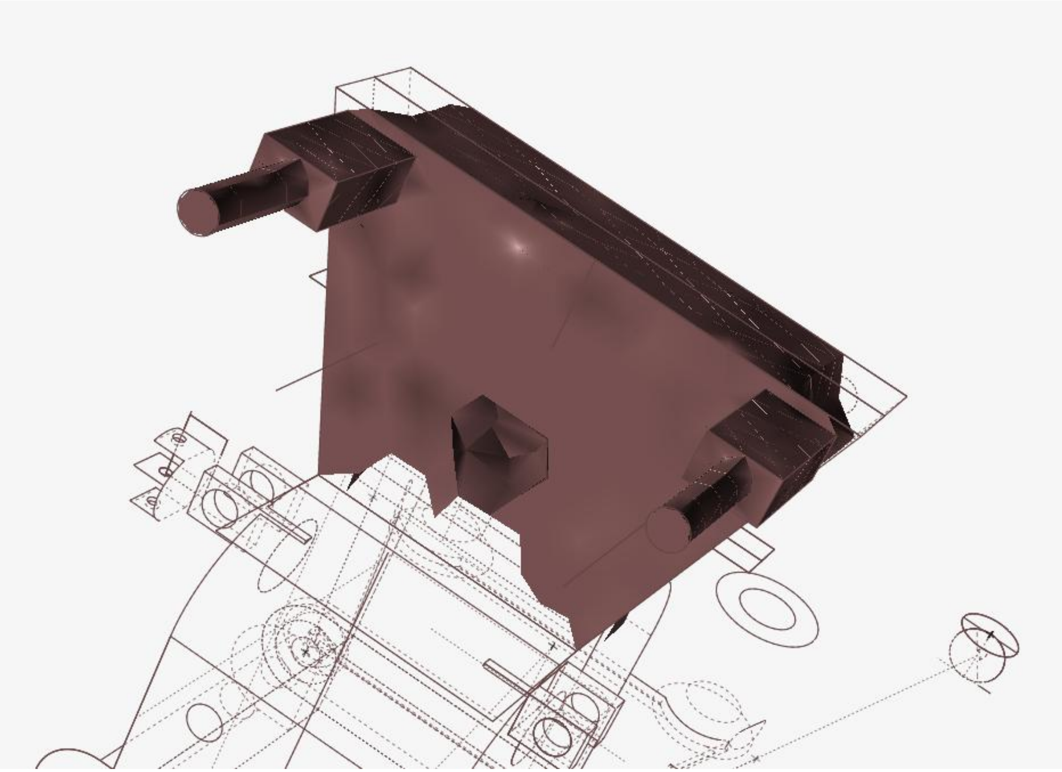
- Cylindrical Supports at bolt holes and bearing
- Keep Geometry outline
- Forces applied at outer cylinder and shock mount point
- 20% weight reduction and 1.2 deflection factor
- Would need to keep material in center for additional stiffness

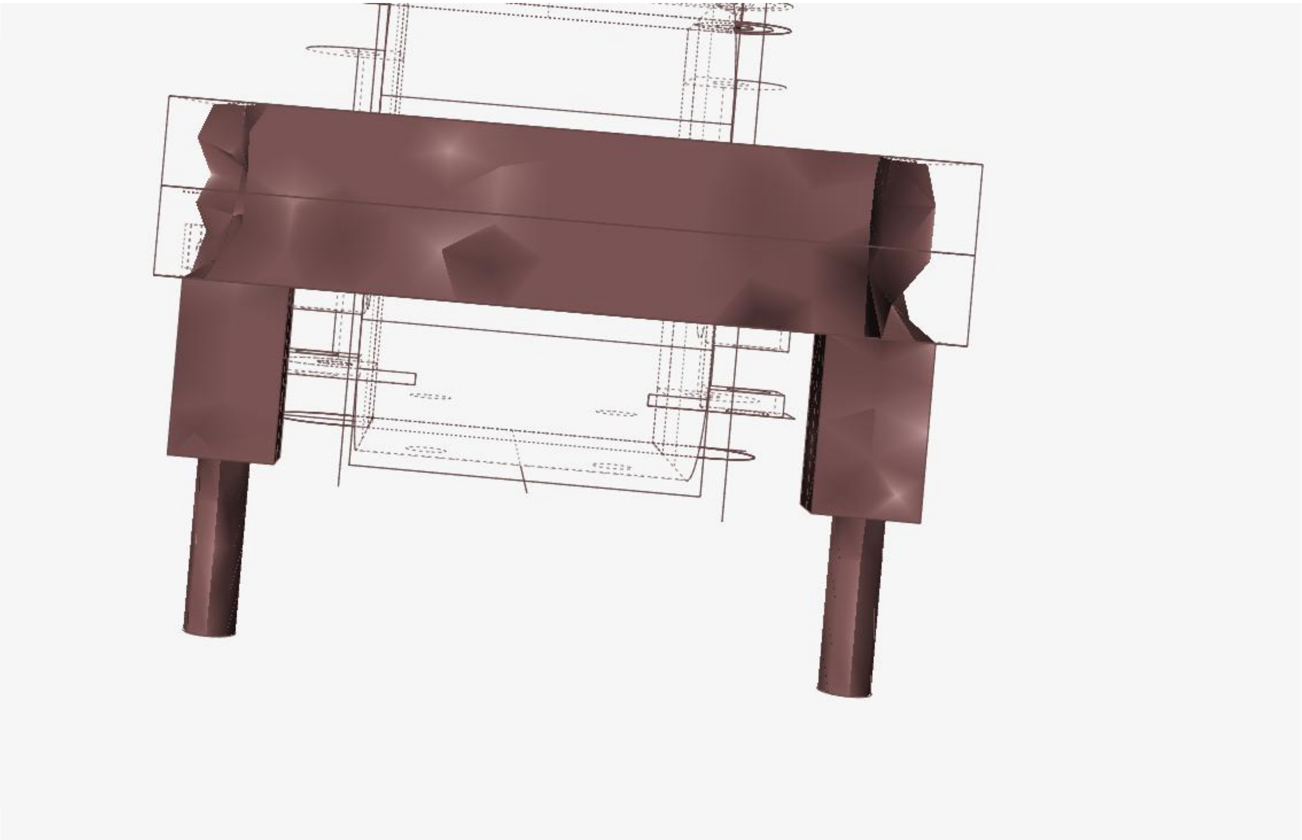


Analysis and Optimization

Suspension Center Piece Topology Optimization

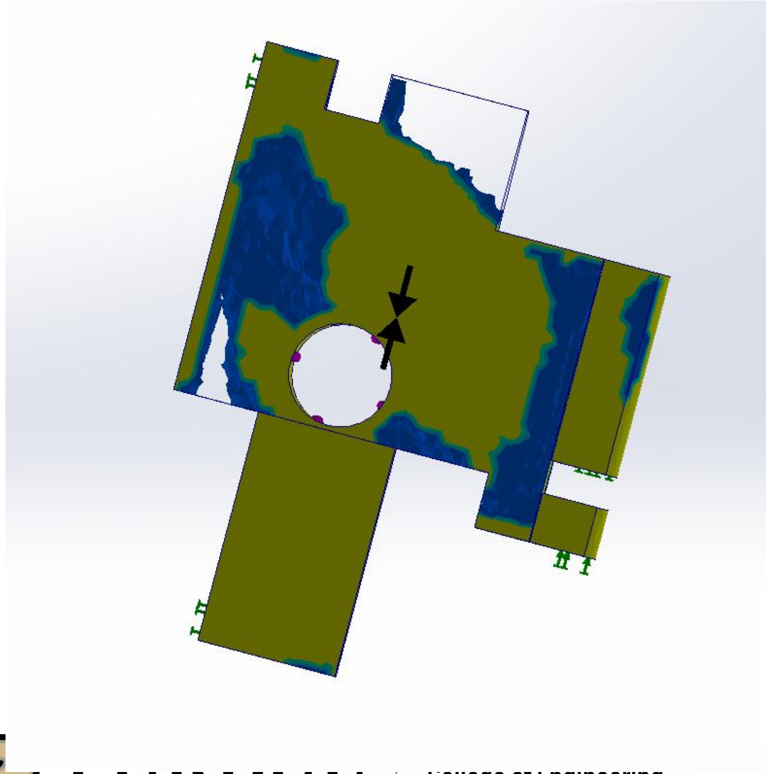
- Fixed geometry
- 100 lb applied at 30 degrees

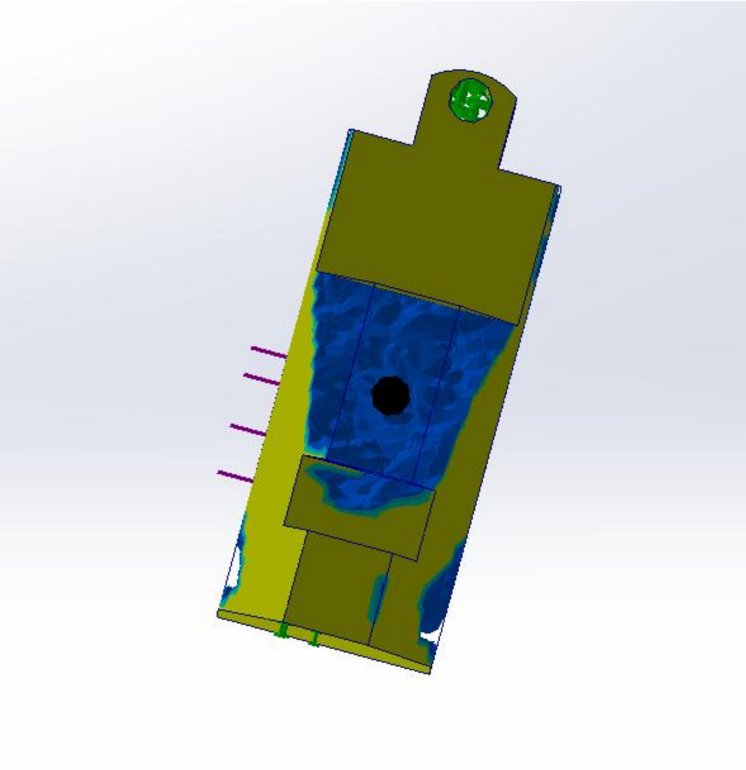




Wheel Attachment Topology Optimization

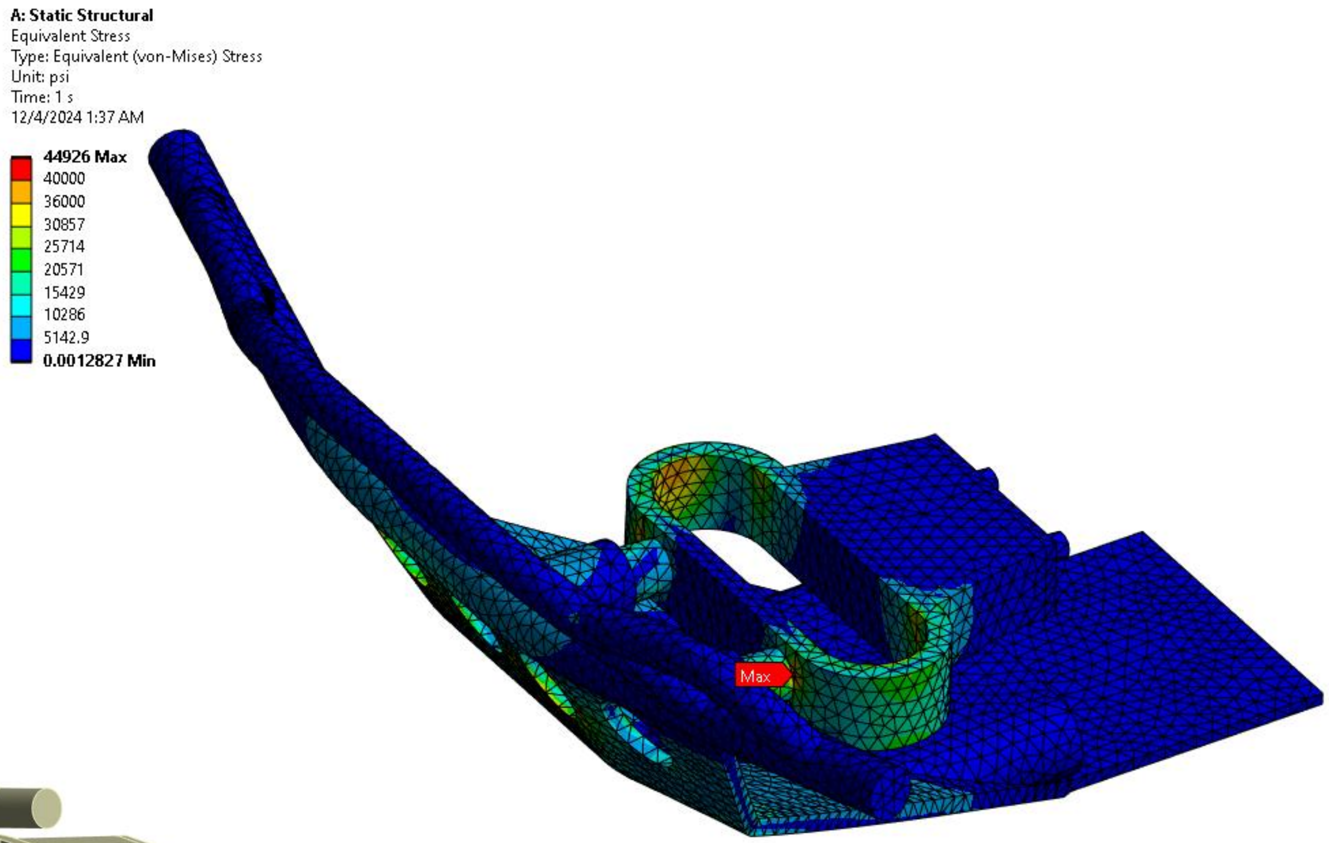
- Manufacturing constraints on holes for bolts and wheel
- Fixed geometry at outer boundaries
- Force Applied at the Wheel Center Inboard
- 10% weight reduction and 1.1 deflection factor





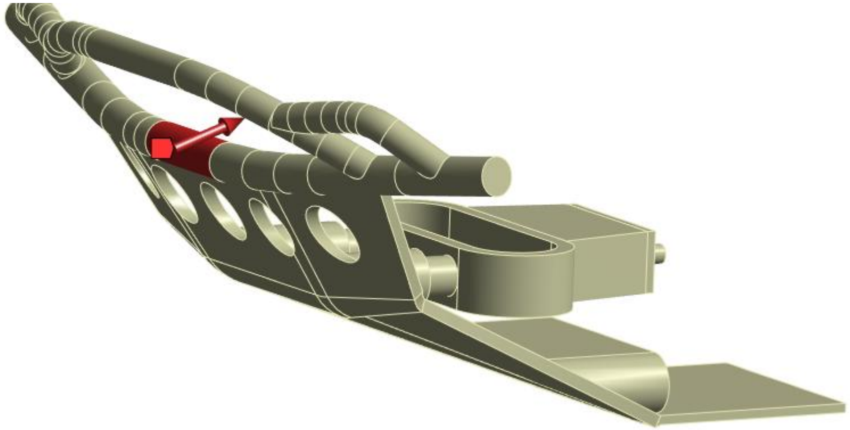
Front Bumper FEA

- Cylindrical Supports at bolts and posts
- Force applied as shown
- Tetrahedral Mesh Size: .1"



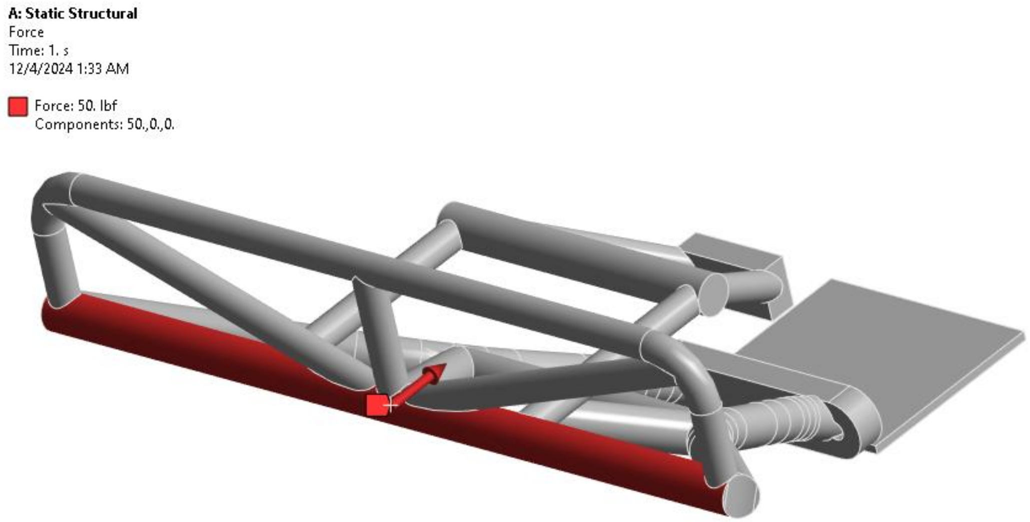
Details of "Force"

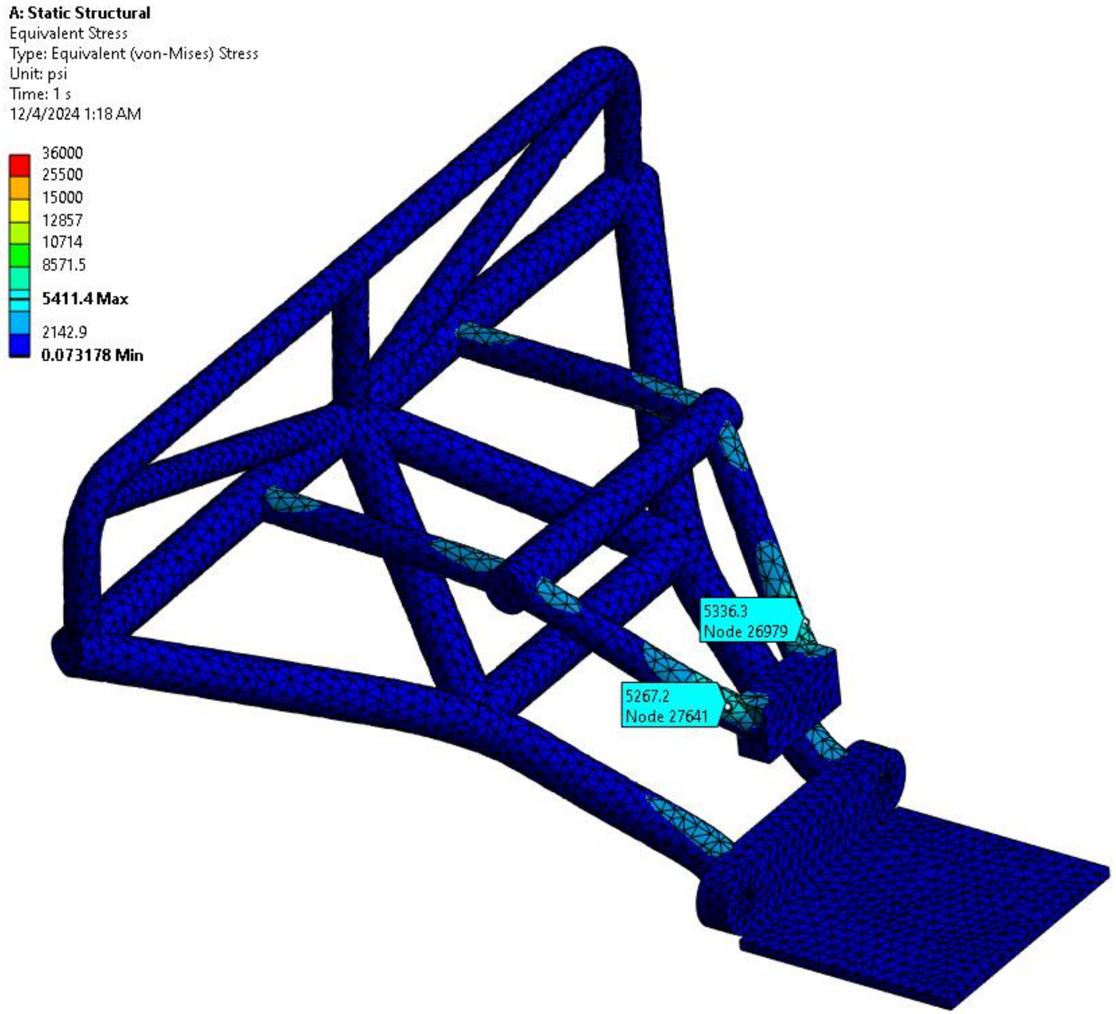
Scope	
Scoping Method	Geometry Selection
Geometry	1 Face
Definition	
Type	Force
Define By	Components
Applied By	Surface Effect
Coordinate System	Global Coordinate System
X Component	0. lbf (ramped)
Y Component	-150. lbf (ramped)
Z Component	50. lbf (ramped)
Suppressed	No



Rear Bumper FEA

- Cylindrical Supports at bolt holes, all fixed
- Tetrahedral Mesh size: .1"
- Force applied: 50 lbf





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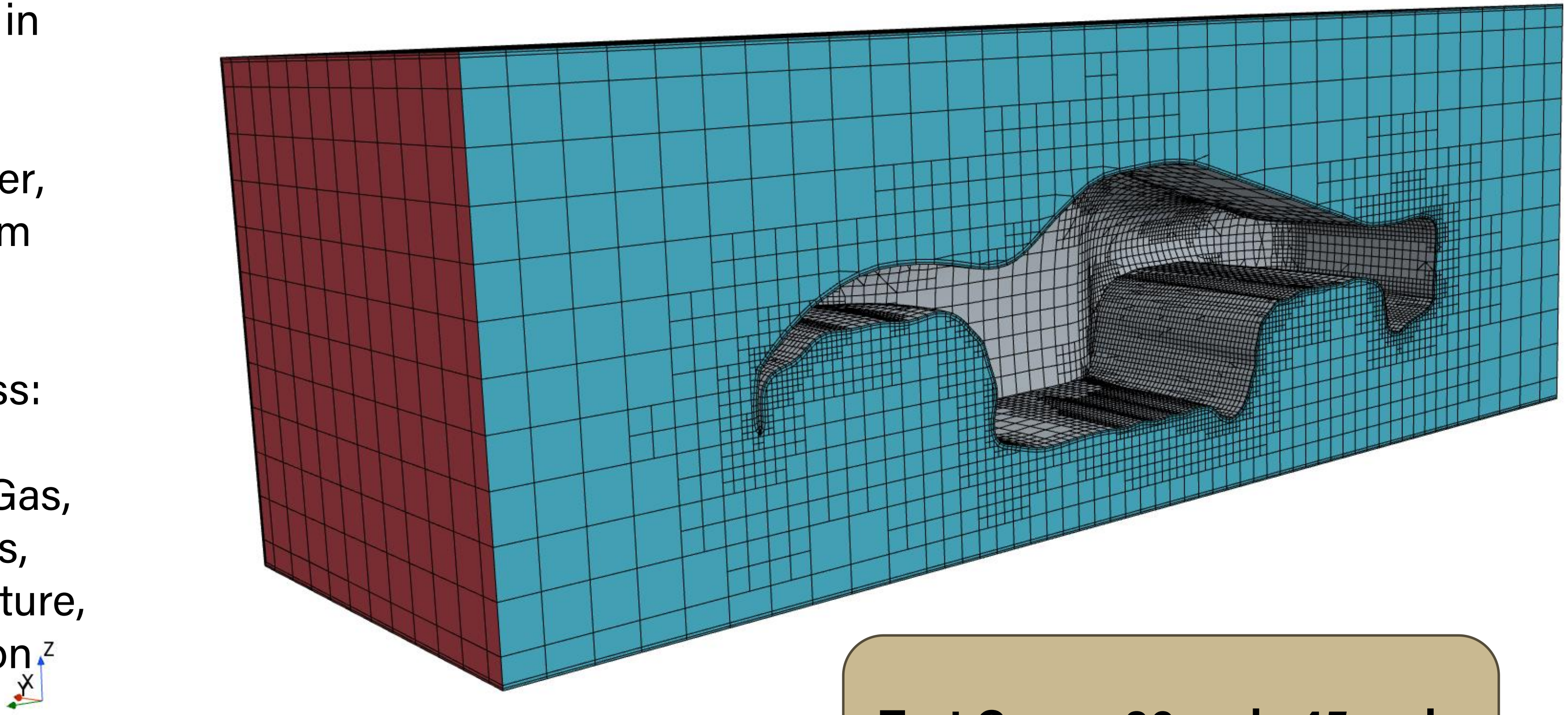
CFD

Shell CFD

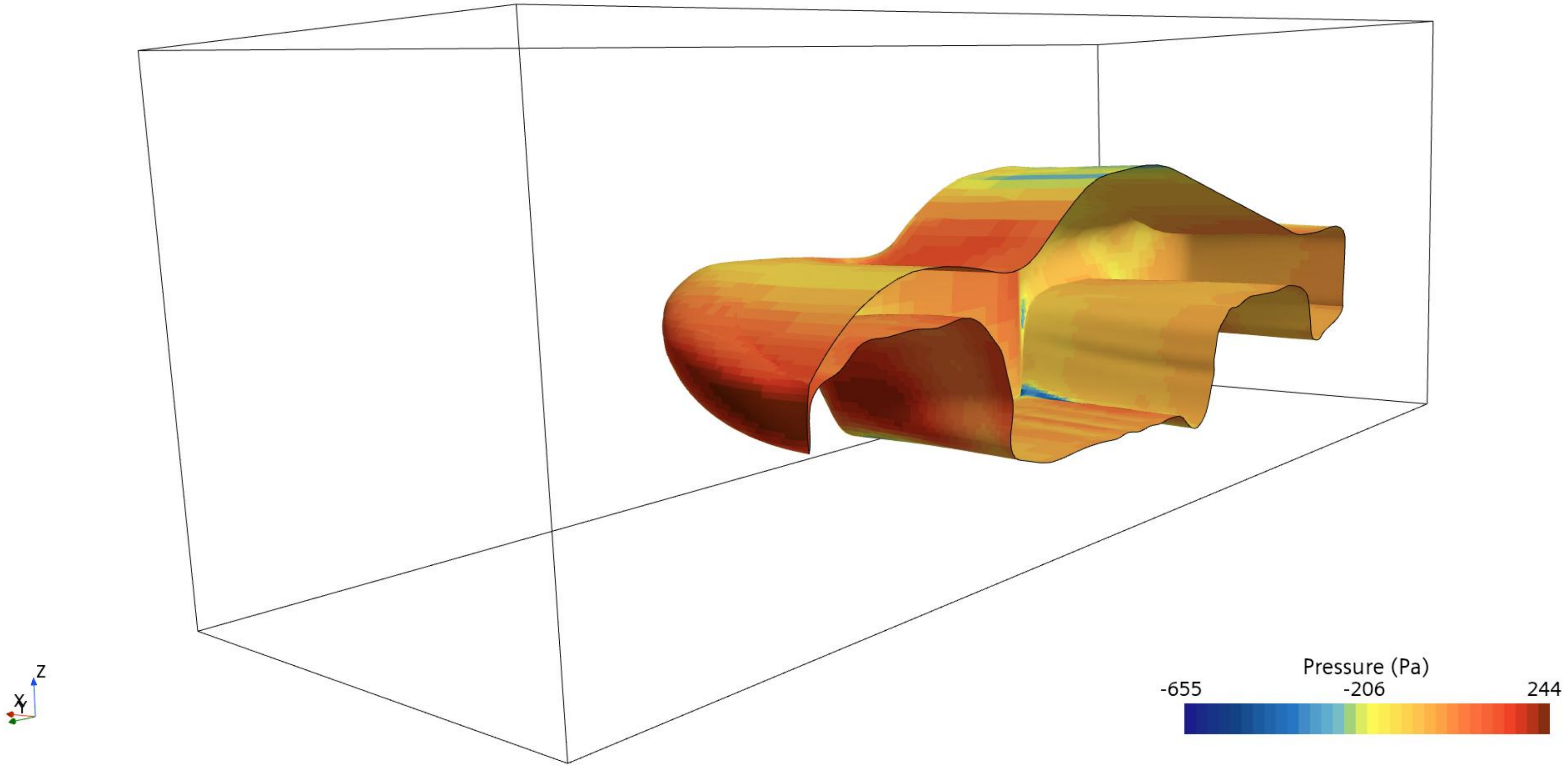
- Mock wind tunnel created in CAD

- Meshers: Surface Remesher, Trimmed Cell Mesher, Prism Layer Mesher
- Element Size: 0.025m
- Prism Layer Total Thickness: 10% (of base size)
- Physics Model Selection: Gas, Segregated Flow, Ideal Gas, Segregated Fluid Temperature, Steady, Turbulent, K-Epsilon Turbulence

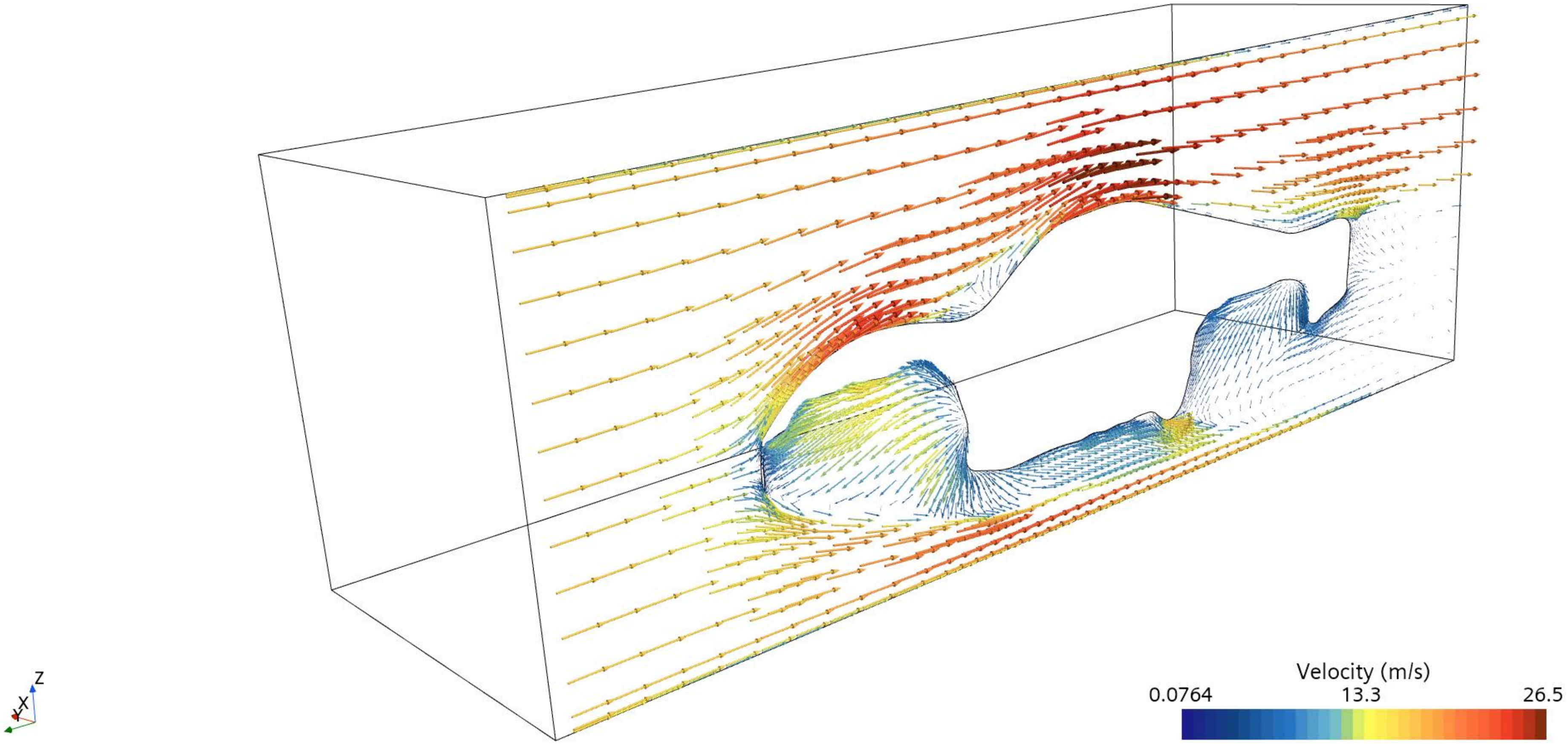


Test Cases: 36 mph, 45 mph, 70 mph, 100 mph

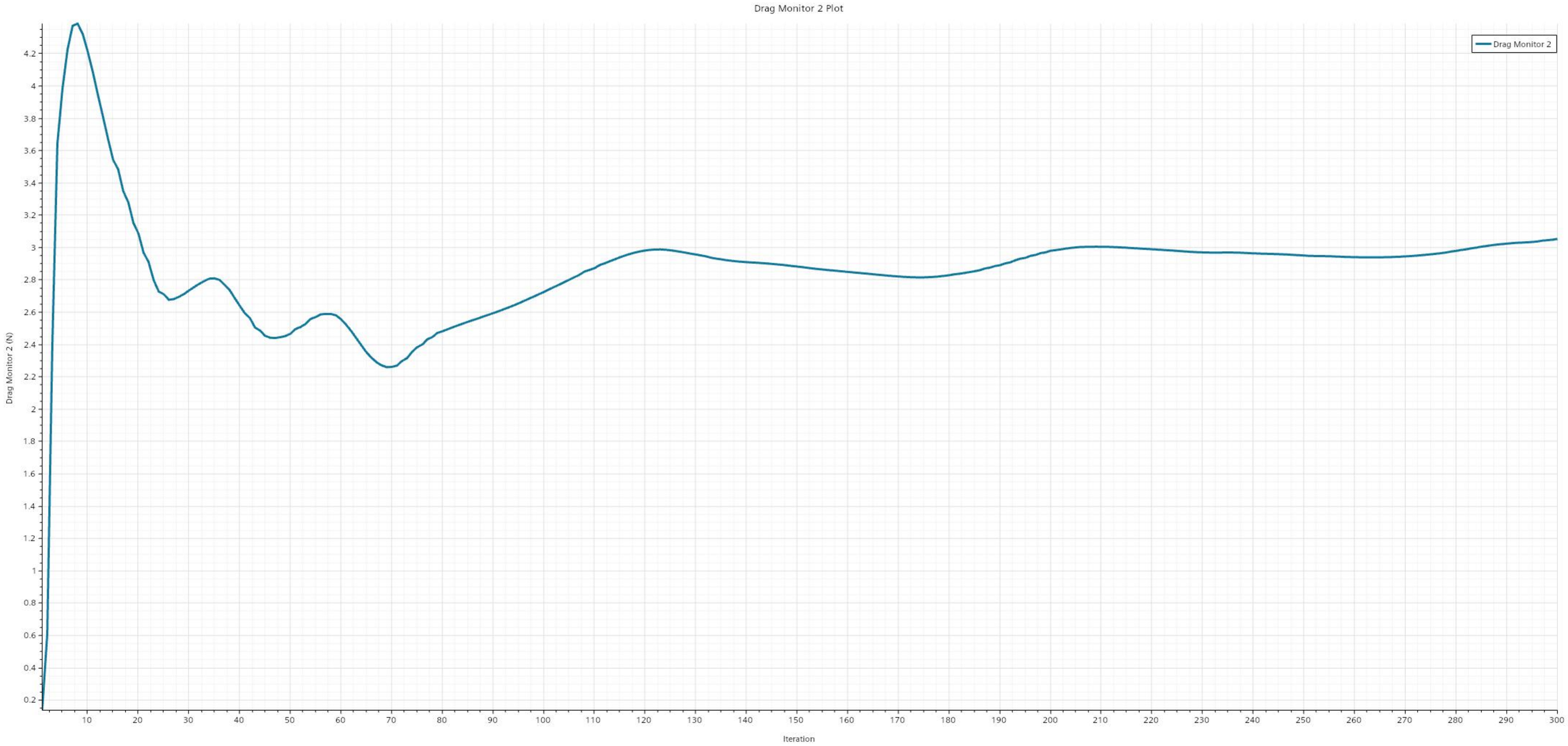
36 mph – Scalar Scene



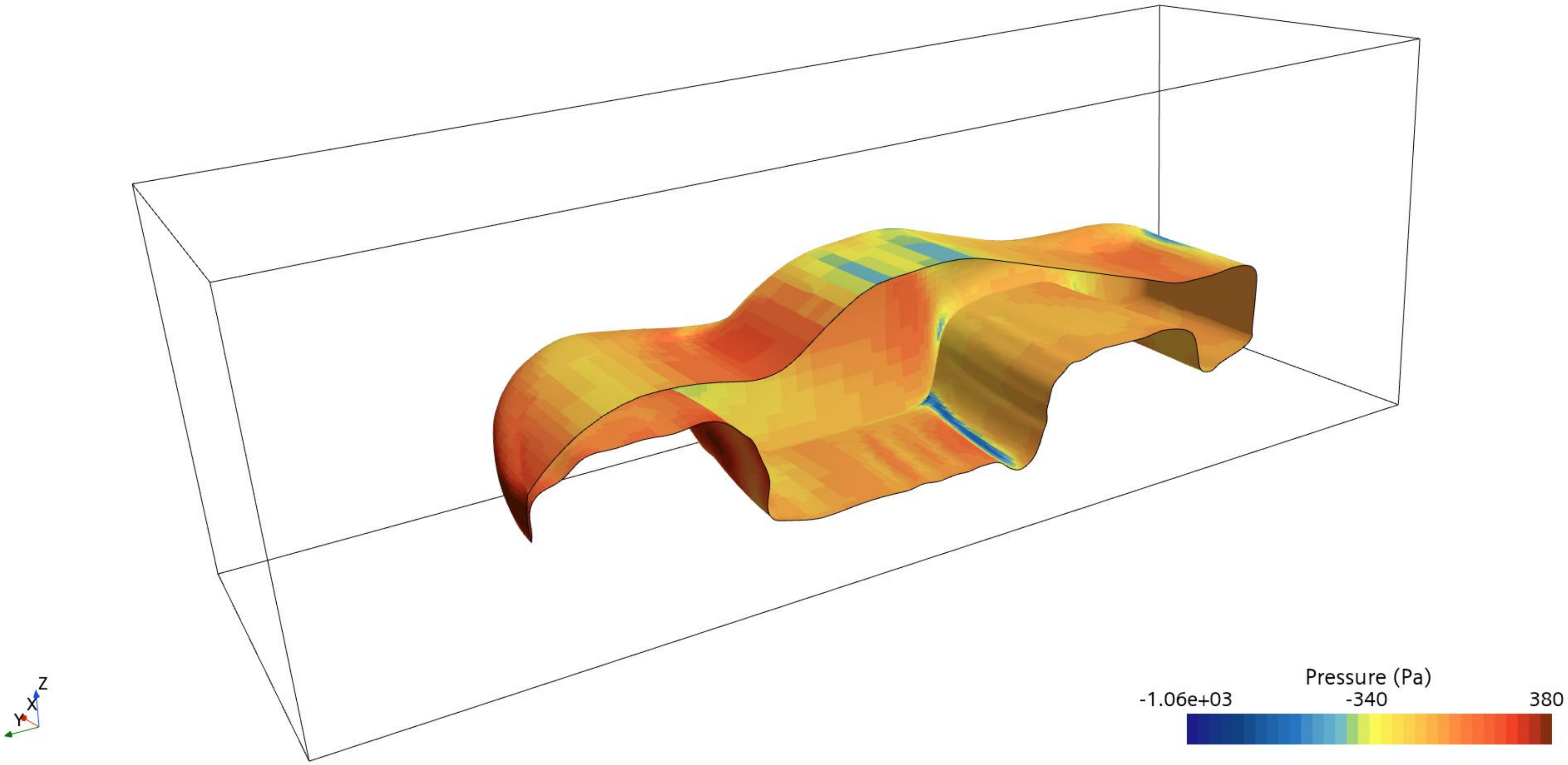
36 mph – Vector Scene



36 mph – Drag Force Plot

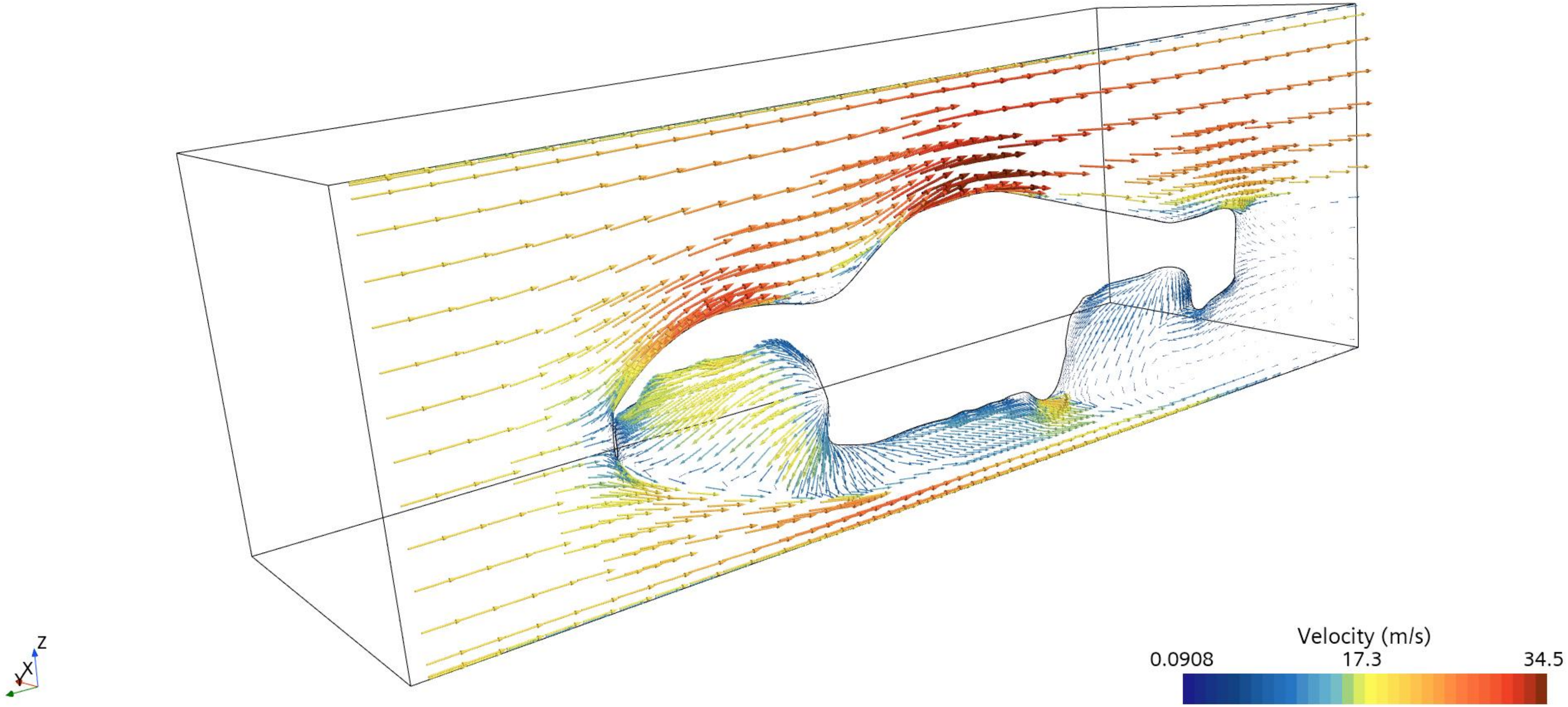


45 mph – Scalar Scene



CFD

45 mph – Vector Scene



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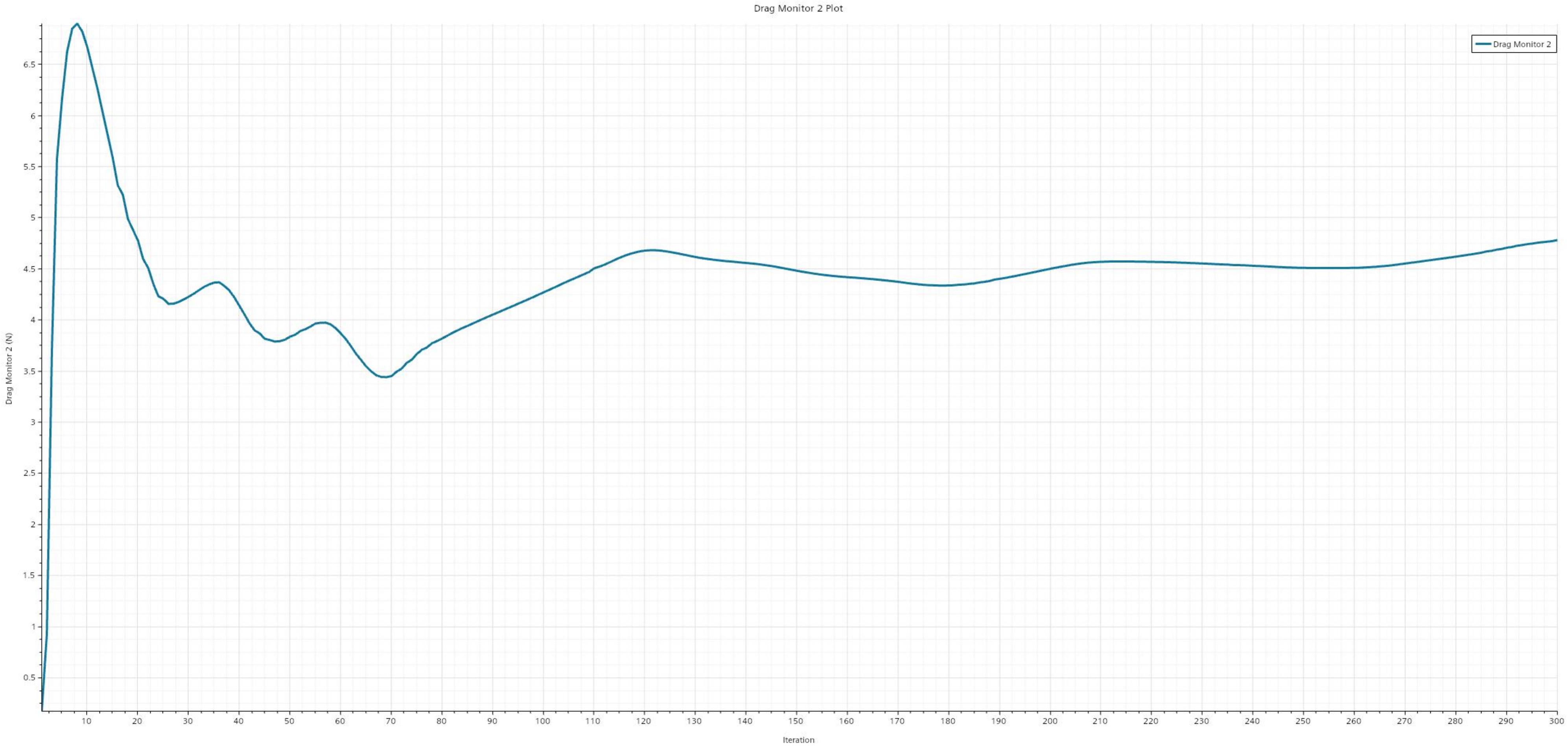
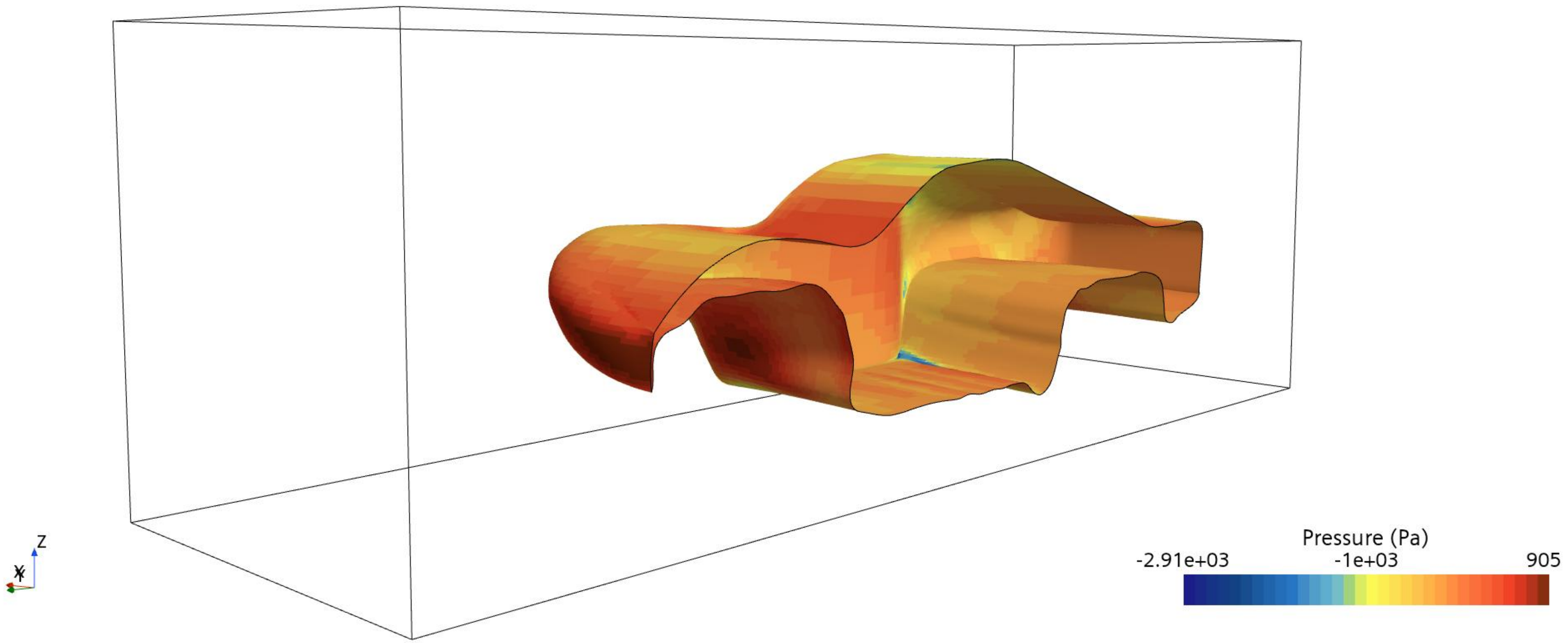
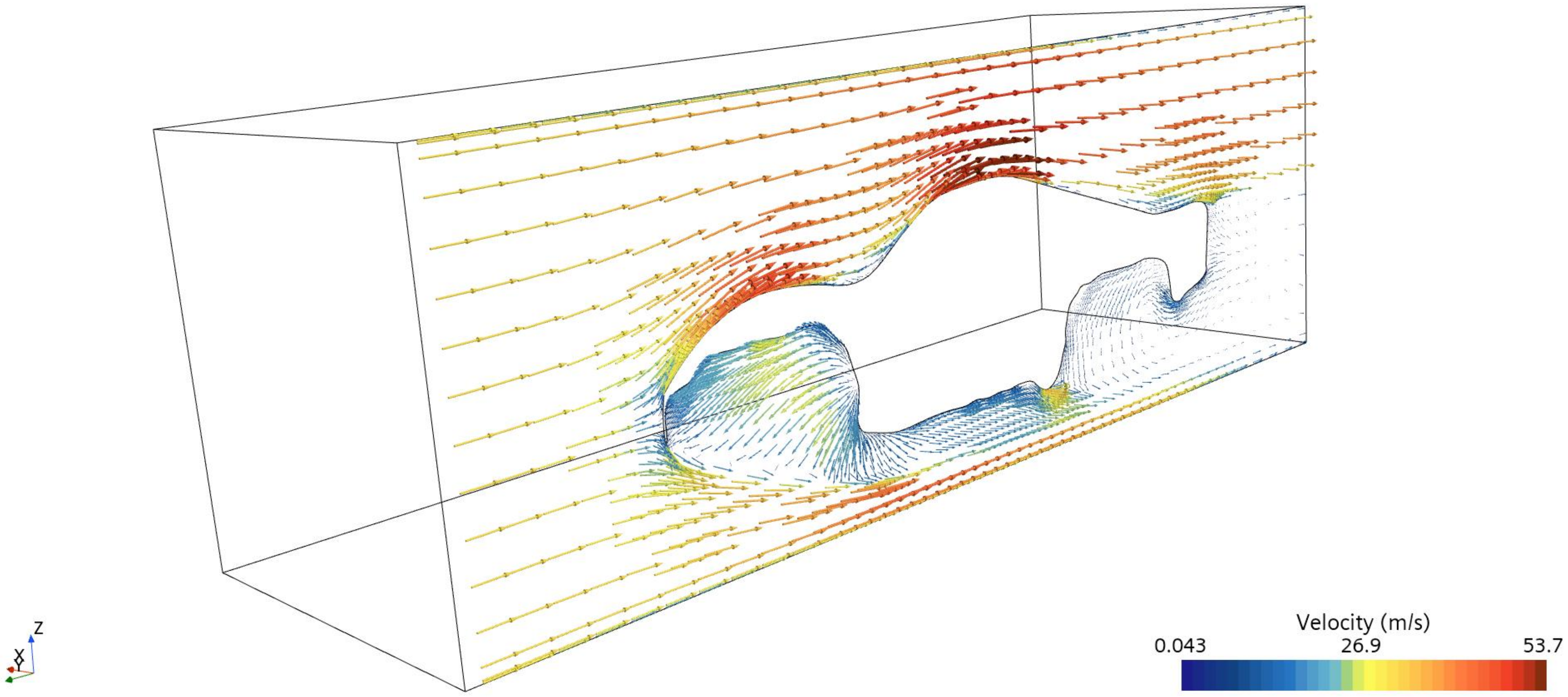
45 mph – Drag Force Plot



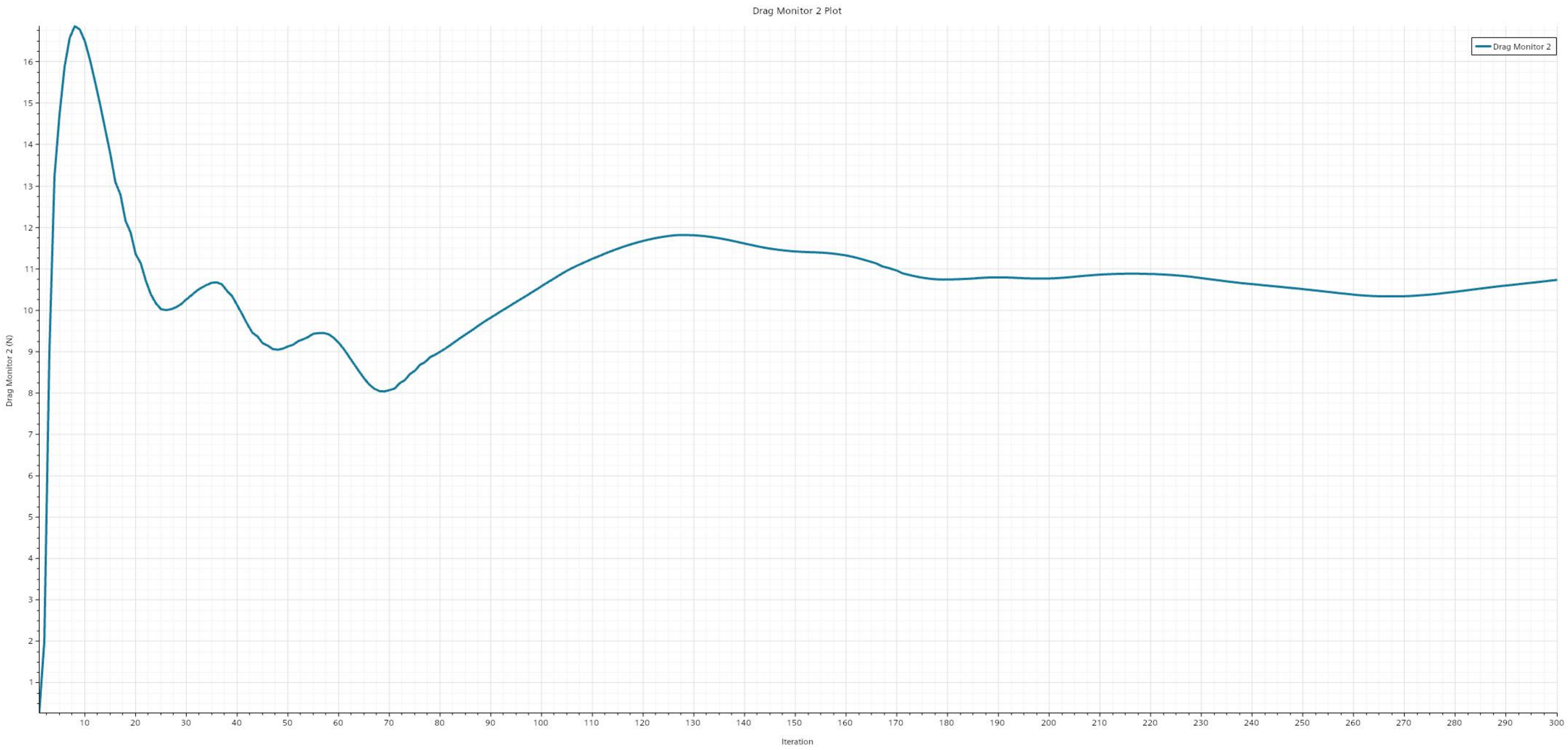
70 mph – Scalar Scene



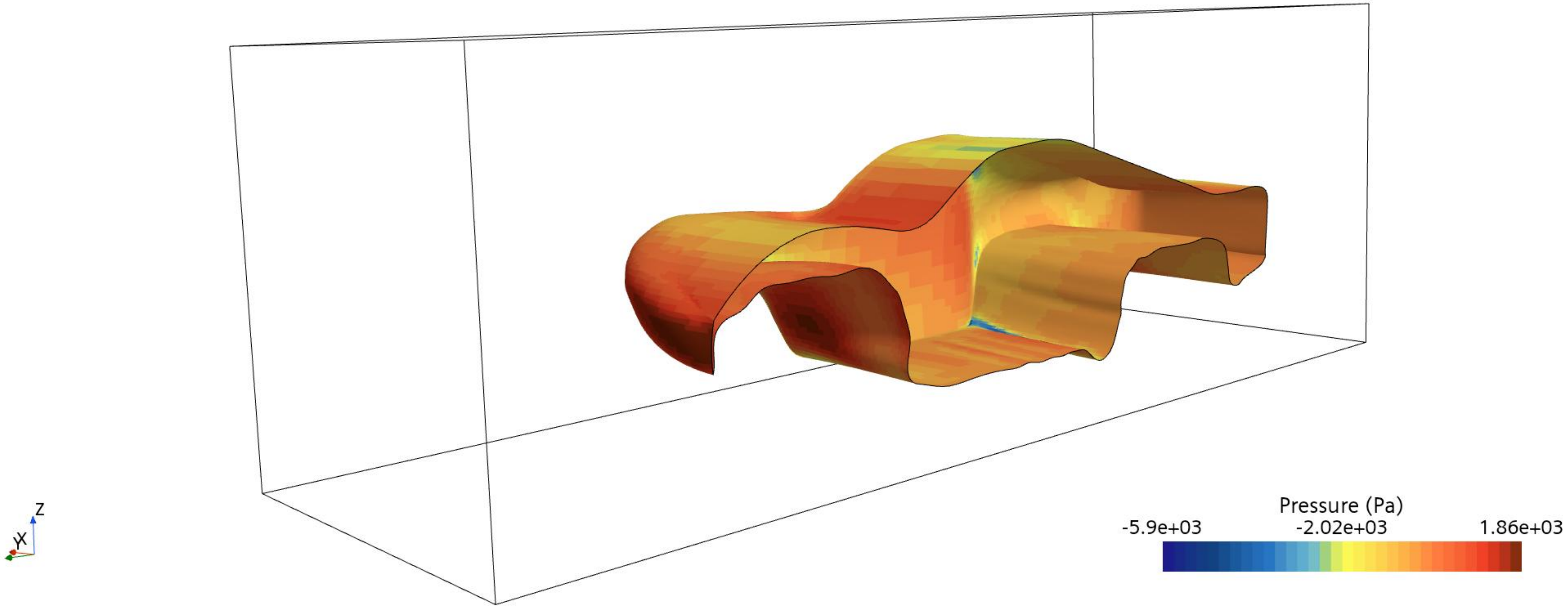
70 mph – Vector Scene



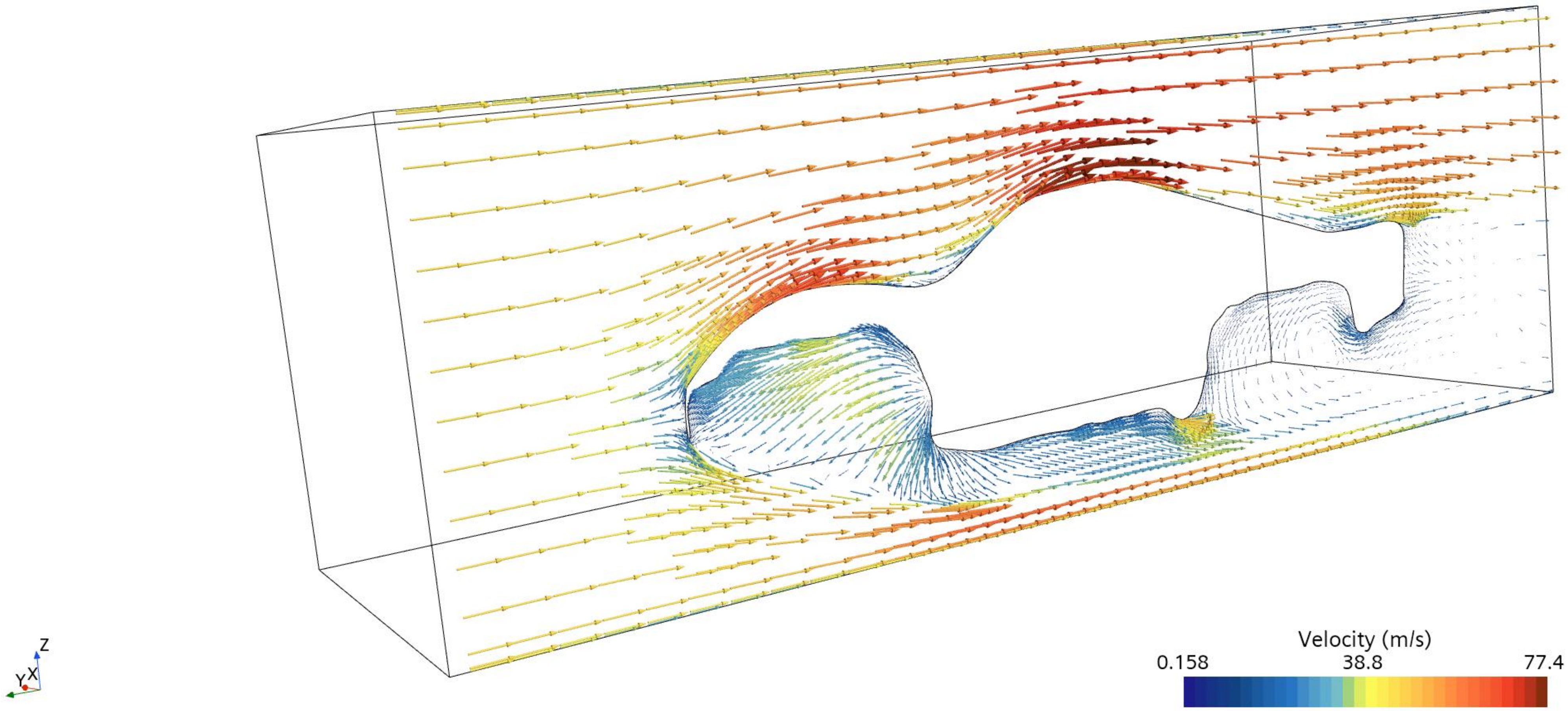
70 mph – Drag Force Plot



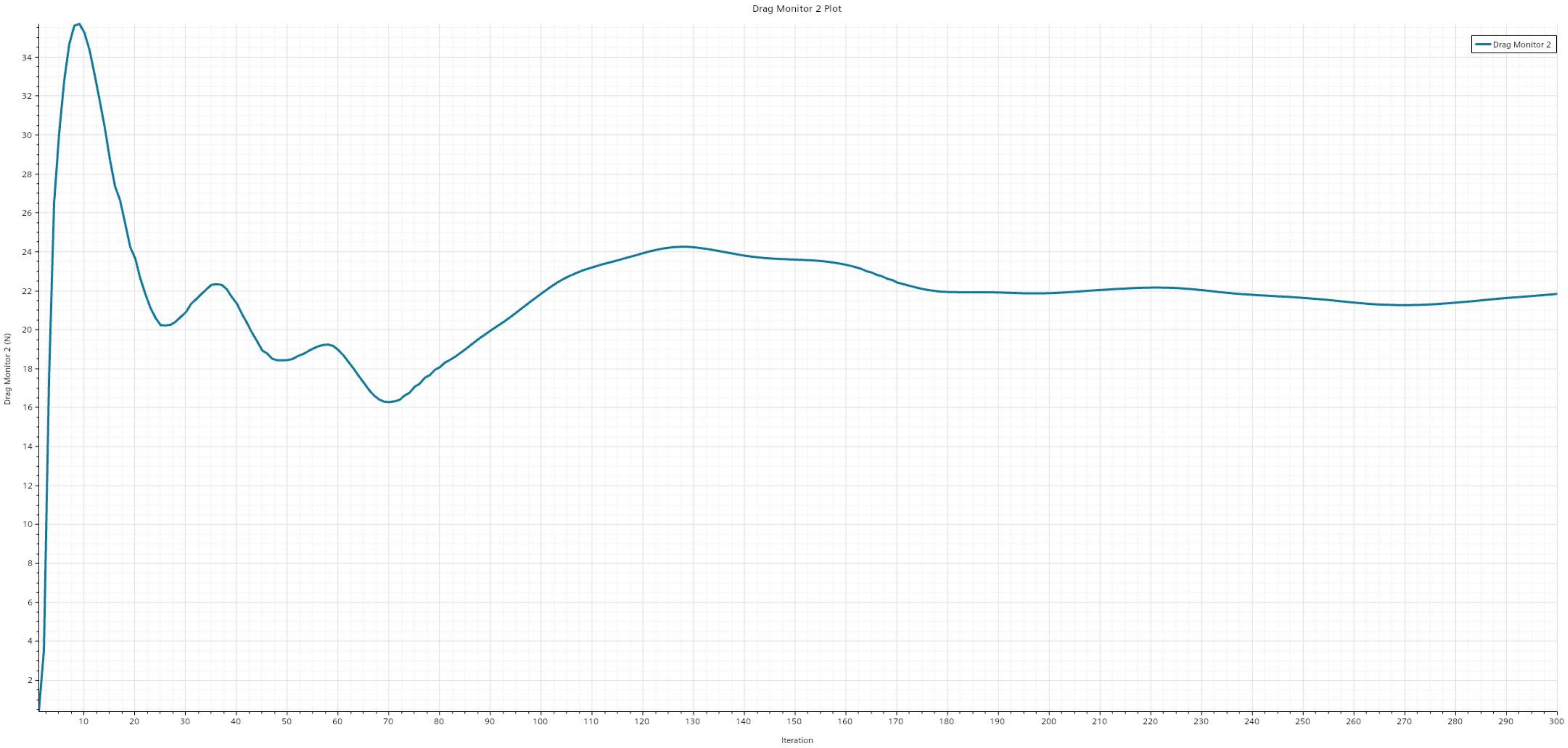
100 mph – Scalar Scene



100 mph - Vector Scene



100 mph – Drag Force Plot



Drag Force at 300th Iteration

- Drag Increases as speed goes up in expected manner
- Therefore, methodology conducted for CFD is valid and these results can be used to draw some conclusions

Case	Force (N)
36 mph	3 N
45 mph	4.75 N
70 mph	10.8 N
100 mph	22 N

VISUALIZATION

Full Assembly Visualization

Full Assembly Visualization

Full Assembly Visualization

Visualization

Full Assembly Visualization

Part Visualization

Suspension Assembly Visualization

Part Visualization

Shell Visualization

Improvements, Successes, and Difficulties

What we did well:

- Thorough FEA, CFD, and Topology Optimization
- Unaltered CAD for optimization later
- Communication
- Organization

Future Improvements:

- Focused on optimizing wide range of parts, did not have time to implement them into CAD
- Phase out OneDrive (not good for CAD structures and file sharing) for Teamcenter, etc.
- More robust scaling factor
- More CFD at different angles
  - Rear wing addition, other technical improvements

Difficulties

- Version control for CAD parts and assemblies
- Breaking or replacing references when files moved for organizational purposes or scaled
- File sharing system made development slower
- Scaling factor, when changed, would randomly break some constraints in assemblies
- Difficult time constraints prevented implementation of optimized parts into assembly for accurate weights

THANK YOU