# SAE Mini Baja

## Engineering Analysis

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# Overview

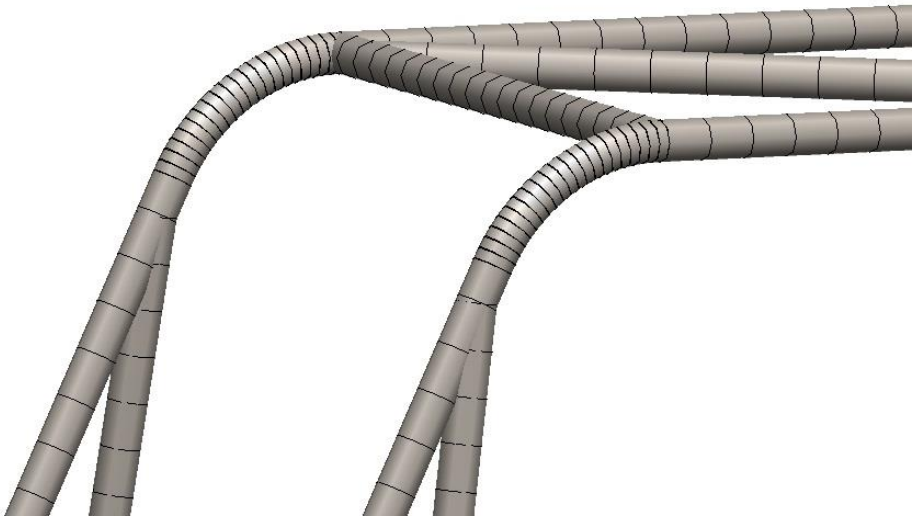
- Design Problem
- SolidWorks Simulation
- Refined Frame Designs
- Analysis Assumptions
- Strength Tests
- Simulation Results
- Project Plan
- Conclusion

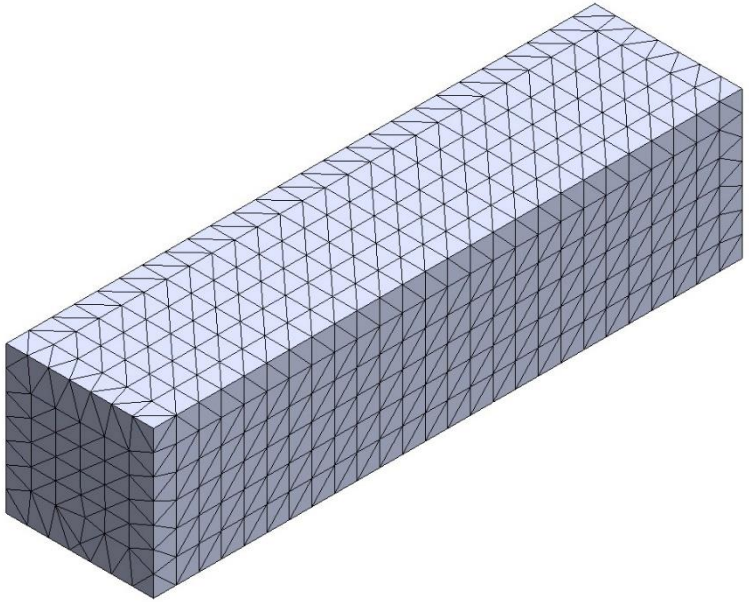
# Problem Statement

- NAU has not won an SAE Baja event.
- Goal is to design the lightest possible frame within the SAE rules.

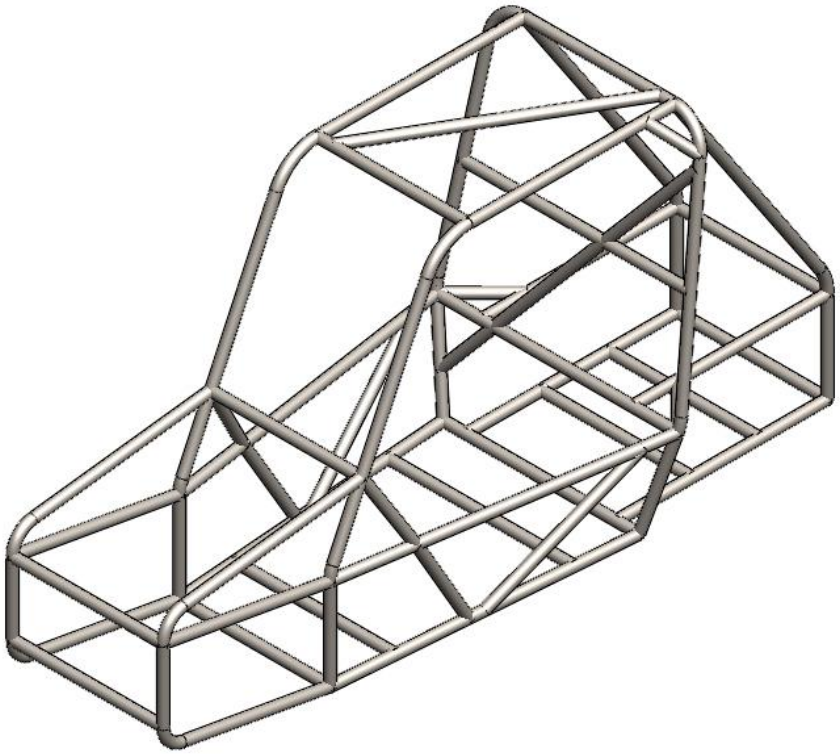
# SolidWorks Simulation

- Beam elements for frame analysis
- Tetrahedral elements for solid components

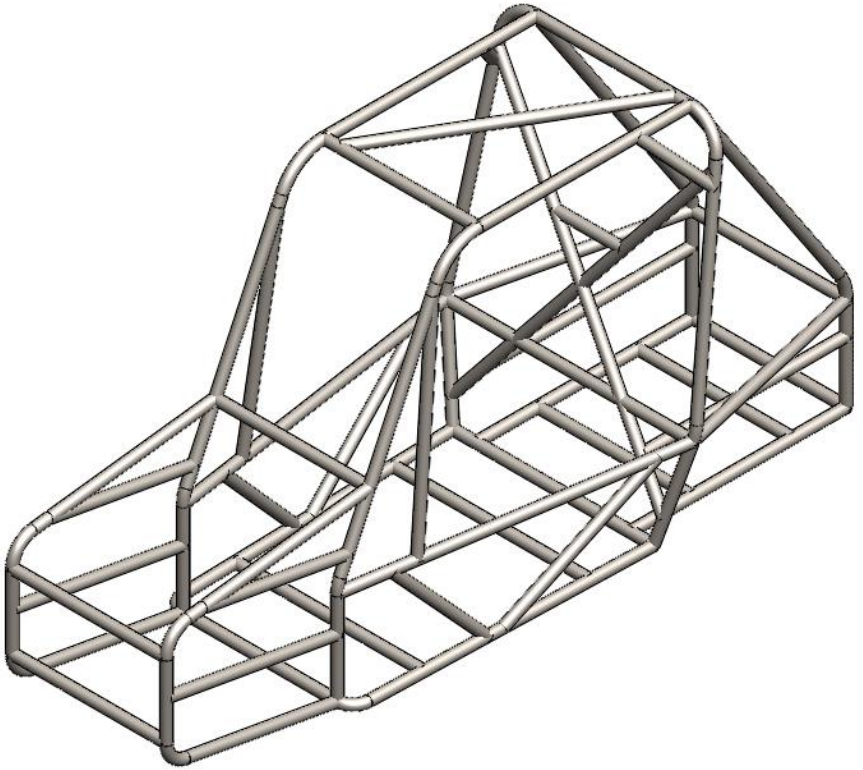




# Refined Frame Designs

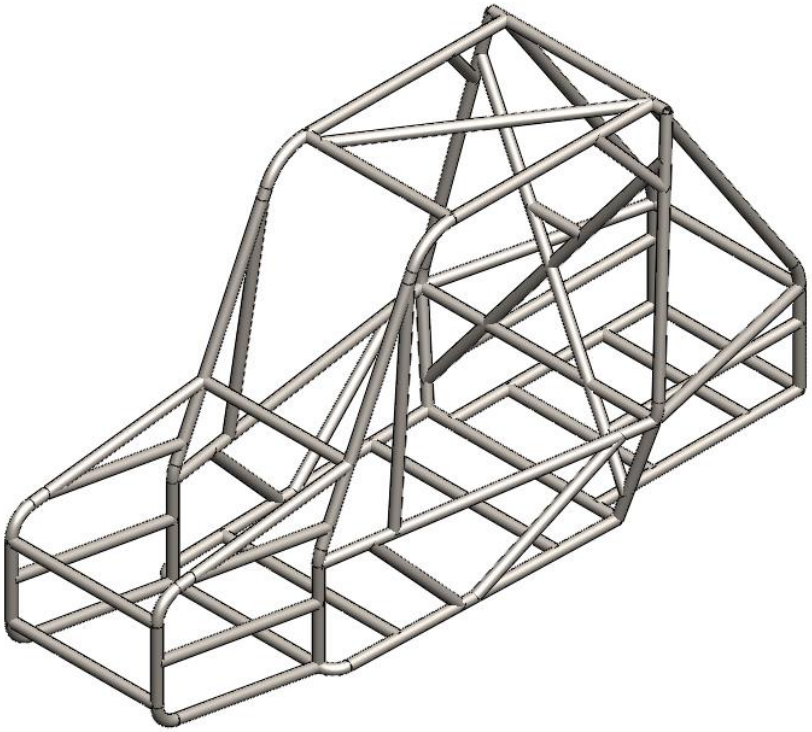


Design 5

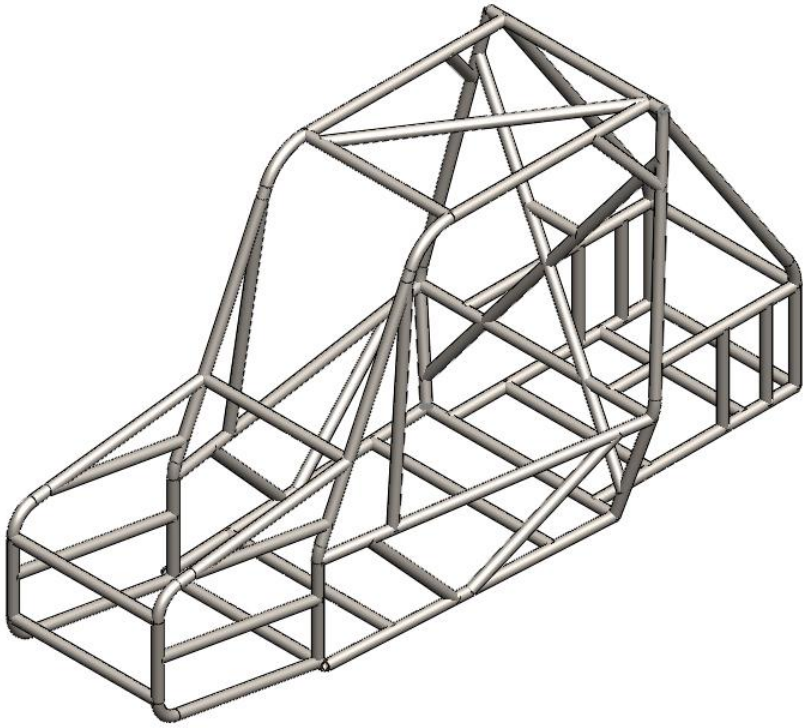


Design 6

# Refined Frame Designs



Design 7



Design 8

# Simple Loading Case

- 6000 lb distributed load on the roof
- Design with highest FOS
- Design with most even stress distribution
- Advanced tests performed on the best design

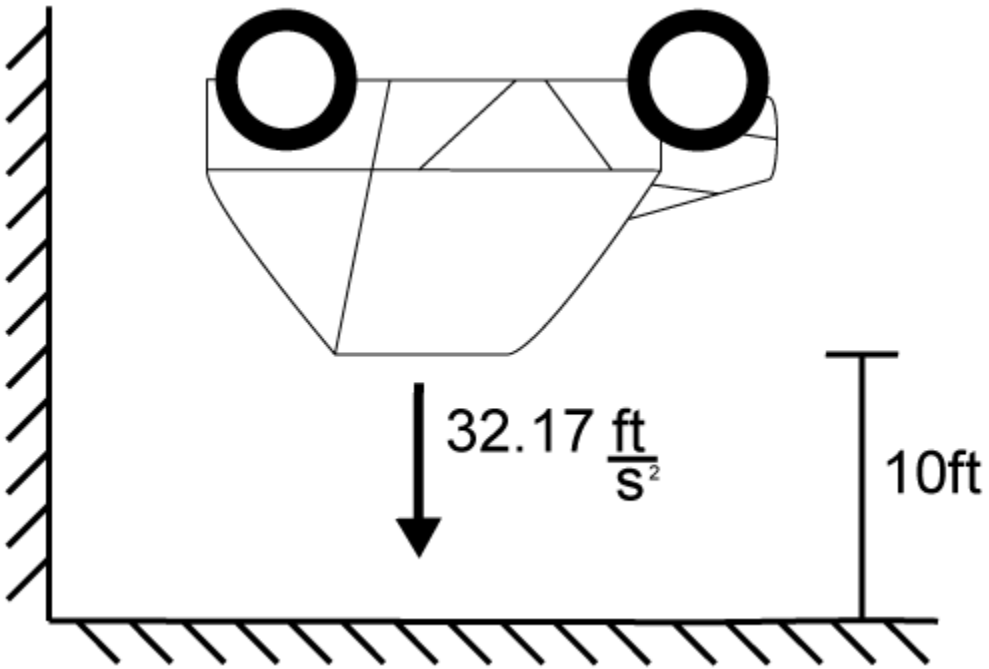
# Simple Loading Results

| Design | Max Stress [ksi] | Max Deflection [in] | Yield Safety Factor |
|---|---|---|---|
| 5 | 61.61 | 0.256 | 1.08 |
| 6 | 61.20 | 0.210 | 1.09 |
| 7 | 60.16 | 0.202 | 1.11 |
| 8 | 56.89 | 0.206 | 1.17 |

# Frame Impact Tests

- Drop Test
- Front Collision Test
- Rear Collision Test
- Side Impact Test
- Static simulations at maximum impact acceleration
- All are worst-case scenario

# Drop Test

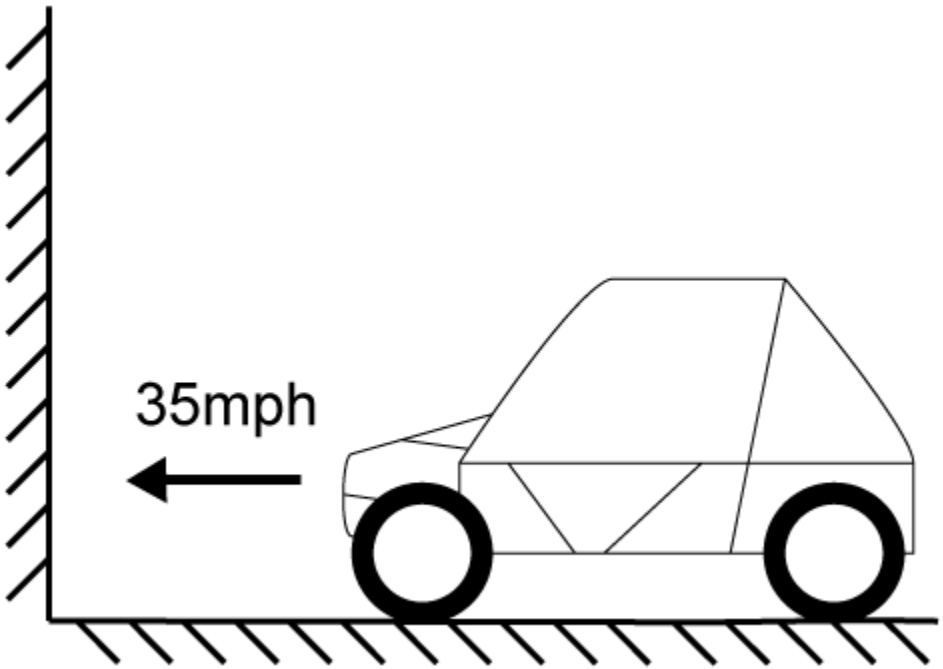


# Drop Test

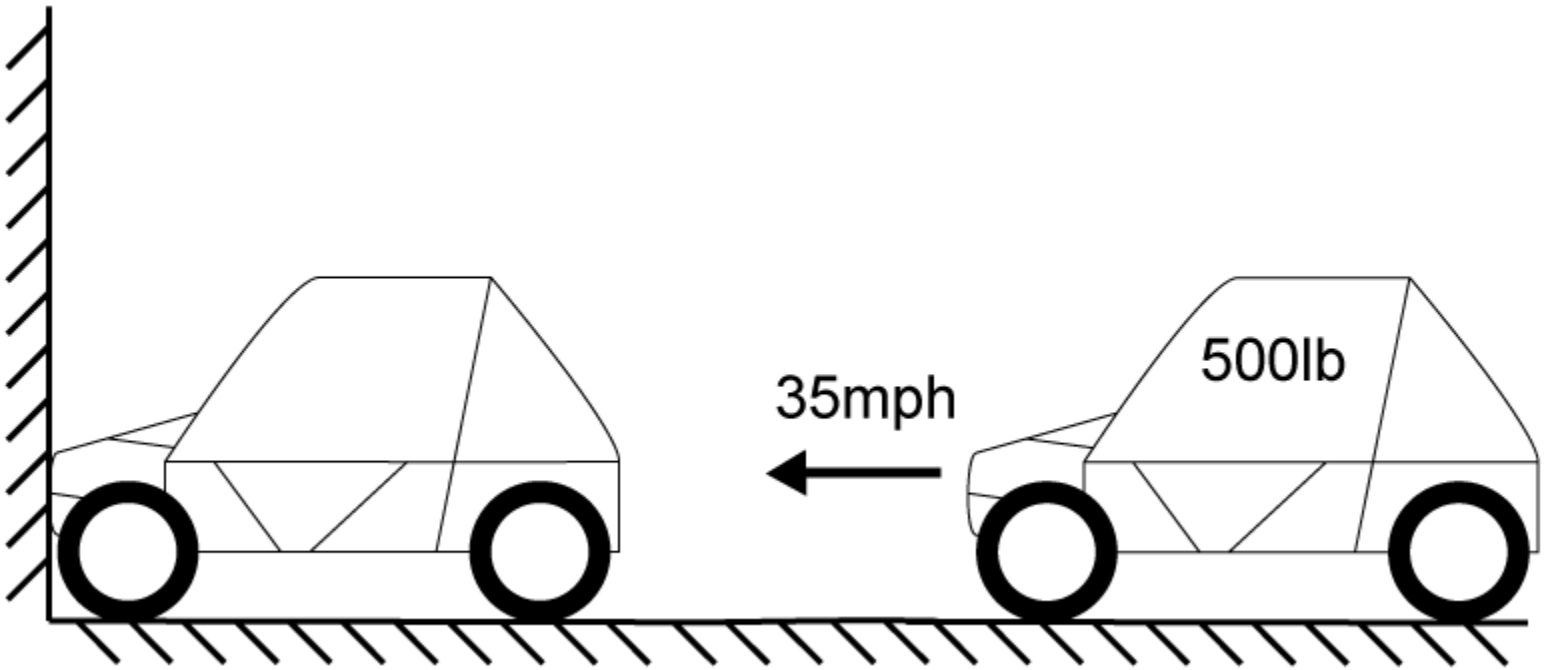
$$F = m \cdot \frac{\sqrt{gh}}{t}$$

- F = force
- m = mass
- g = acceleration of gravity
- h = drop height
- t = impulse time

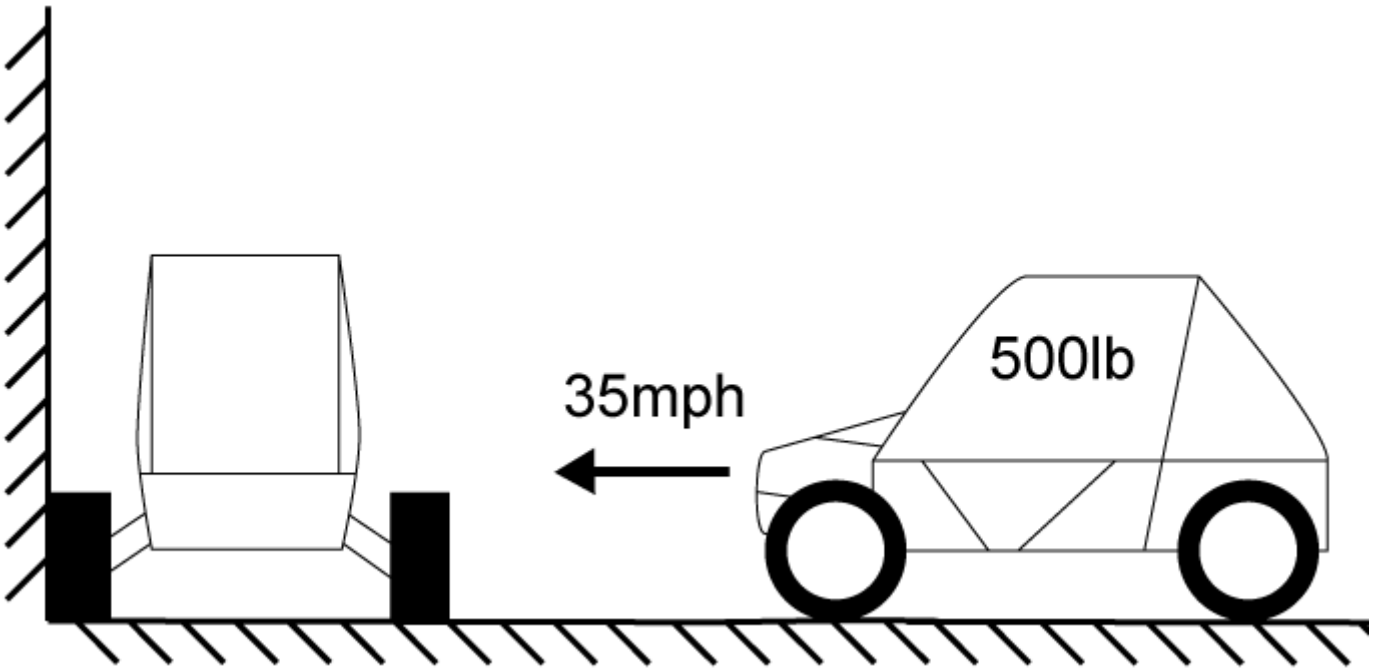
# Front Collision Test



# Rear Collision Test



# Side Impact Test



# Impact Tests

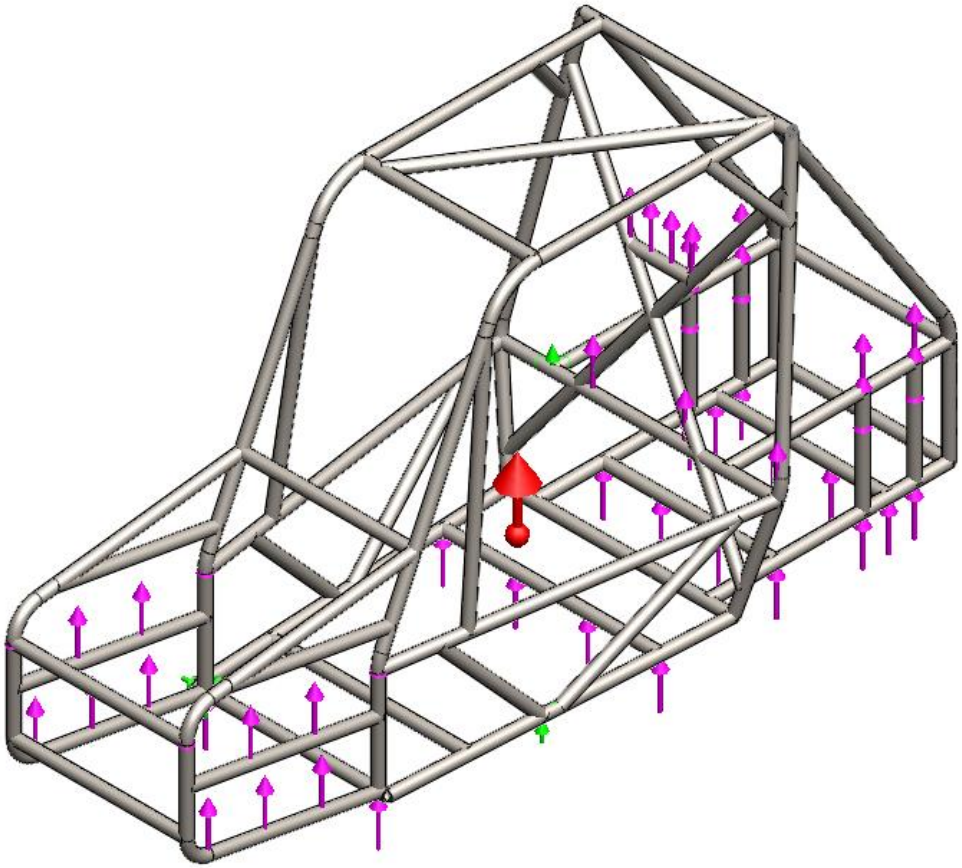
$$F = m \cdot \frac{V_0}{t}$$

- F = force
- m = mass
- $V_0$ = initial velocity
- t = impulse time

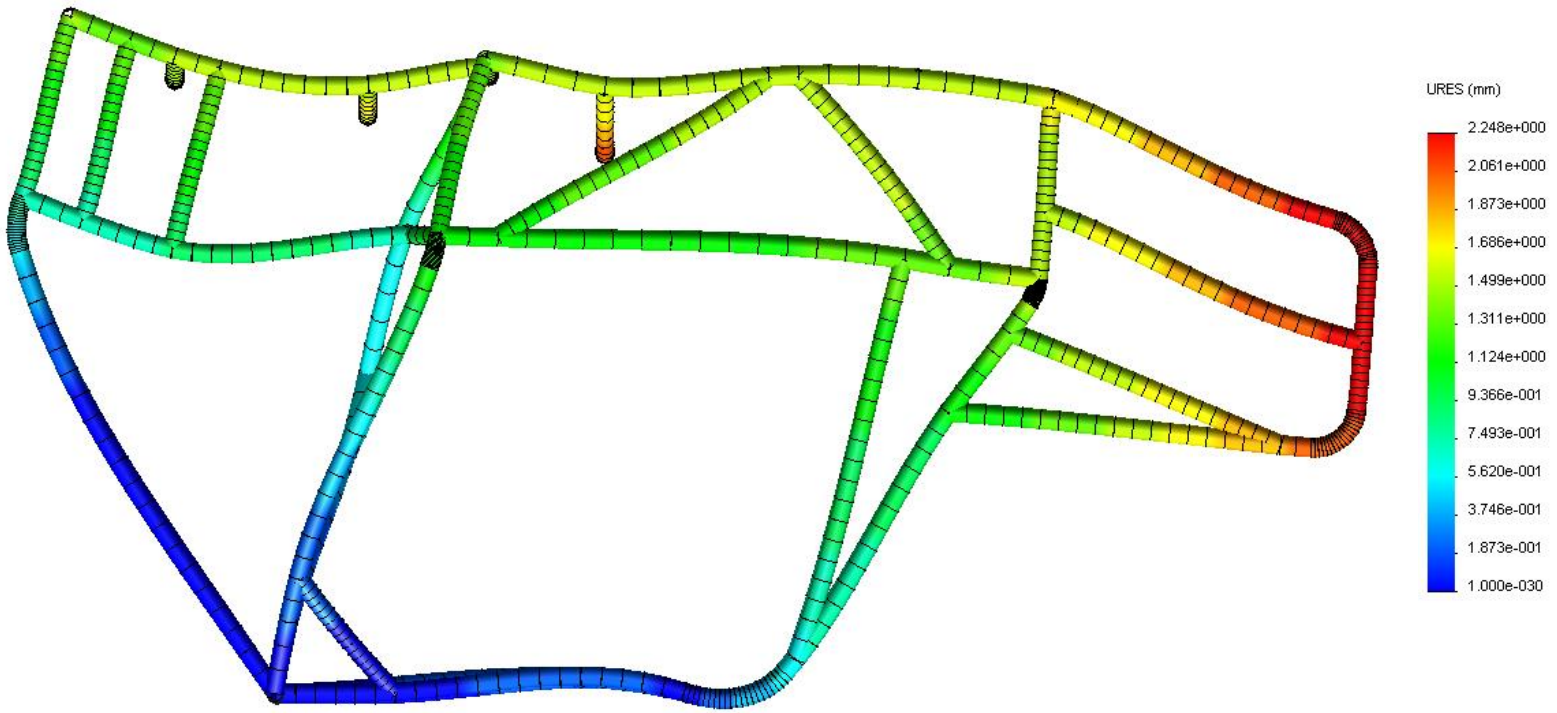
# Analysis Assumptions

- Frame Weight of 100.29 lb
- Drivetrain Weight of 120 lb
- Suspension Weight 50 lb per corner
- Driver Weight of 250 lb
- AISI 4130 Tubing, 1.25 in Diameter, 0.065 Thickness

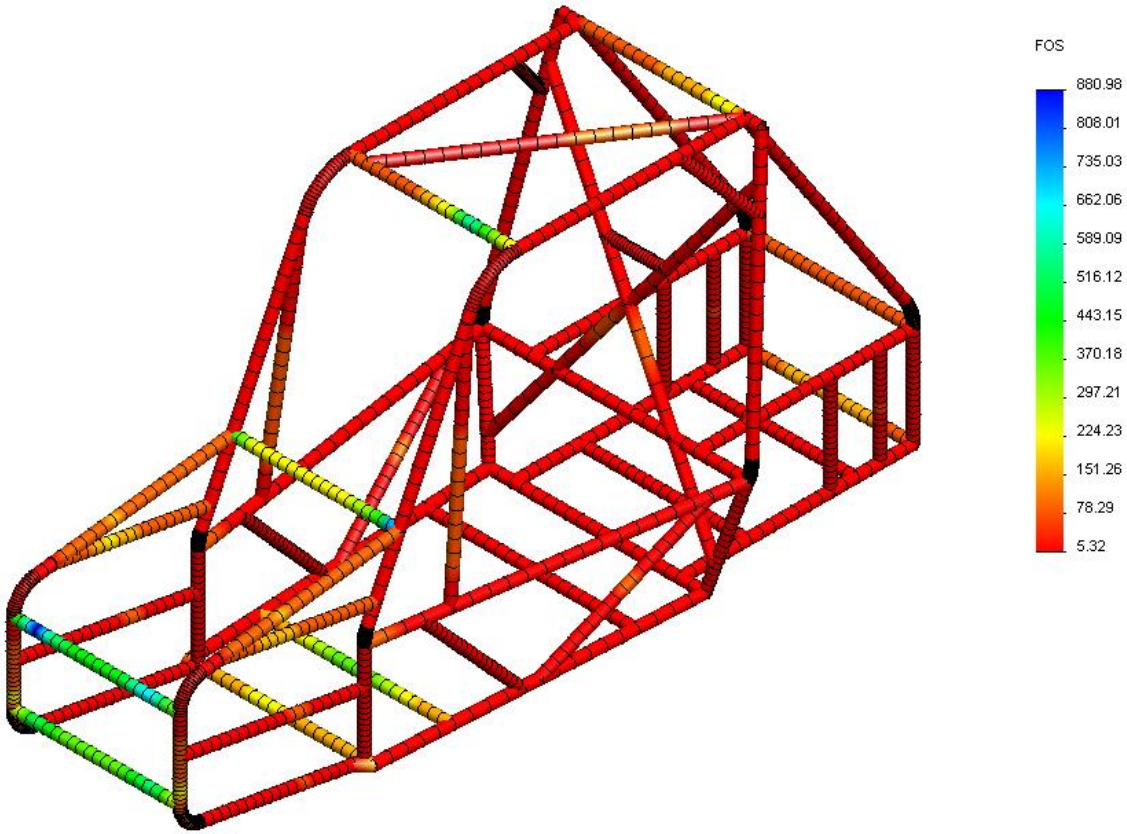
# Loading Example



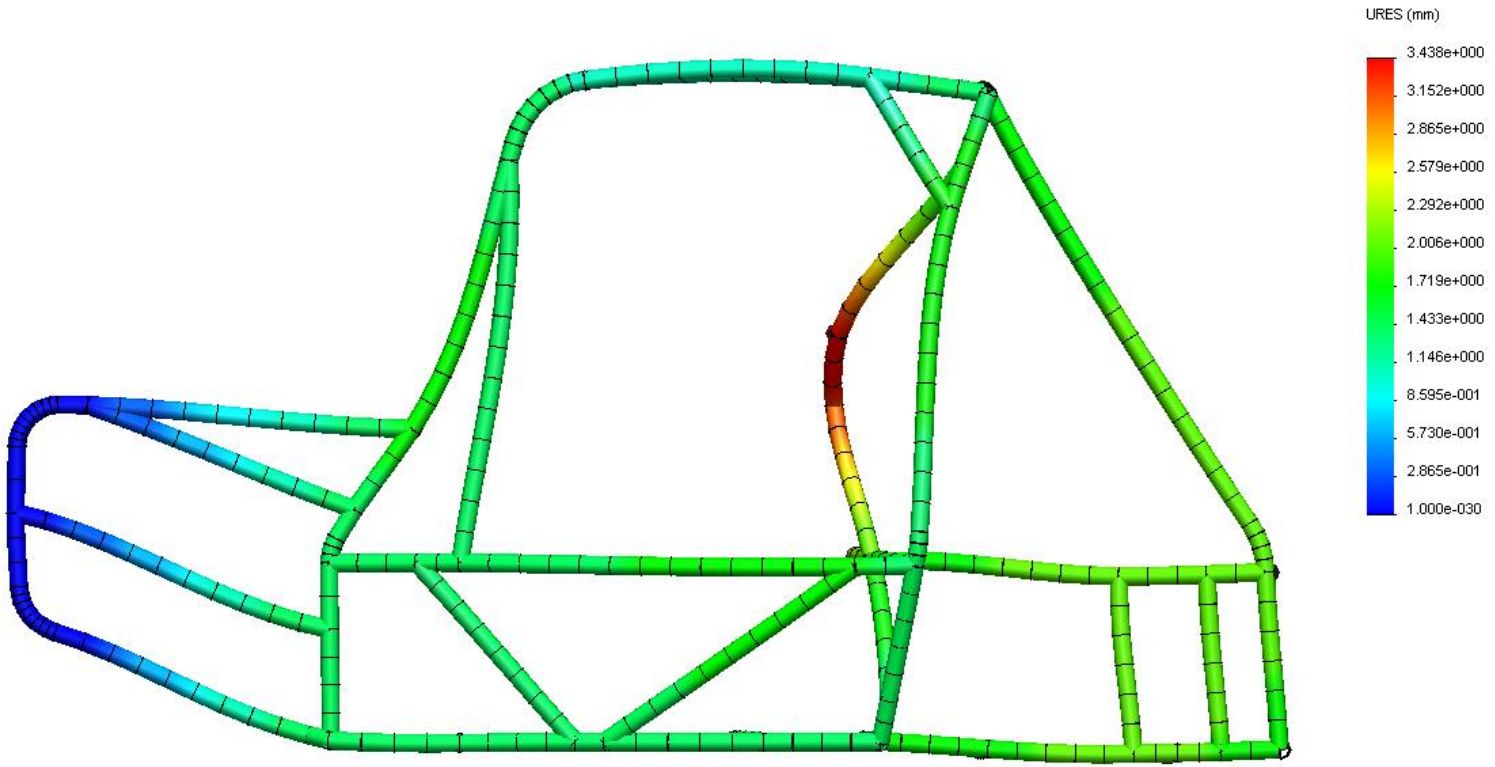
# Drop Test Deflection



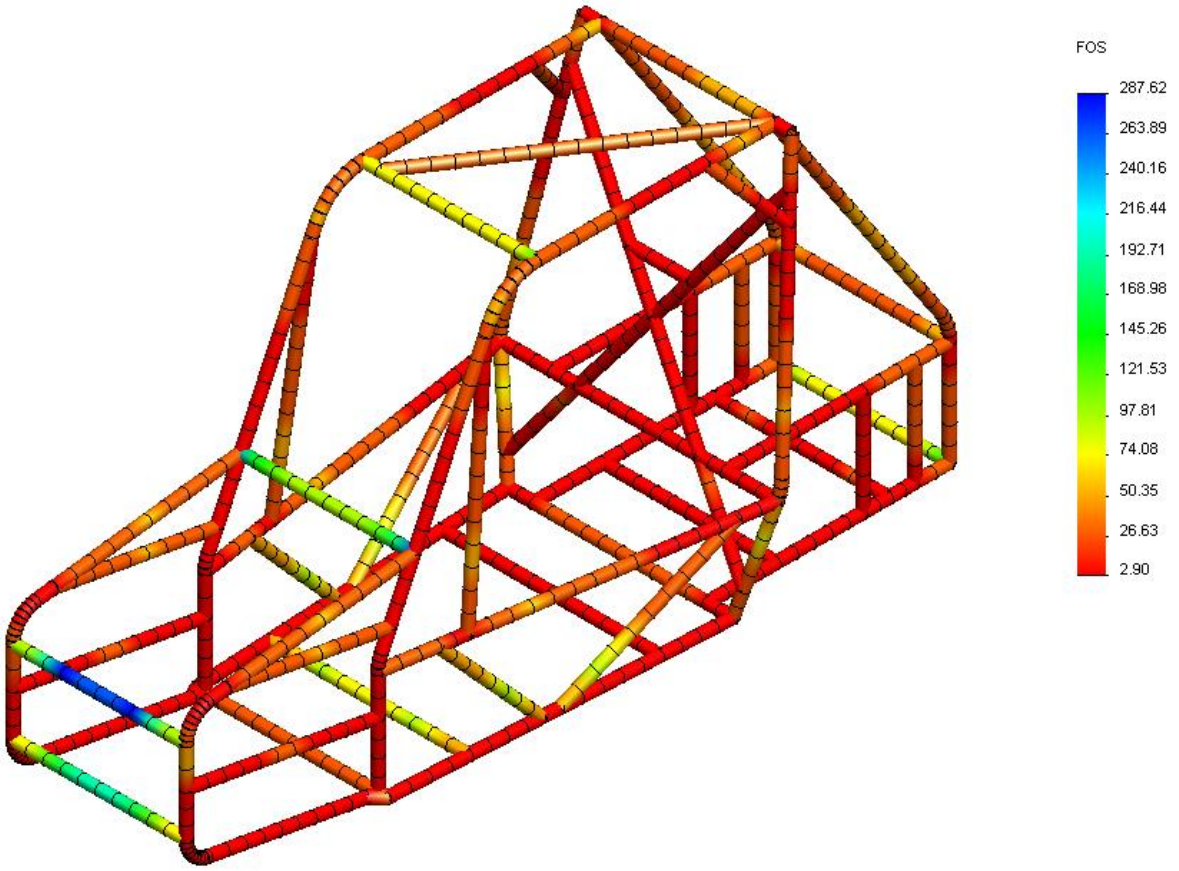
# Drop Test Safety Factor



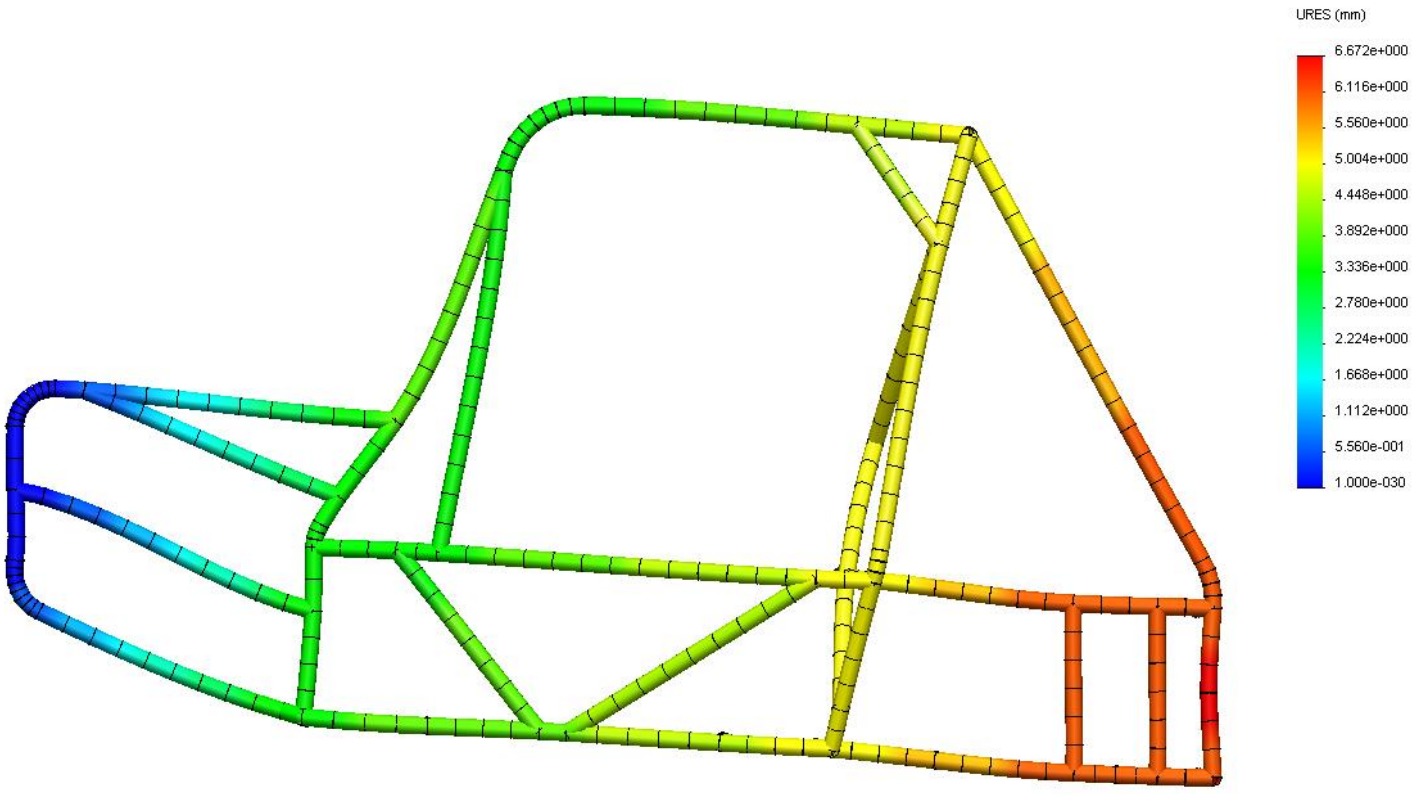
# Front Collision Deflection



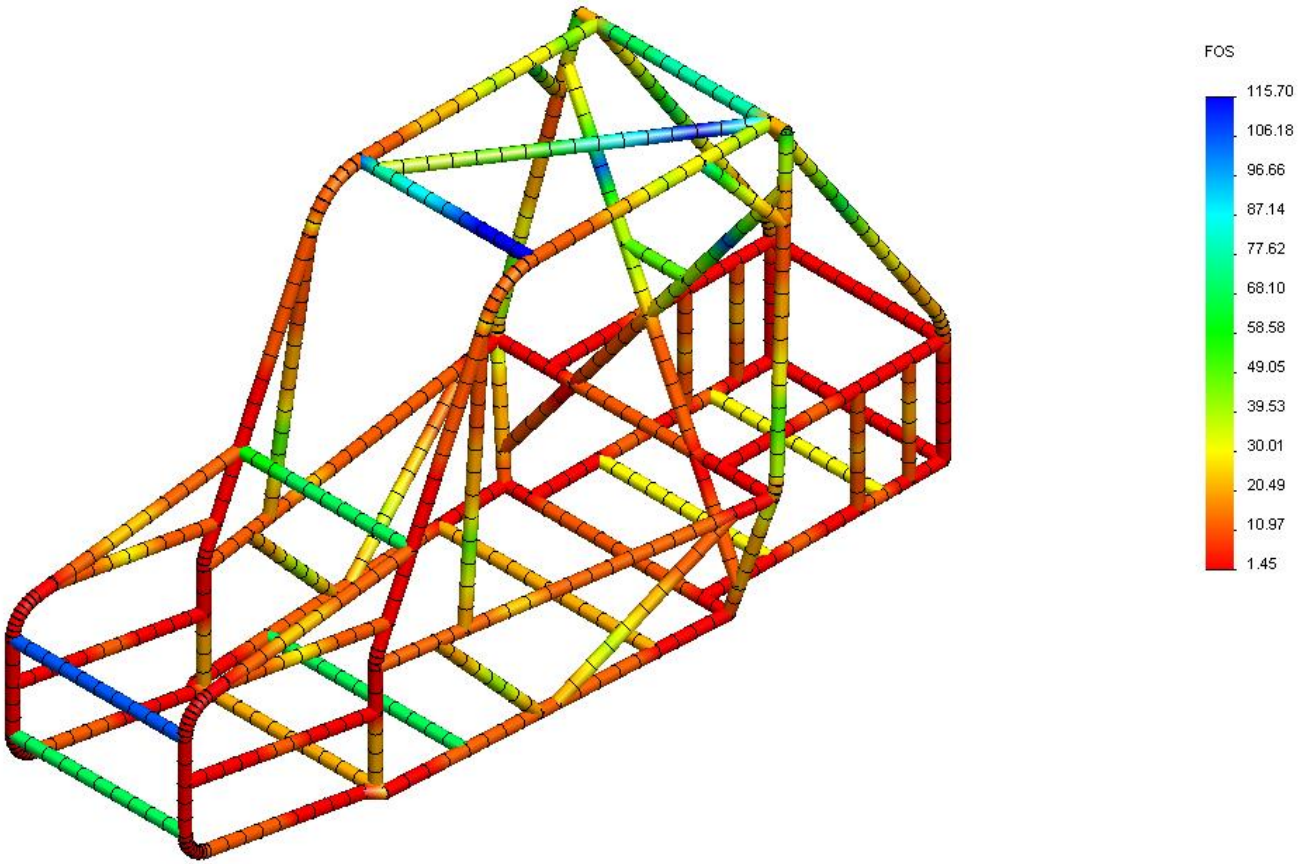
# Front Collision Safety Factor



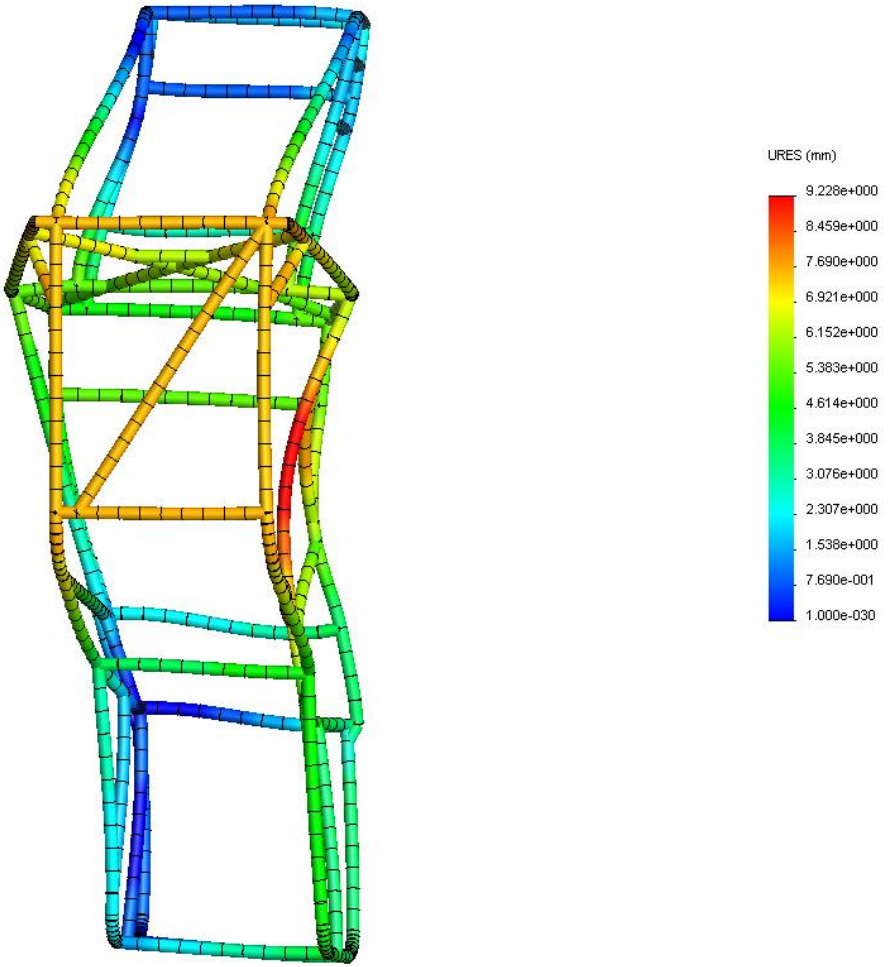
# Rear Collision Deflection



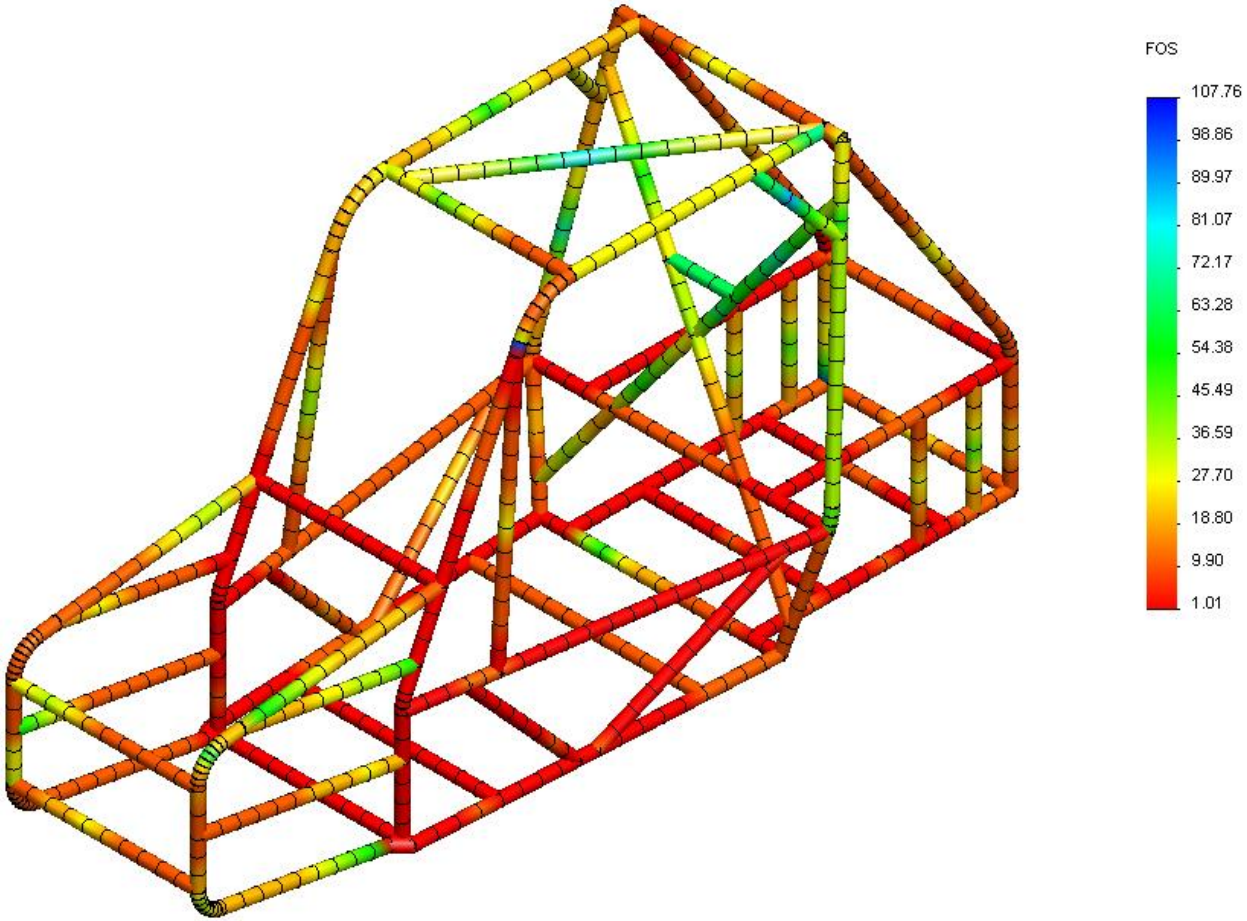
# Rear Collision Safety Factor



# Side Impact Deflection



# Side Impact Safety Factor



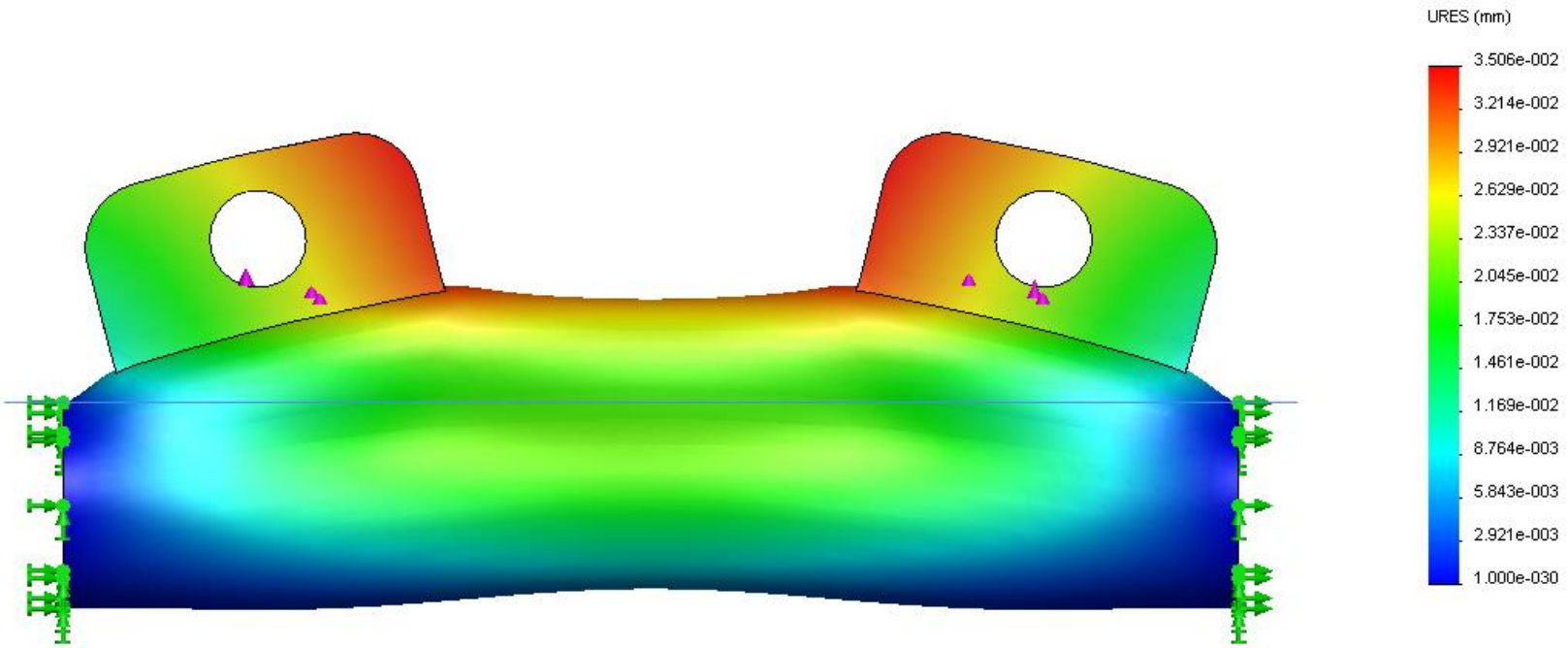
# Impact Results Summary

| Test | Max Deflection [in] | Yield Safety Factor |
|---|---|---|
| Drop | 0.089 | 5.32 |
| Front Collision | 0.135 | 2.90 |
| Rear Collision | 0.263 | 1.45 |
| Side Impact | 0.363 | 1.01 |

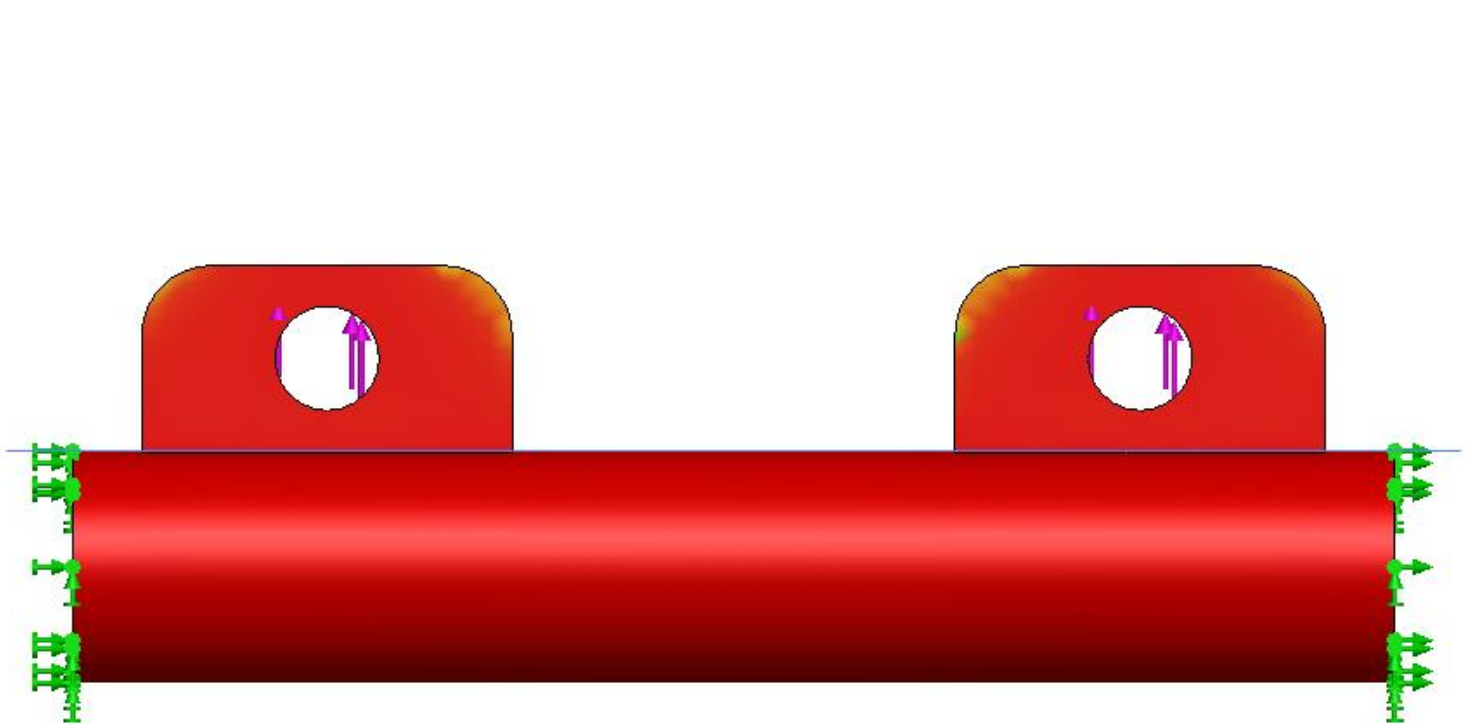
# Tab Shear Test

- Driver harness mounts
- Suspension mounts
- Drivetrain mounts
- Extreme loading cases
- Intentionally overdesigned
- Adds little additional weight

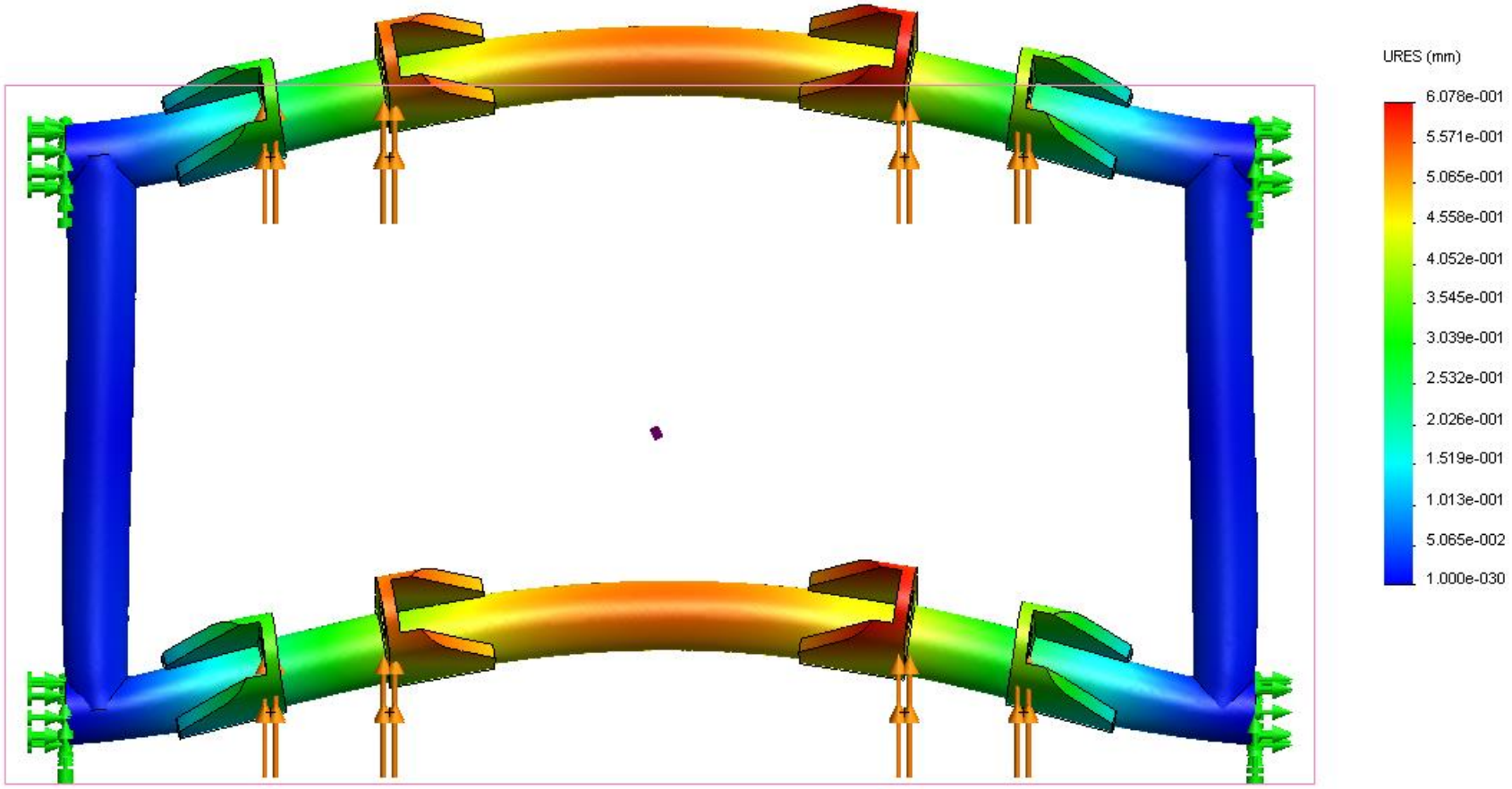
# Driver Harness Mount Deflection



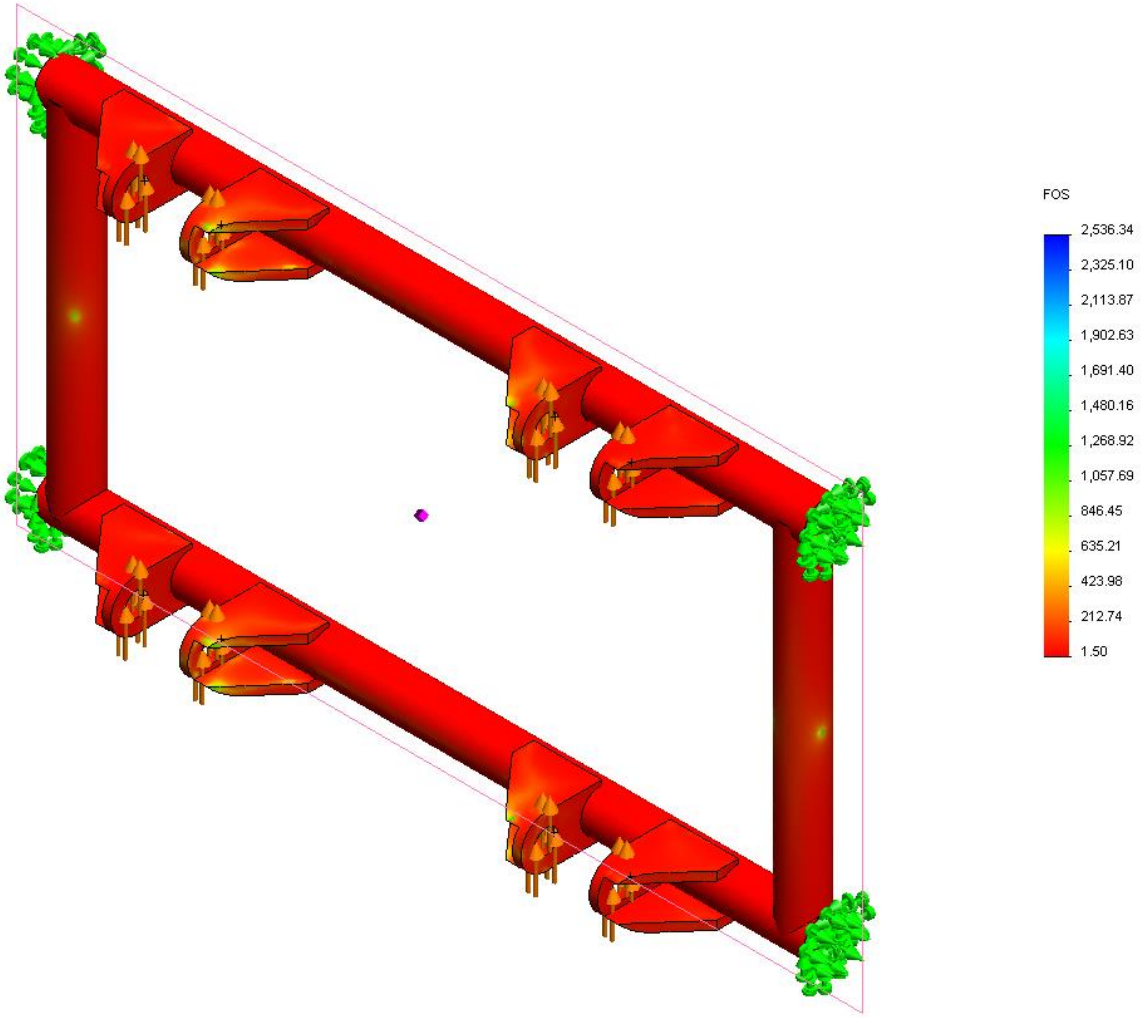
# Driver Harness Mount Safety Factor



# Frame Tab Deflection



# Frame Tab Safety Factor



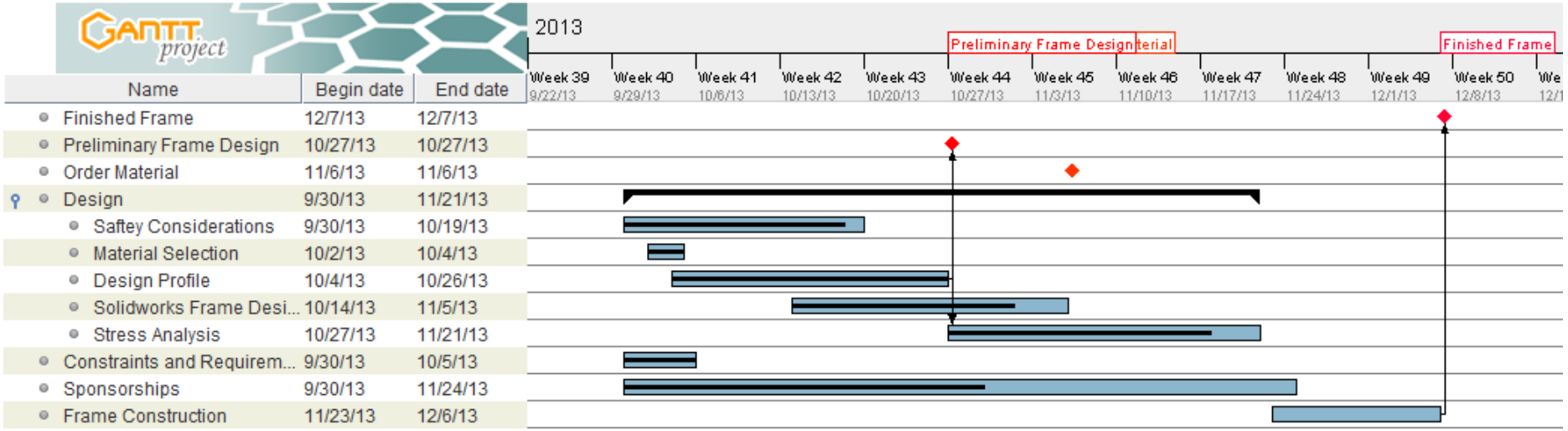
# Tab Shear Results

| Test | Max Deflection [in] | Yield Safety Factor |
|---|---|---|
| Driver Harness | 0.001 | 4.70 |
| Frame Tab | 0.024 | 1.50 |

# Engineering Design Targets

| Requirement | Target | Actual |
|---|---|---|
| Length [in] | 108 | 88.175 |
| Width [in] | 40 | 32 |
| Height [in] | 41 | 44.679 |
| Bending Strength [N-m] | 395 | 485.95 |
| Bending Stiffness [N-$m^2$] | 2789 | 3631.14 |
| Wall Thickness [in] | 0.062 | 0.065 |
| Pass Safety Rules | TRUE | TRUE |

# Project Plan




| Name | Begin date | End date |
|---|---|---|
| Finished Frame | 12/7/13 | 12/7/13 |
| Preliminary Frame Design | 10/27/13 | 10/27/13 |
| Order Material | 11/6/13 | 11/6/13 |
| Design | 9/30/13 | 11/21/13 |
| Saftey Considerations | 9/30/13 | 10/19/13 |
| Material Selection | 10/2/13 | 10/4/13 |
| Design Profile | 10/4/13 | 10/26/13 |
| Solidworks Frame Desi... | 10/14/13 | 11/5/13 |
| Stress Analysis | 10/27/13 | 11/21/13 |
| Constraints and Requirem... | 9/30/13 | 10/5/13 |
| Sponsorships | 9/30/13 | 11/24/13 |
| Frame Construction | 11/23/13 | 12/6/13 |

# Conclusion

- Problem Overview - NAU has not won an SAE Mini Baja competition. The Team will build the lightest possible frame.
- SolidWorks Simulation - Beam analysis used for frame. Tetrahedral analysis used for tabs.
- Refined frame designs – Designs 5 through 8 were analyzed. Design 8 had the highest safety factor.

# Conclusion

- Drop, front impact, rear impact, and side impact tests were performed. Design 8 passed all tests.
- Seat belt harness mount and frame tabs were analyzed. Both are well within safety limits.
- Team is on schedule. More time was allocated for frame analysis.

# References


- Owens, T., Anthony, Jarmulowicz, D., Marc, Jones, Peter “Structural Considerations of a Baja SAE Frame,” SAE Technical Paper 2006-01-3626, 2006.
- Silva, Martins, Maira, Oliveira, R. P. Leopoldo, Neto, C. Alvaro, Varoto, S. Paulo, “An Experimental Investigation on the Modal Characteristics of an Off-Road Competition,” SAE Technical Paper 2003-01-3689, 2003.
- Tester, John, Northern Arizona University, personal communication, Nov. 2013.