# Baja SAE Frame


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## Abstract


SAE Baja Collegiate Design competition is a nationwide competition in which students teams from many universities compete in a series of events designed to test the Baja vehicle to its limits. Student teams must engineer and build a single seat off-road vehicle. It must be able to traverse rugged terrain like rough roads or steep hills while offering the upmost level of safety for the occupant. A group of 15 students from NAU is participating in this competition at University of Texas, El Paso in late April. Three five person teams have designed the frame, drivetrain, and suspension. Our team is responsible for the vehicle frame and chassis design and analysis. The frame keeps the occupant safe in the case of an accident and it serves as the platform to where all other components are attached. The primary objective is to minimize the weight of the frame in order to maximize chances of winning at the SAE Baja Collegiate Design competition. The team also has to make sure that the vehicle complies with the all the rules in the SAE Baja competition, including the proper positioning seatbelts and restraints and engine kill switch placement on the vehicle.


## Problem Definition

The purpose of the frame is to protect the occupant in the event of a collision or rollover, and to provide a chassis to mount the other subsystems. A minimum spacing between the driver and the frame must be maintained to ensure driver safety, and minimum strength requirements must be met. There are specific requirements for the geometry of the frame. There must be a gap of at least 6 inches in all directions between the driver's head and the frame, and there must be at least 3 inches between the frame and the driver's body. The frame must be must be constructed of an SAE standardized tubing size or tubing having equivalent bending strength and stiffness. A 64 inch tall driver weighing 250 pounds must be able to sit comfortably in the vehicle with all the proper safety devices. The vehicle must be no wider than 64 inches and no longer than 108 inches.

The specific goal for our sub-team is to design the lightest possible frame that satisfies all the criteria specified in the 2014 Baja SAE rulebook. This will maximize the team's chance of winning an event at the completion. To achieve this goal, the team must use lightweight materials and minimize the size of the frame. At the same time, the frame must be designed to meet all the safety requirements. competition.

Engineering Design

## Design Approach

SAE specifies AISI 1018 tubing with 1-inch outside diameter and 0.120-inch wall thickness to be used for all critical frame members or tubing of equivalent bending strength and stiffness. The lightest tubing size that exceeds the SAE minimum requirements is AISI 4130 steel, 1.250-inch outside diameter tubing with 0.065-inch wall thickness. This is the tubing selected regardless of the frame design, and is 27.1% lighter than the stock tubing.

| Diameter [in] | Wall Thickness [in] | Stiffness [%] | Strength [%] | Weight [%] |
|---|---|---|---|---|
| 1.000 | 0.120 | 100 | 118 | 100 |
| 1.250 | 0.065 | 130 | 122 | 72.9 |

The vehicle was designed to look like a race truck from the Baja 1000. The roll cage and all other critical members were constructed using tubing with1.25 inch outside diameter and 0.065 inch wall thickness. Parts of the rear were made from with 1 inch outside diameter tubing with 0.035 inch wall thickness to save weight [Figure 1].

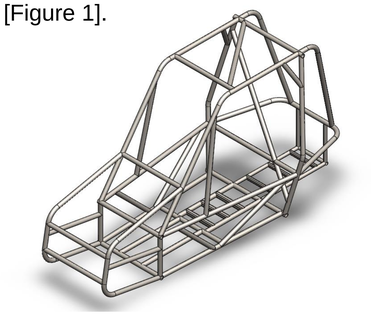

**Figure 1:** Frame design

## Numerical Testing

To validate integrity of the frame design, a simple test was done to show the stress distribution and yield factor of safety for the design [Figure 2]. An arbitrary load of 6000 pounds was evenly applied to the top bars of the roll cage and a static stress simulation was performed in Solidworks.

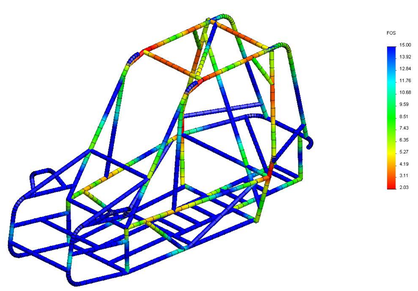


**Figure 2:** Frame stress distribution

## Fabrication

All manufacturing was done at the NAU Fabrication Shop. All the tubing was bent using a hand bending jig. The frame was welded using the GMAW (gas metal arc welding) process. A wooden jig was assembled so the frame could be welded properly.

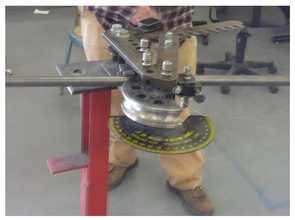
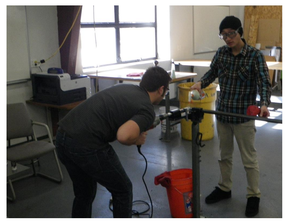
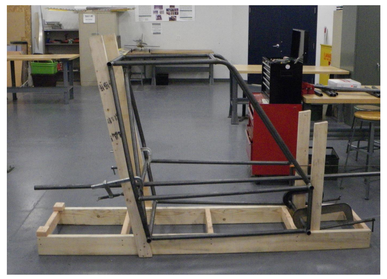
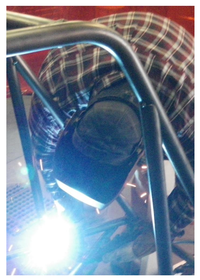

**Figure 3:** Clockwise from top left: tubing bender, tubing being notched, frame being welded, partial frame in jig,

## Competition

The 2014 Baja SAE competition was held at the University of Texas El Paso campus. There were four dynamic events at the competition: acceleration, hill climb, maneuverability, and suspension and traction. Along with the dynamic events there was also a four hour endurance race designed to test the vehicles performance.




**Figure 4:** Clockwise from top left: acceleration event, hill-climb course, suspension and traction event, maneuverability challenge.

## Results

There were 96 competitors at the 2014 Baja SAE competition. Results for each event are shown below.

| Event | Position |
|---|---|
| Sales Presentation | 18th |
| Design Event | 45th |
| Acceleration | 64th |
| Hill-Climb | 56th |
| Maneuverability | 27th |
| Suspension and Traction | 56th |
| Endurance Race | 46th |
| **Overall** | **51st** |

## Cost Analysis

The cost for the frame is shown in the table below. The cost includes the price of the raw materials and cost to manufacture the part.

| Part Name | Cost [USD] |
|---|---|
| Complete Roll Cage | 445.27 |
| Firewall | 14.87 |
| Hitch | 43.96 |
| Body Mounts | 47.76 |
| Seat Mounts | 16.69 |
| Suspension Mounts | 29.00 |
| Tube Caps | 36.01 |
| Transmission Mounts | 14.00 |
| Body Panels | 207.67 |
| Number Panel | 16.05 |
| Skid Plate | 58.23 |
| Cockpit Footwell | 4.99 |
| **Totals** | **$974.48** |

## Conclusion

The frame was heavier and larger than the others at the competition, making it slower. Due to its size, the turning radius was large. With our vehicle being larger, it was able to accommodate a wider range of driver sizes. For future NAU Baja vehicles, the frame can be shrunk to minimize weight and maximize maneuverability.

## References


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