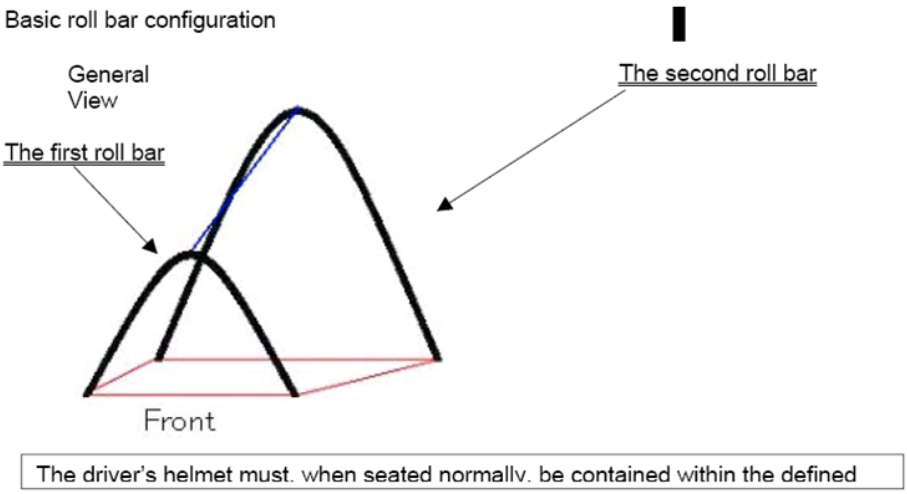
# Tufts University Solar Car Roll Cage

## Requirements (Taken from the International Solar Car Federation)

**International Solar Car Federation Roll Bar Specifications:**
All vehicles must be equipped with the first and second roll bars (as shown in the specifications below) to prevent direct damage to the driver and serious cockpit deformation in the event of a collision or of a car turning over.



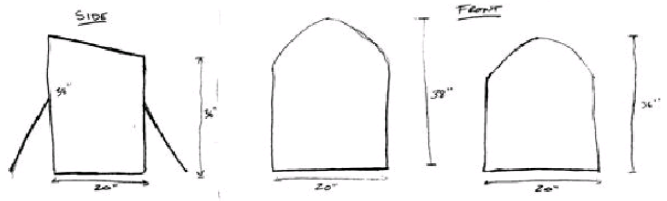

The first and second roll bars form the basic element of the rollover structure. These structures must be made of steel tubes or other material of sufficient tensile strength to protect the occupant from a force of 4w (w=weight of vehicle) The structure must be bolted, welded or otherwise structurally incorporated to the vehicle according to sound engineering practice. For vehicles whose bodywork fulfills the function as the first and second roll bars, the installation of additional roll bars is not necessary.
Roll bars shall meet the following dimensional criteria:

- The line extended from the top of the first roll bar to the top of the second roll bar must be above the driver's helmet when he/she is seated normally in the vehicle.
- The top of the first roll bar must be higher than the top of the steering device.
- The first roll bar must cover the steering device with steered wheel(s) in the straight position ahead when the vehicle is viewed from the front.
- The second roll bar must cover the driver’s shoulder when the vehicle is viewed from the front. In case that the bodywork of the vehicle covers the driver's shoulder, the second roll bar may cover only the driver's head.
- The second roll bar must have enough strength for lifting or towing with the driver on-board.

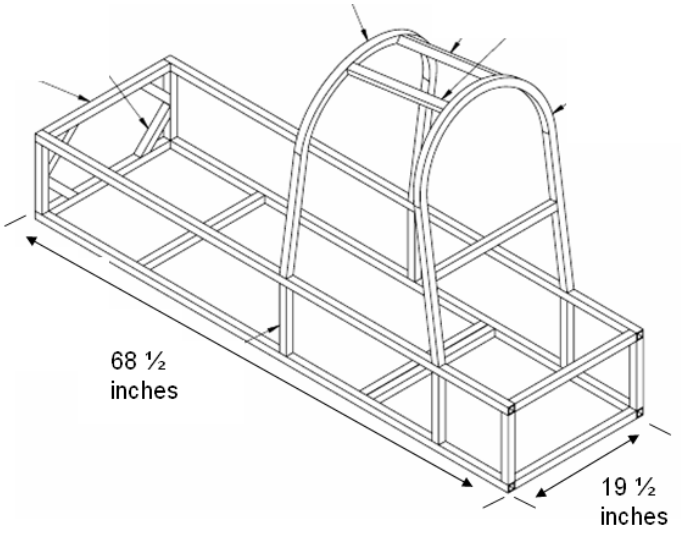
General descriptions:
Roll bars must be designed and constructed so that, when correctly installed, they minimize the risk of injury to the occupant. The responsibility to secure the necessary strength rests with competitors.
No part of roll bars must hamper the entry/exit of the occupant or take up the space designed for the occupant.

## Initial Roll Cage Dimensions:

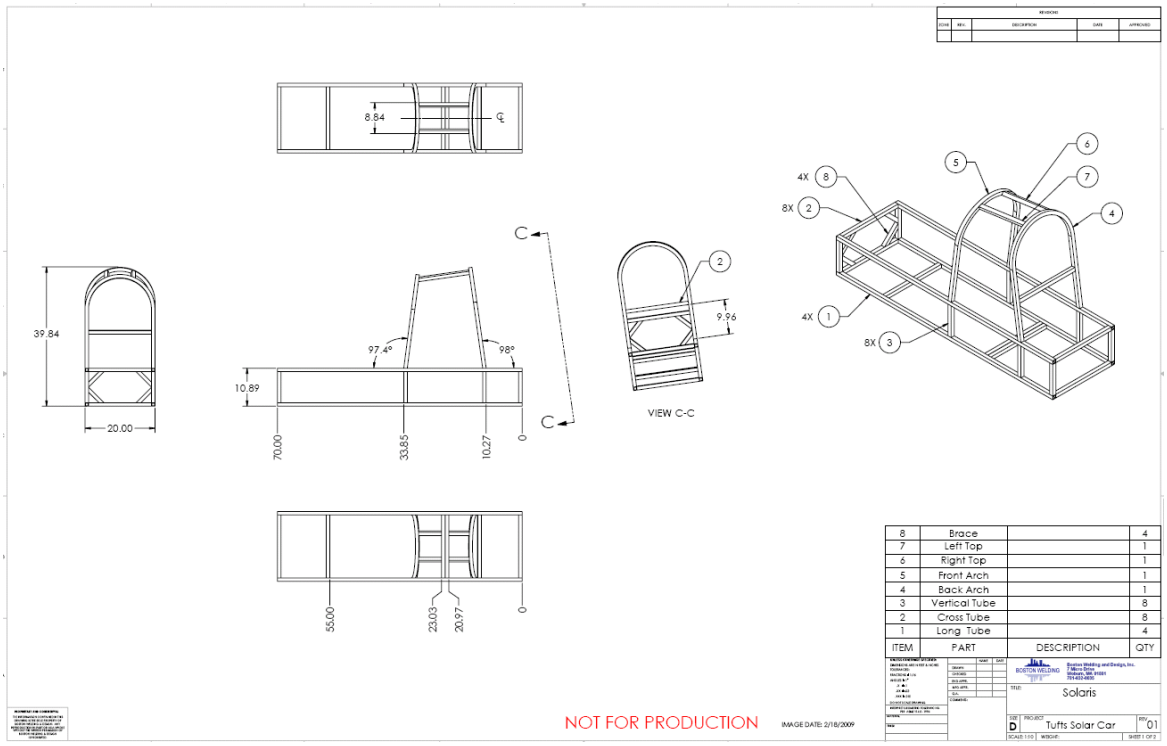
We did initial analysis by taking measurements of our bodies and averaging them. We then got the seat and helmet from these measurements and calculated the height required for the seat to be at a 27-degree incline. Thus the height of the roll cage is 36 inches in the front and 38 inches in the back. The bars will go directly within the monocoque frame to the initial dimensions were 20 x 70 inches. (See below)



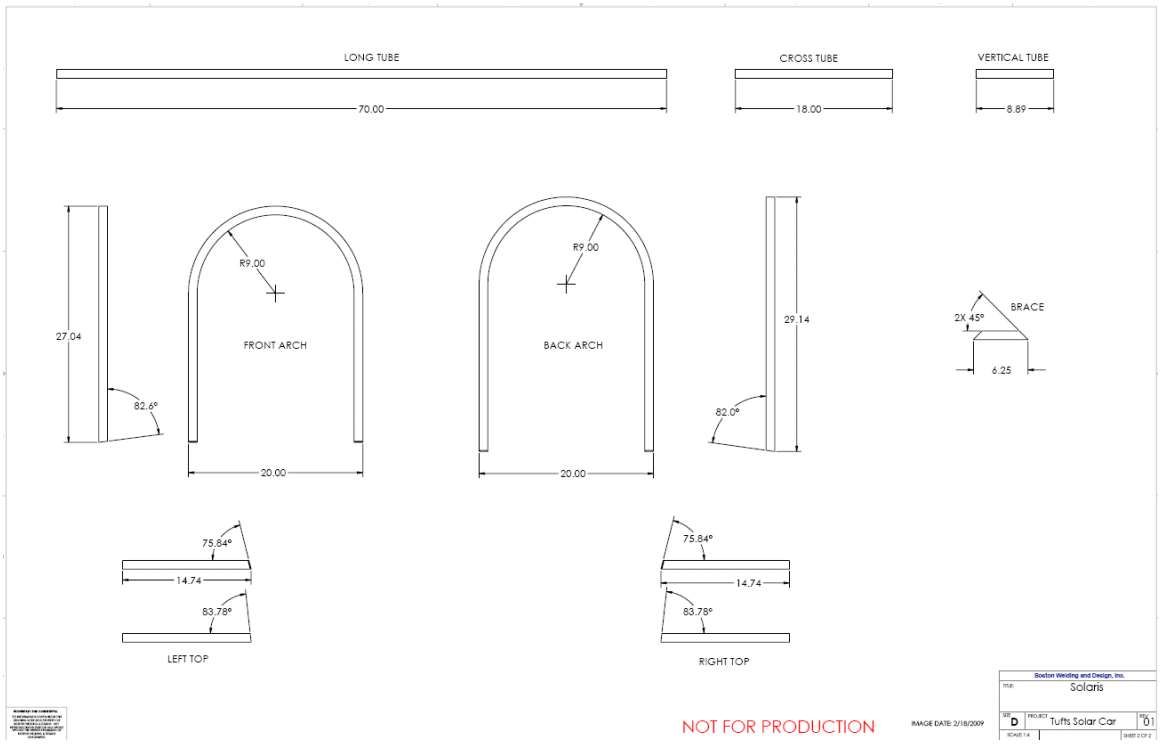

## Final Roll Cage Dimensions:




Below are the drawings for the roll cage:




| ITEM | PART | DESCRIPTION | QTY |
|---|---|---|---|
| 8 | Brace | | 4 |
| 7 | Left Top | | 1 |
| 6 | Right Top | | 1 |
| 5 | Front Arch | | 1 |
| 4 | Back Arch | | 1 |
| 3 | Vertical Tube | | 8 |
| 2 | Cross Tube | | 8 |
| 1 | Long Tube | | 4 |

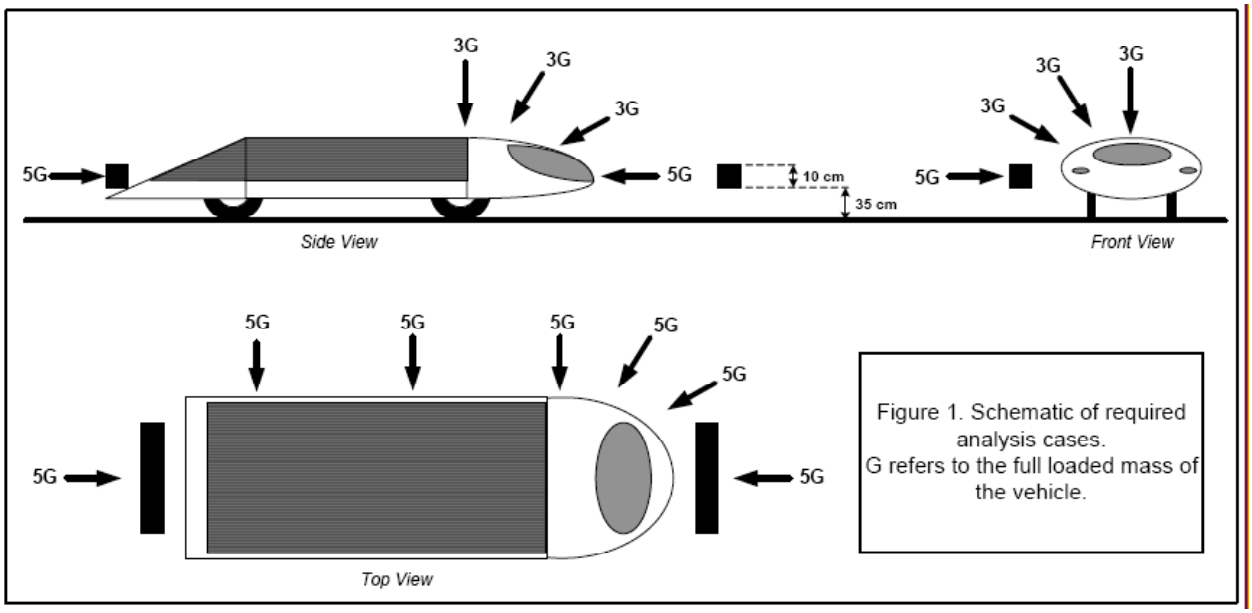



All the tube is 1/8” wall and the yield strength of the AISI 1020 used for material is about 50 ksi. The program assumes that all connections are full penetration welds. As it is with a low carbon steel (AISI 1020) and .125 wall the entire weldment weighs about 83.5 lb. Going to a .083 wall would bring the

weight down to around 55.5 lb and it would still probably be strong enough. Doubling the material strength to an aircraft grade 4130 steel with a .049 wall would bring the roll cage weight down to around 33 lb. As of now the cage will weight 83.5 lbs.

## Analysis

To do analysis we considered the stipulations given in the regulations for the World

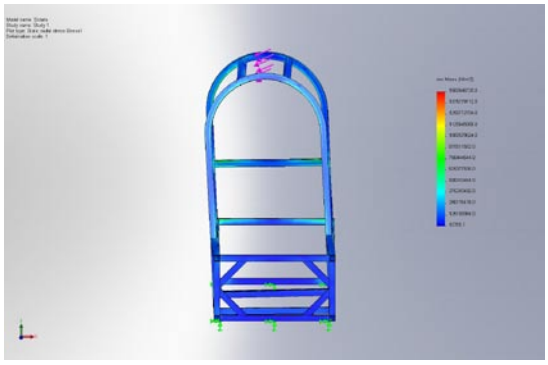



At 75 ksi the yield strength is higher than the 67 ksi listed for annealed 4130 in Solidworks. The deflections shown are graphically accurate. The region around the front roll bar shows the greatest deformation but it doesn't exceed the yield strength. For comparison to the scales on the right side, Solidworks shows a von Mises number of 460000000. So the combined stresses showing colors above that number are areas of permanent deformation.

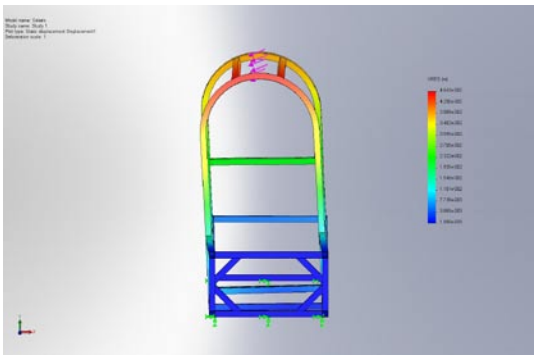
Alloy 4130 Material Easy-to-Weld Aircraft-Grade 4130 Alloy Steel Finish/Coating Unpolished (Mill) Shape Tubes Tube Type Square/Rectangular Tube Wall Type Solid Tolerance Standard System of Measurement Inch Specifications Met Aerospace Material Specifications (AMS) and Military Specifications (MIL) AMS Specification AMS -T-6736A MIL Specification MIL-T-6736B

An outside company, Boston Welding, did a Solaris study for us and used a 1-3g, 2-5g, and a 3-5g study to verify our calculations. Each of their studies had multiple cases where they applied the force. The jpegs show where each study is anchored, where 1000 lb is applied, and graphic deformations. These images demonstrate that the cage bends but does not break. Following are the attached jpegs for the different studies.

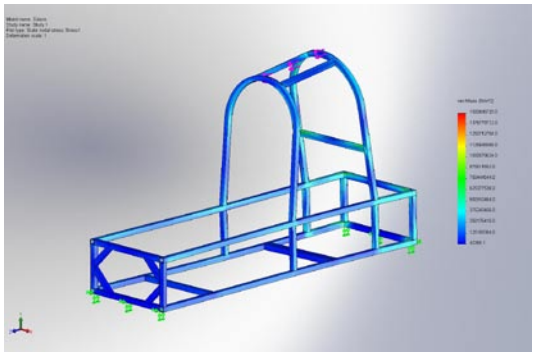
1-3g stress 1



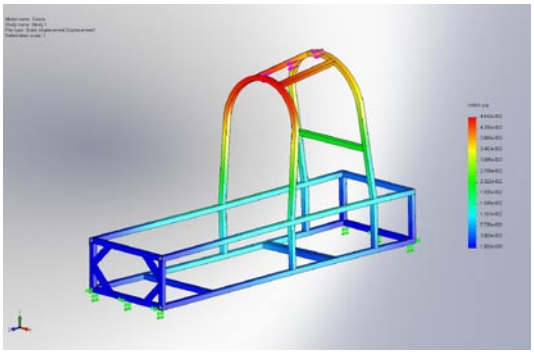
1-3g displacement1



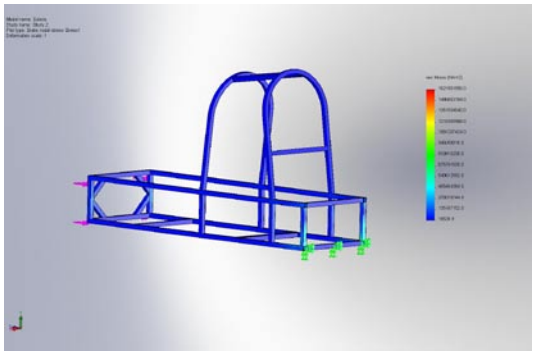
1-3g stress2



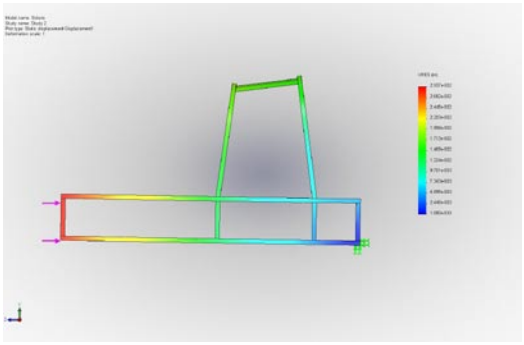
1-3g displacement2



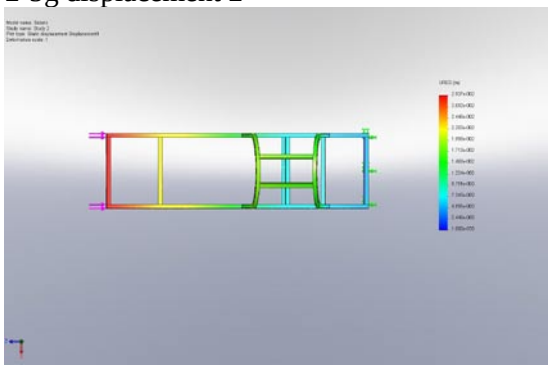
2-5g stress 1



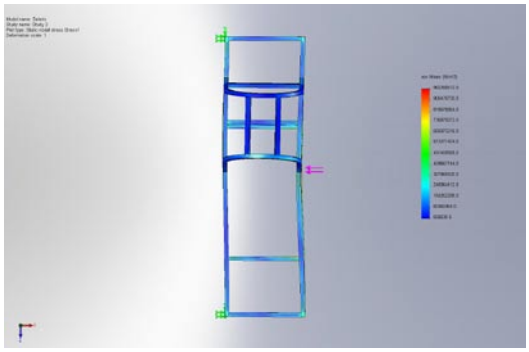
2-5g displacement 1



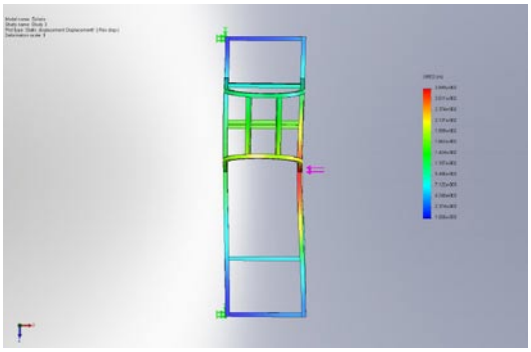
2-5g displacement 2



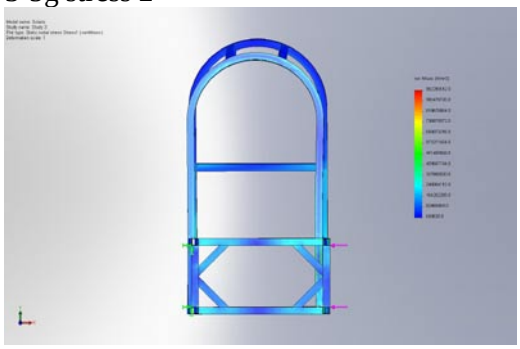
3-5g stress 1



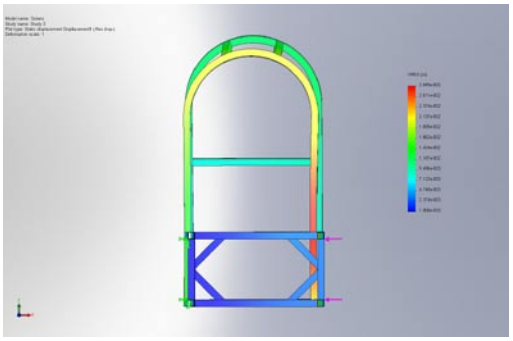
3-5g displacement 1



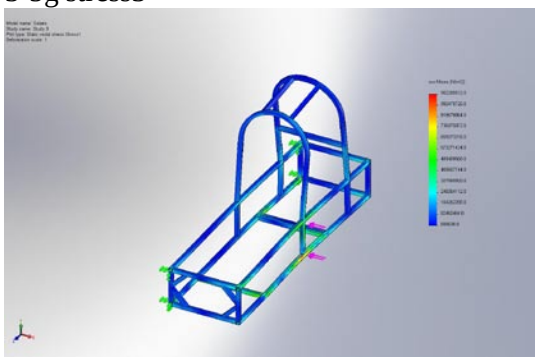
3-5g stress 2



3-5g displacement 2



3-5g stress3



3-5g displacement 3