The University of Connecticut
Formula SAE 2010
Design Report

I. Suspension

The first step to designing the suspension is picking out the ideal set up. We were able to obtain a free copy of Lotus suspension analysis software from Lotus Engineering. This tool was used to optimize the geometry as shown in figure 1. We chose to go with converging A-arms, -1 degree of static camber with one degree of change per inch of suspension travel, one degree of front toe in and one degree of toe out in the rear with minimal change in bump/droop. The static roll center is between one and two inches. After finding coordinates for the all of the pivot points in the suspension we were able to translate them to our suspension CAD drawings and make sure that our physical drawings fit up. Ease of assembly and maintenance were also top priorities for the design of the suspension components. Each corner will utilize the same upright, hub, spindle, wishbones, and mounting points, which makes repairing any damage easy and cheap. Mounting the brake rotor is on the inside of the upright also helps to minimize the scrub radius on our tire. The upright was designed with minimal weight in mind. The team optimized the design in Solidworks CAD and FEA. The upright and associated brackets were then printed using a rapid prototype process. The printed parts were given to Yankee Casting to be made out of magnesium which is a very lightweight and strong. The components can be seen in figure 4.

II. Chassis

The frame was designed using Solidworks CAD keeping mounting points for the suspension and engine in mind. The frame was analyzed using Solidworks FEA to help optimize the tubing wall thickness to give adequate tensional rigidity and minimize weight as seen in figure 5. With a lot of triangulation the team was able to obtain a torsional rigidity of 2500 lbs per degree while only weighing 62 lbs. We made sure that the frame would comply with all of the templates and envelopes required by the rules. The 2010 frame was over a foot shorter and 12 pounds lighter than last years. The body was made out of two layers of colored carbon fiber. A polystyrene mold was used and the carbon fiber was vacuum bagged to remove any excess resin and eliminate any air bubbles. The resulting body was extremely light and elegant.

III. Brake system

The design criteria for the brake system is it must lock all four wheels and comply with all the rules. The brake system consists of 4 wheel disk brakes actuated by a tandem master cylinder. The brake pedal uses a 5:1 pedal ratio to multiply the input force applied by the driver. A Wilwood tandem remote master cylinder with a 24.5 mm bore was used to meet the requirement of having two independent front and rear brake circuits. We chose this setup over a dual master cylinder and balance bar system because it was easier to install and was only half the cost. We are able to adjust the rear brake pressure by using a proportioning valve in line with the rear brake circuit. This valve is mounted on the dashboard to allow the driver to easily adjust the brake balance for different driving conditions. The brake calipers chosen were Wilwood PS1's. These calipers were used because they apply enough pressure on the brake pads to lock up all four wheels as required by the rules. The calipers are also very light and cheap compared to similar calipers. The brake rotors are custom machined out of 304 stainless steel. They utilize a floating button attachment to the hub which allows the rotor to move .065" axially which keeps the brake rotor centered between the brake pads resulting in even pad wear and consistent brake feel, as well as reducing heat transfer to the hub. The brake rotors were mounted on the inboard side of the wheel, which allows them to receive more cooling air than the previous outboard design.

IV. Engine

The engine we will be using this year is a 2003 Suzuki GSX-R600. This engine is an aluminum 599cc 4 cylinder 4 stroke engine with multiport fuel injection. Being an aluminum engine it has a good power to weight ratio, which keeps weight low while giving plenty of power. Being a liquid cooled engine it will be easier to tune and keep a constant temperature with a thermostat, which results in a more efficient engine. The main reason that we chose this engine is the availability in New England, which made it easy for us to buy multiple motors so we could have a parts engine and have money to rebuild our racing engine to our specifications. The second reason that we chose this engine is that it has smaller porting then other equivalent engines. The reason that we want smaller porting is so we can increase the velocity behind the valves which will in turn push more air in to and out of the cylinder on each stroke.

We purchased two engines for the 2010 competition. One of the engines was totally rebuilt with new pistons and bearings. Additional weight was cut off the flywheel to reduce rotational mass and blueprint the whole engine. A custom low profile oil pan was designed with baffles to keep oil from moving away from the pickup tube so the engine will always receive a constant feed of oil. This will give us a smoother running engine that will be reliable through competition. The intake and exhaust were custom designed to meet FSAE rules and tuned using Helmholtz principles to make the most amount of power. The intake is a runner plenum system with 4 equal length runners shown in figure 6. The exhaust is a 4-2-1 system, which produces more power throughout the power band.

V. Drivetrain Design

The drivetrain system consists of every component from the engine output shaft to the wheels. This car uses stock Suzuki GSX-R600 clutch plates and retains the integrated transmission. The clutch is cable activated as in the stock GSX-R configuration and the shifter has both manual and electro-pneumatic operation capabilities. Final drive ratios were chosen to fit the traditional autocross course which does not see speeds greater than 50 mph. The goal was to only use 2 gears (first and second) for the entire course, with first primarily a starting gear and second the main drive gear. Third and fourth gears were retained for "airport-style" autocross situations. The primary drive sprocket has been downsized to 12 teeth to reduce the final drive ratio without largely increasing rear sprocket size. The rear sprocket is 45 teeth and attached to an offset housing on a Honda TRX450FE front differential. The housing offset allows the differential to be centered in the car so that equal length axles can be used. This allows for common spares and equal torsional deflections with similar axle cross-sections. The differential is a cam and pawl limited slip type and while known for a ratcheting feeling on lockup, its locking behavior can be tuned by changing spring shim thickness. The choice was made for cost and weight considerations. The differential mounts to the GSX-R swing arm mounts, linking it to the engine, to isolate it from frame deflections. Chain tensioning was accomplished by the differential mount. Honda TRX450FE constant velocity joints are used on the inboard side of the halfshafts and Taylor Race tripod joints are used on the outboard side. A custom axle with both Honda and TRE tripod splines is utilized.

VI. Ergonomics

The car is equipped with both electro-pneumatic and manual shifting systems, with the pneumatic shifting system providing main shifting duties and the manual shifter serving as both a backup and means for drivers who prefer manual shifters over electronic shifters to change gears. The pneumatic system is actuated by two simple push buttons mounted to the cars steering wheel allowing the driver to keep their hands on the steering wheel at all times improving car control. The pneumatic shifting also interfaces with the ECU, allowing the driver to perform a clutchless upshift any time they wish to do so. The standard sequential manual shifter is included on the car alongside the pneumatic system because it adds a complete redundancy to a vehicle critical function at the cost of only 1.5 pounds of added weight.

Driver comfort is enhanced by a bolstered seat with 3.5 inches of total fore aft adjustment. At central adjustment of the seat the steering wheel is approximately 12 inches from the driver's torso. The steering wheel is brought close to the driver by a Delrin spacer placed between the wheel quick release and the wheel mounting plate. Spacers can be swapped out to accommodate different sized drivers should seat adjustability prove insufficient to meet their needs. Driver distraction is kept to a minimum with the use of digital outputs only. LED's are used to convey all relevant parameters to the driver those being, rpm range, coolant overheat and low all pressure. Extra indicators for items such as actual RPM, lap timing, fuel consumption, and ect were deemed unnecessary for a car targeted primarily at auto cross.

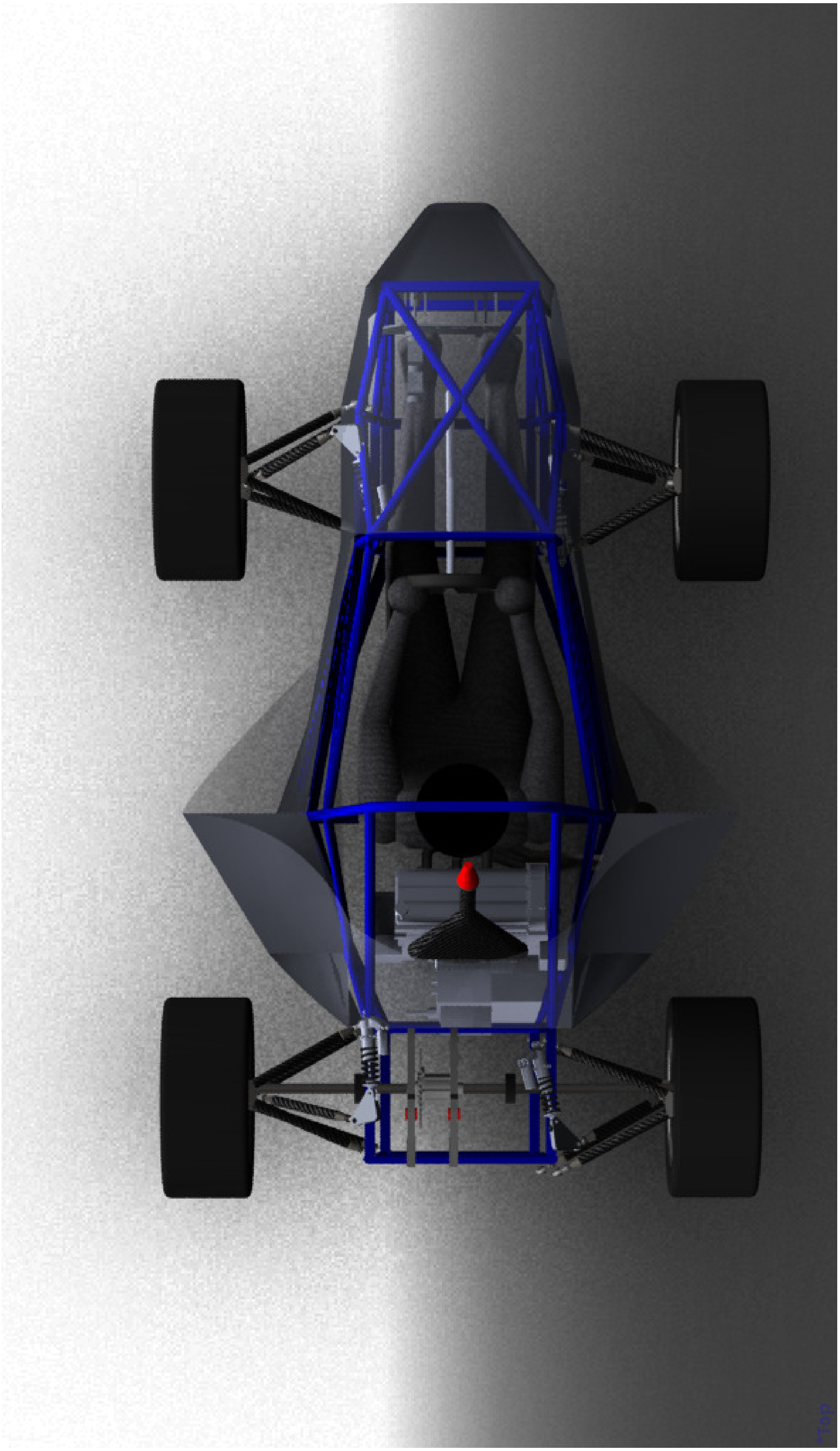

Figure 1. Top view of the 2010 car

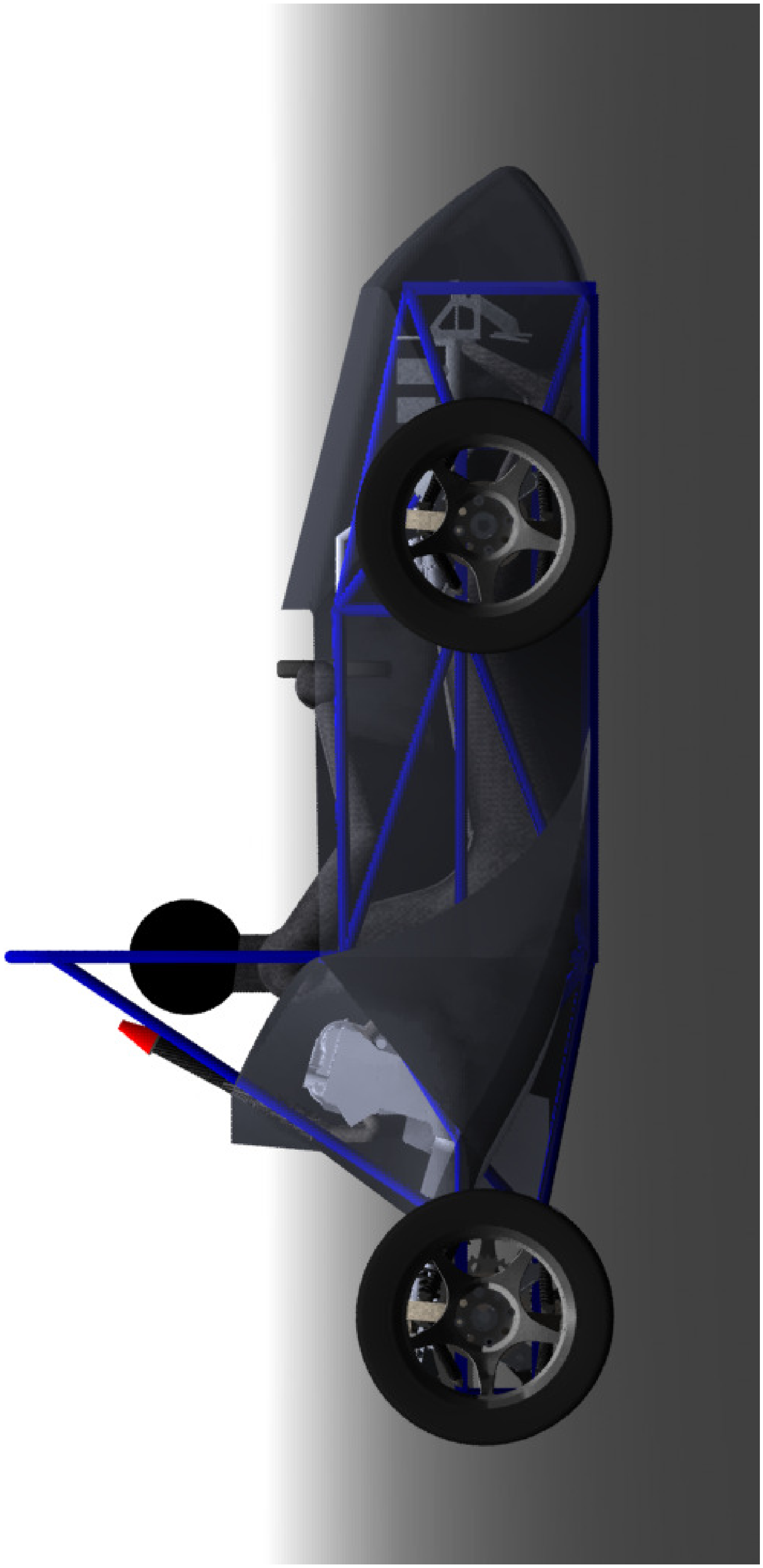

Figure 2. Side view of the 2010 car

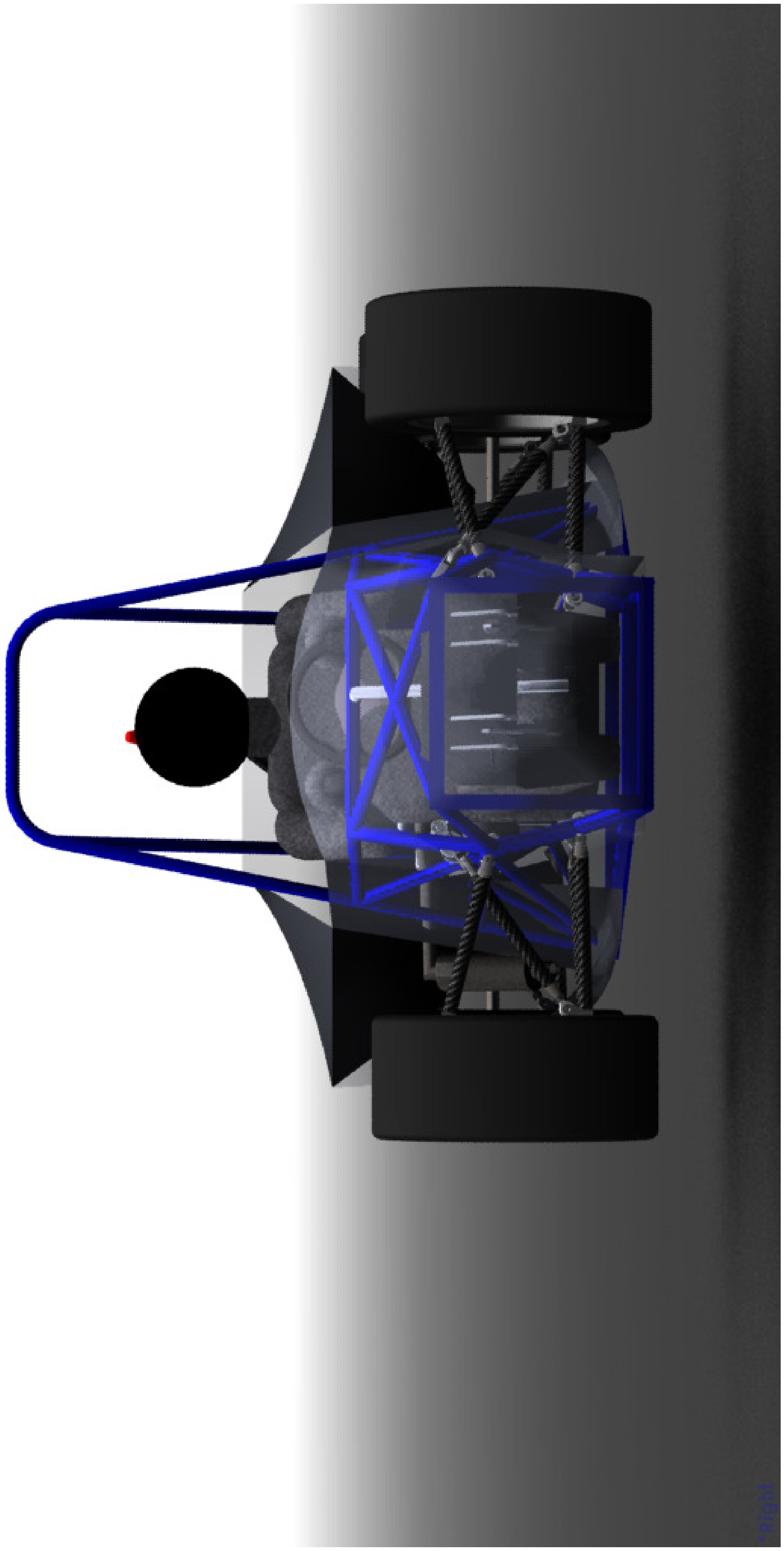

Figure 3. Front view of the 2010 car

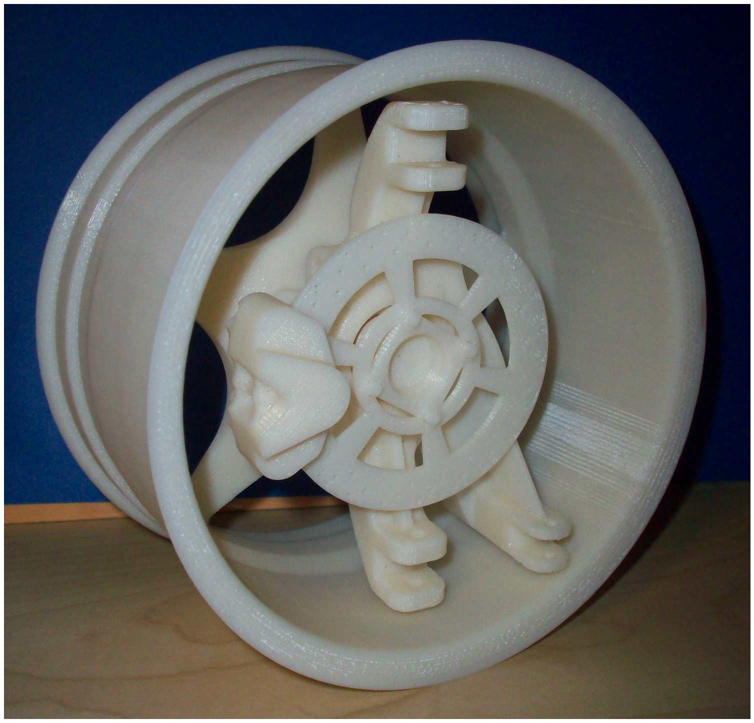

Figure 4. Rapid Prototype of Suspension Components

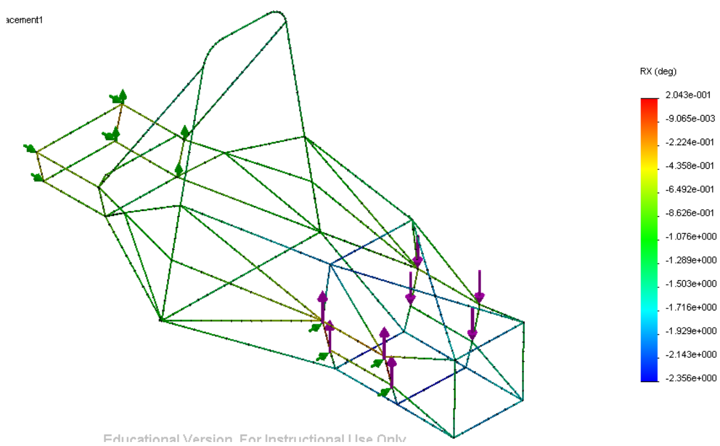

Figure 5. Frame torsional rigidity analysis

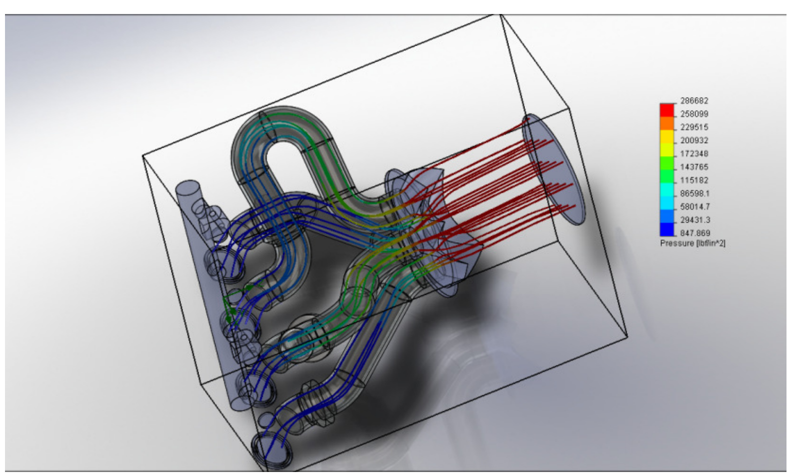

Figure 6. Intake design flow simulation