Orion Racing India has been participating in Formula Student for the past 4 years. This year our major technical aims were extensive usage of composite materials, improved driver ergonomics and making the car extremely robust and reliable. Composite Systems was introduced as new entity to facilitate further research.

Chassis –

The Aeton car is made of tubular Steel space frame. The material used is AISI 1020 cold rolled Seamless tubes of diameter 25.4mm and variable wall thickness varying from 2.4mm to 1.25mm. The Welding used is CO2 welding. We designed the chassis for a Torsional Rigidity of 2000 N/m. Ergonomic considerations were taken using a wooden dummy. Steel fixtures were employed to ensure precision during manufacturing. Also the engine bay has been designed to remove the engine from the top easily.

Suspension –

Suspension geometry was designed for a 270kg vehicle with a 70kg driver and 45% front and 55% rear static weight distribution. We have designed an aspect ratio of 0.848 and the front and rear wheel frequencies have been set to 2.2 Hz and 2.0 Hz respectively for smaller front amplitude of vibration to enable driver visibility and control. Front geometry brake anti-dive is at 14.4%. We have increased the geometric roll centre's height from the ground, thus decreasing the moment arm length between the vehicle's theoretical centre of mass and the geometrical roll centre. An additional design consideration for this was for the increase in the height of the lowest member of the nose resulting in an increase in elevation in the cockpit's floor to aid ergonomics. The shock-absorbers have been mounted inboard actuated by pushrods in the same transverse plane. Steel wishbones and aluminium bellcranks and uprights with hard-anodizing and EN-47 spring steel anti-roll bars comprise the system.

Steering –

The major goal set this year was to reduce the steering effort to aid the driver. We also designed a new custom wheel since the previous wheel was very small. Analysing tire data, we calculated the maximum slip angles on basis of speed and testing results. We selected a 100% static Ackermann to 76% dynamic Ackermann due to excessive tire wear and the slip angles being considered for maximum case only. Ackermann geometry also gave us better turning radius at lower speeds. We are running a rack and pinion due to easy manufacturability and ease of the system. The column is manufactured out of EN31 since gear cutting was easy on it and it is also stronger than EN24 or EN8. We have used two bearings to support the shaft and to stop misalignment at both wheel end and gear end. The tie rod point on the upright is also bolted on to give variable geometry. The toe is point is behind the upright to distribute the load on the upright coming from the calipers and it also moves the rack towards the Front Roll hoop eliminating template problems.

Brakes –
The brake pedal is designed to withstand 2000N of foot force as per the new rule. Considering the dynamic change in bias, the brake pedal is kept tilted towards the driver side. The brake rotors of 220mm (front) and 218.5mm (rear) and master cylinder bore diameter of 0.625 inch (front) and 0.7 inch (rear) were selected to provide natural bias. Al-2014 was selected as the material for front hubs for its high yield strength, good fatigue properties and easy machinability.EN-24 spring steel was selected for rear hubs as it was designed to mate with the splined axles of EN-24 material. For the ease of routing the accelerator cable was routed using a 90 degree spherical ball joint. Also tension springs were replaced by torsion springs to prevent interference of the driver's foot while operating the pedals with mount of tension springs. Hubs were designed to facilitate the easy removal of brake rotors from the outboard side without disassembling the wheel assembly.

Powertrain –
The primary objective of the powertrain was to provide for a reliable engine package with a properly tuned engine and a dry sump lubrication system to overcome the starvation issues. Unfortunately due to time constraints we could not put the dry sump system onto the car but it has been completely designed and tested on the last year's car. The components designed were Oil reservoir, pressure relief valve housing and flat oil pan. As the stock pressure relief valve wouldn't fit inside because of the flat oil pan we had to design a housing so that the relief valve would fit into the main oil gallery and maintain oil pressure. The material used was Al 6351. We tilted the engine for a flat oil pan for ease of manufacturing. The co-ordinates of the stock oil sump were recorded using a CMM which were then put onto CAD to design the pan. A thermal load analysis was done on the oil pan to check for warping under high temperature. The material used was Al 6061.

Air Intake and Exhaust –
Our major goal for the air intake system was to reduce the weight of the by 25%. To achieve this, we manufactured the airbox using rapid prototyping (SLS). The material selected was Duraform PA due to better stress capacities. A layer of epoxy resin was also coated to make the airbox stronger. Also, the restrictor has been made completely of carbon fibre. For the airbox, we made use of the kinetic energy conservation, rolling flow plenum design, incorporating a diffusing section at the inlet to increase airflow to the extreme left and right cylinders. Inlet velocity for the airbox at peak suction pressure was calculated to be 433.59m/s. The exhaust system was made using mild steel and was then coated with a heat resistant ceramic coat. A 4-2-1 header design was preferred over the 4-1 header design so as to increase mid-range performance. Both, the intake and the exhaust system have been designed for an engine speed range of 8,500 to 10,500 rpm. The injector seats and offset adaptors have been machined from a single piece of Aluminium. The airbox is mounted towards the main roll hoop to avoid template problems.

Cooling –

The major goal of the cooling system was to design a reliable cooling system which would give variable heat rejection rate by controlling the flow rate of electric water pump. We have employed NTU method for heat rejection calculations. The stock cooling pump on Honda CBR600 F4i varies its flow rate according to the engine RPM, thus the cooling system will not operate when the engine is stalled. Hence we have used Davies Craig EWP80 electric pump which gives flow rate depending on the amount of voltage supplied to it. We have also used Davies Craig 8" thermatic fan instead of stock fan, the main reason being weight. We tested the flow rate of pump at 12V DC to be 75 LPM which is within the limits of manufacturer's claim. We also tested the free stream velocity of air by our fan to be 7.5 m/s. For calculations for radiator size were done for 70LPM water side flow rate and 5m/s velocity accounting for water side and air side losses. The radiator is fabricated out of aluminium due to its light weight and good thermal conductivity. We have also taken in consideration the proper placing of radiator so that the natural air flow is perpendicular to the radiator. The side pod incorporating the radiator is of diverging-converging section to achieve good air convection and good pressure drops.

Drivetrain –

The design was with the goal of improving the drive ability of the car and the reliability of the system. We have used a Salisbury Differential since it gives different settings of Torque Bias Ratios to choose from and for its better tuning options. The Differential has been mounted to facilitate easy assembly and can accommodate different sizes of sprockets easily by varying the length of the shackle plates that support the light weight aluminum differential mounts to chassis from one end which can be substituted for turnbuckles for fine tuning. A 520 chain has been used instead of the 525 chain that has been used for the past years. An Aluminum Driven Sprocket and an Integrated Tripod joint with Stub Axle to transmit drive from the differential have been designed and successfully implemented. Rear Hub assembly was designed in such a way that it is very convenient for the assembly and disassembly of the driveshafts without having to disturb the suspension system. The rear hub is driven by a tripod joint which drives a half shaft inserted into the hub from the outside the hub assembly. If the shaft is removed outwards then the outboard tripod will be disconnected and entire driveshaft assembly is easily removed. To prevent accidental removal of the half shaft a back plate is bolted to the hub on the outer side so that the half shaft does not come out.

Electronics –

The main aim this year was to make a robust and reliable electronics system which aids vehicle analysis and quick troubleshooting.

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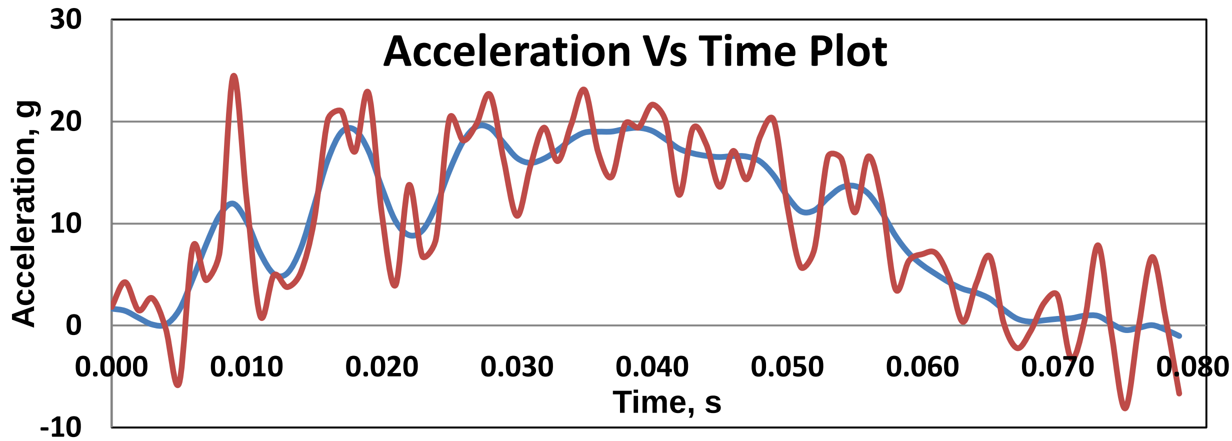
Design Process: Proteus Simulation-Breadboard Testing- Rough implementation- Final implementation. This helped to identify many redundant circuits. All units except the ECU were designed and developed In-House. Data Acquisition System is built around a dsPIC33FJ128GP706A controller., logging the data into a USB flash drive. It can log data at a much higher rate than a SD card which we were using until last year. This system can take inputs from 18 sensors. We also have a GPS system with a higher update rate (4Hz) and capable of logging data independently. This year we have also developed a telemetry system which we use to monitor the car while it is running. We have also developed a LCD system for the driver to view certain parameters of the car. The LCD system can communicate with the data acquisition system over the CAN bus.

Composites –

The Aeton's Impact attenuator is made up of prepreg carbon fibre. It has increasing layers towards the base to reduce the G levels and increasing the energy absorbing capacity. Beta foam block filled on the inside is used as the damping element. The Energy absorbing capacity of the attenuator is 16000J. It weighs 550gms with peak deceleration and average deceleration of 19.5G and 9.5G respectively. Prepreg carbon fibre (twill weave,300gsm) with the following orientation: 0-30mm (0/90 +-45 0/90) , 30-140mm (0/90 0/90 +-45 0/90), 140-205mm (0/90 0/90 +-45 0/90 0/90 0/90) , 205-265mm (0/90 0/90 0/90 +-45 0/90 0/90 0/90) was laminated on the epoxy tooling block(male pattern).The part was then vacuum bagged and then cured at 120^{o} C at 8bar pressure for 7 hours. Final pattern was released directly from the pattern to reduce the mould making cost. Carbon fibre (200gsm, 2k, simple weave), glass fibre(460gsm, simple weave) and epoxy resin LY556 with Aradur 991 hardener is used to make the nose, side pods, rear cover, seat and other mounts of the car. The nose and the rear cover of the car is made of 1 layer carbon fibre (200 gsm) and 1 layer glass fibre (400gsm). The nose weighs 1.76 kgs, 400gms lighter as compared to our last year's nose. The rear cover weighs 860gms. The reason for using glass fibre was to add stiffness to the carbon fibre. To reduce mould making cost, we have identical side pods and we could get both the side pods from a single mould only. The side pods and the seat were made of 3 layers of carbon fibre. The side pods weigh 1.19kgs, 330 gms lighter than last year's. The seat weighs 1.2 kgs. Structural foam and chopped strand glass fibre were used as the pattern and mould making materials respectively. The full bodyworks weighs 8.7kgs 39.5% lighter as compared to our last year's bodywork which weighed 14.2 kgs. We also have a Carbon Fibre and Aluminium sandwiched steering wheel which we are still testing. We have also made a prototype air box out of carbon fibre and are now investing time into a composite fuel tank.

Miscellaneous –

We have implemented a fully electronic solenoid shifter because it is much reliable and faster than a hand shifter. It also let us invest some time into Gear change ignition cut to reduce jerks during shifting and a hand clutch, however it is still in the testing phase and has not been implemented on the car fully.

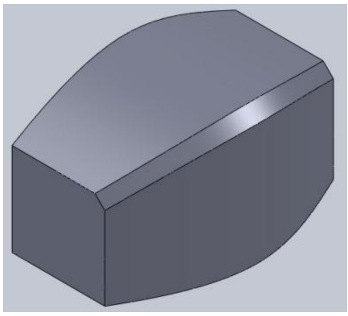


Impact Attenuator

Drop Test

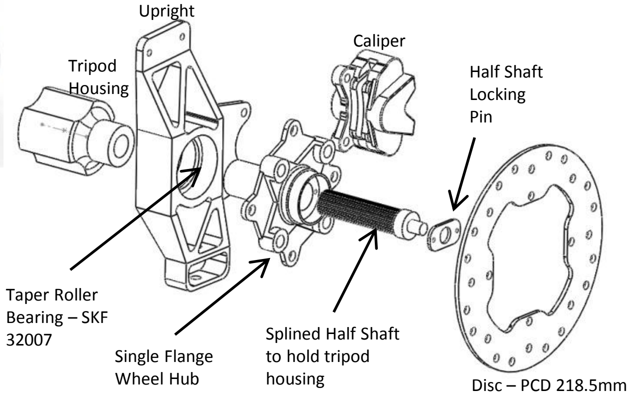
Steering Wheel

Restrictor

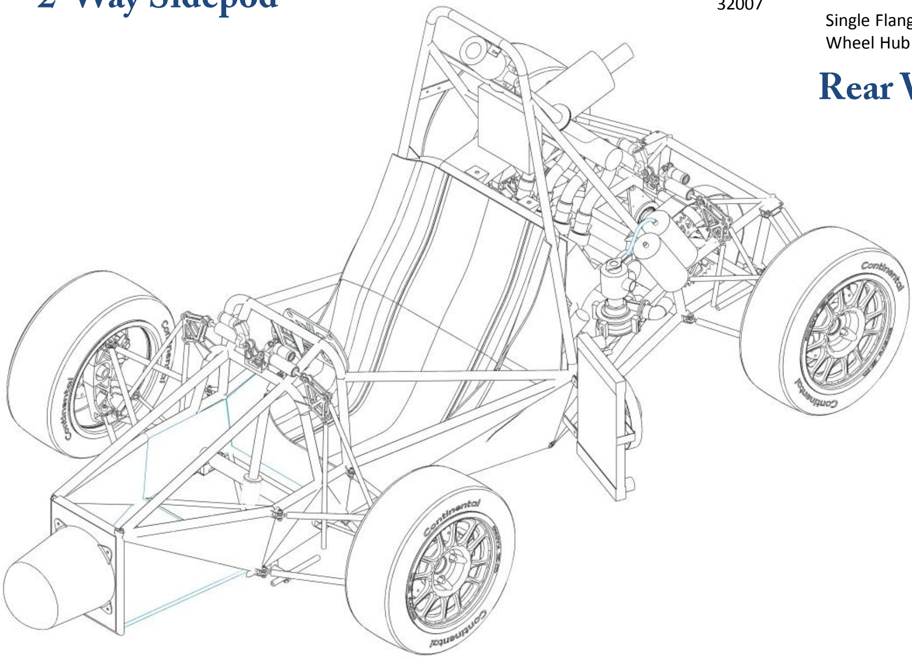


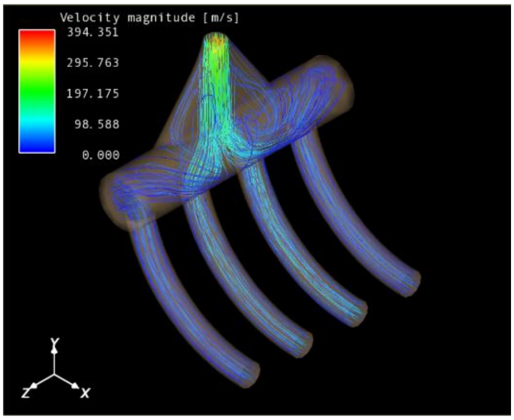
Single Mould for 2-Way Sidepod

Dry Sump Lubrication

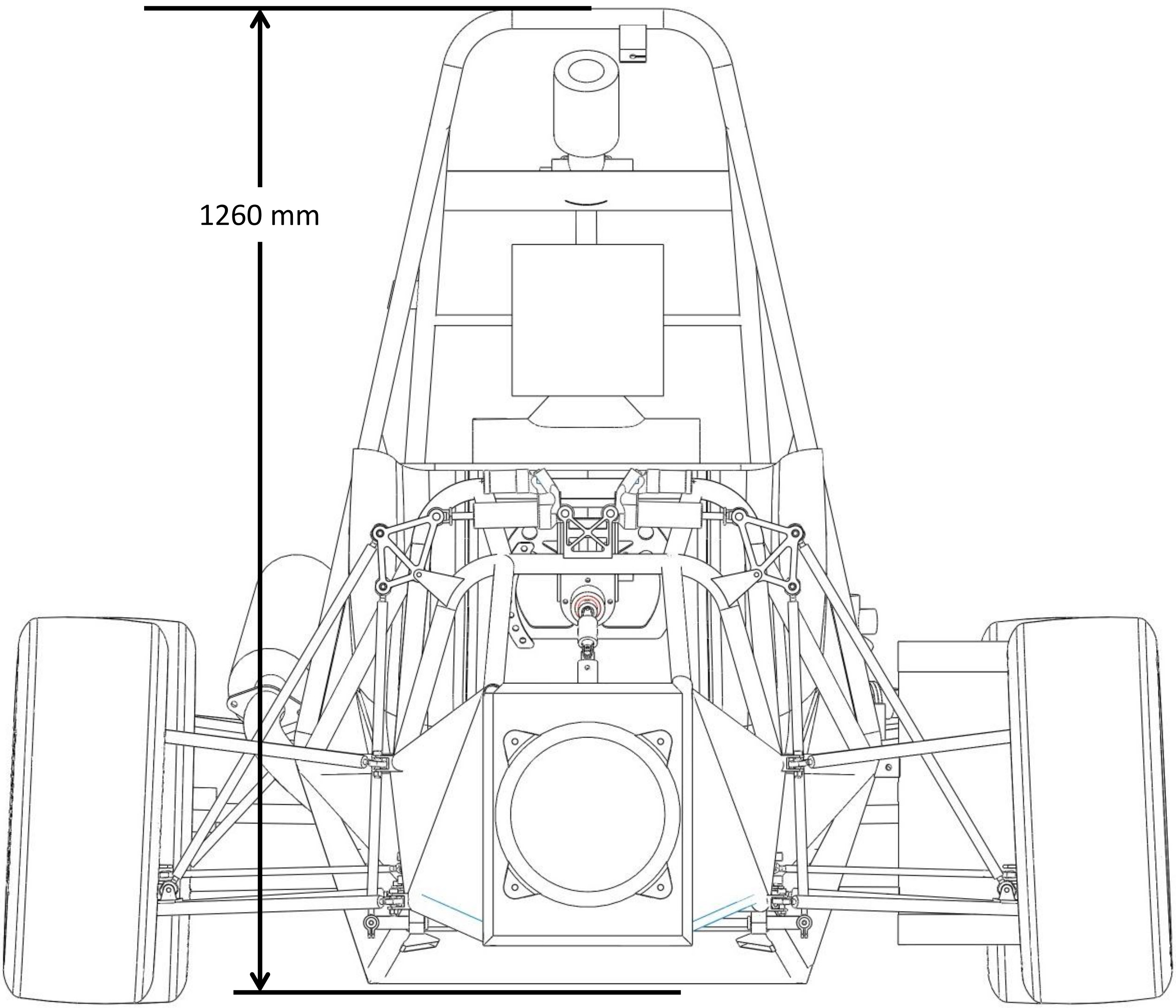


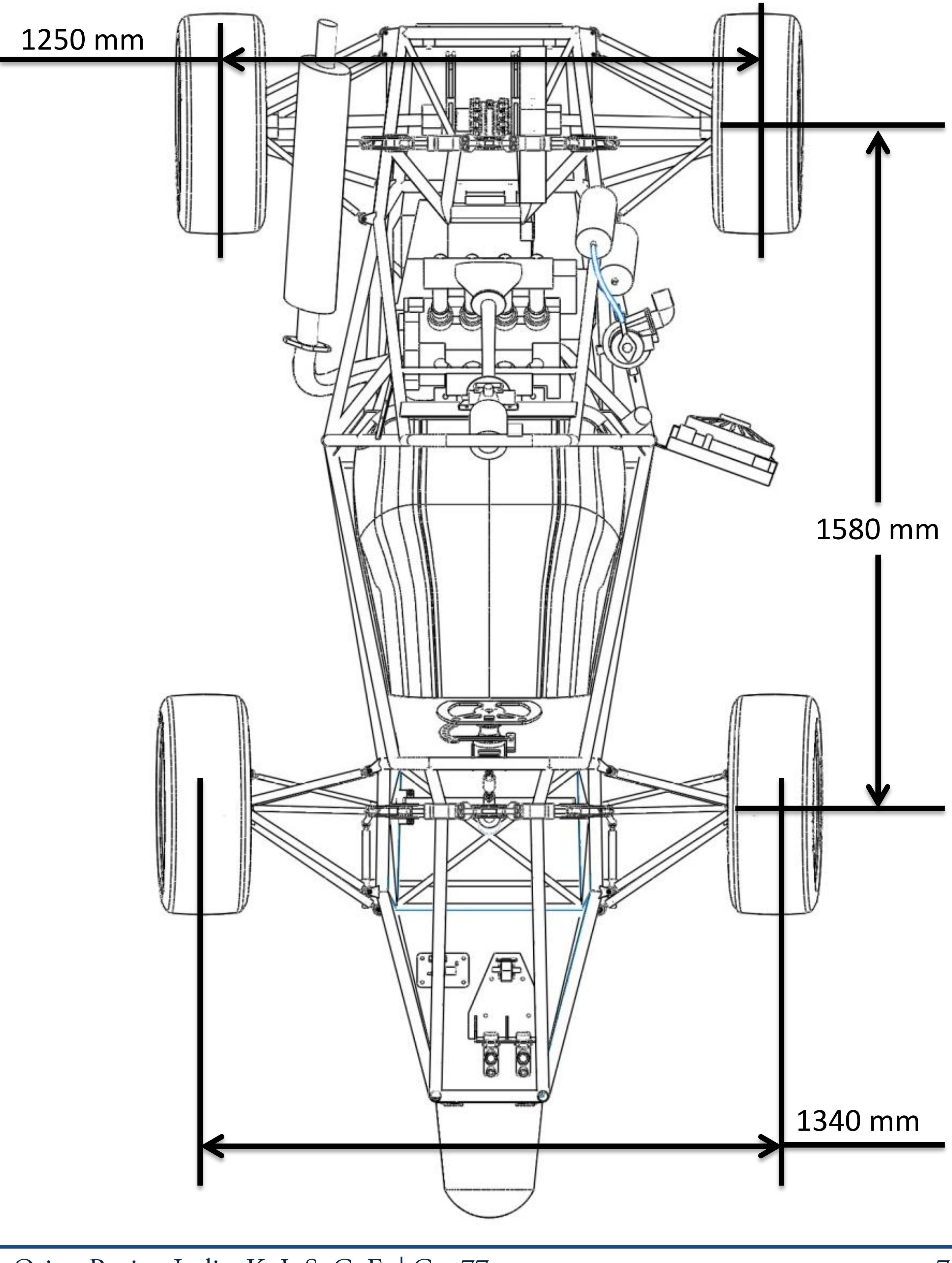
Rear Wheel Assembly

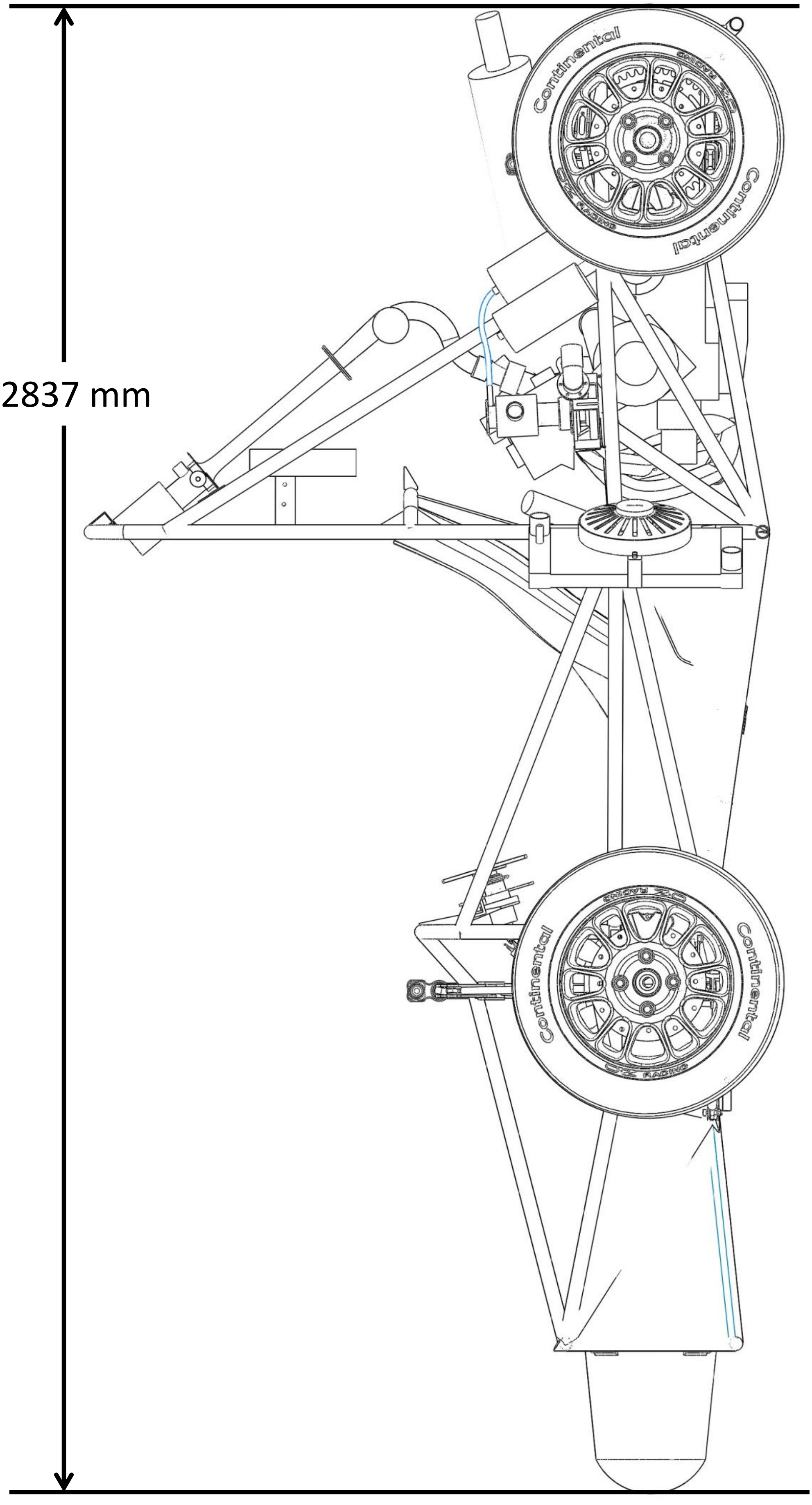




Air Box Flow Simulation


1260 mm


1250 mm
1580 mm
1340 mm


2837 mm