ENGINEERING DESIGN REPORT

The main objectives of the 2012 team of Orion Racing India were to keep the designs simple thus getting on with the manufacturing stage early on in the year and leaving majority of the time for vehicle testing. The increased focus on testing is aimed at ensuring reliability and improving performance. Emphasis was laid on vehicle packaging and the use of alternate materials like carbon fibre and PU foam to reduce the overall weight of the car.

Suspension

The design of the suspension was based on the evaluation of last year's system and its drawbacks. The main objective of this year's suspension team was to design a system that can provide a good transient response, easy manufacturing, assembly and adjustability.

Tires-

The tires selected this year are the Formula Student Radial Tires manufactured by Continental AG. The advantage of using this tire over bias ply is its better transient response, more transmission capacity and longer life.

Rims-

The 13” OZ Racing rims were selected for this year so that packaging of the wheel assembly can be done with ease and it is easier to incorporate the calliper and rotor assembly. Also, a larger steering arm length could be incorporated to reduce effort. All this was at the cost of the increased weight of the large wheels.

Geometry-

Correction made as compared to last year in the roll centre height in the front with respect to the rear. The design incorporated roll centre height of 30.3mm and 44.17mm at the front and rear respectively. Lower front roll centre height is adopted to have less of the total lateral load transfer in the front to combat understeer. The vehicle has a rear push rod actuated and a front pullrodactuated system. The pull rod in the front helps to lower the CG and improve driver visibility.

Uprights-

The uprights were designed keeping in mind the manufacturing processes involved thus keeping the costs to a bare minimum. The material of the uprights is 6061 Aluminium. The design included integral calliper mount and toe control mount for ease in assembly.

Adjustability and Compliance-

Adjustability of major parameters such as toe and ride height was greatly facilitated by the use of LH and RH rod end bearings in the toe control link and push pull rods. Slotted shims have been implemented to allow for easy camber change.

Chassis

This year's chassis is a tubular space frame chassis. The major emphasis was given on good packaging and driver ergonomics. A fixture was constructed to take various dimensions related to driver positions. Rear box was eliminated from chassis caused to reduce overall length by 335mm and overall weight by 3.4kg. The material for the frame- ASTM A 179 and DIN 2391 st 52 was selected after suitable physical and chemical tests. Welding process used was TIG welding resulting in neater and stronger welds. The filler material used was AWS ER70 S2 of 1.6mm diameter.

A light weight carbon fibre seat has been moulded to provide the driver with an ergonomic seating position. Rib structures are provided at the back of the seat to increase its stiffness.

A 700 gram impact attenuator has been manufactured from carbon fibre with a peak deceleration value of 19g. Beta foam has been incorporated as a precautionary measure.

Steering

The steering mechanism comprises a rack and pinion gear set with the pinion connected to the steering wheel via steel columns and splined universal couplings. The splined universal couplings have been selected since they provide better stress distribution over the circumference of the column as compared to bolted couplings that were used in 2011. This also reduces the chances of compliances in the assembly after excessive usage. The 2012 steering system has been designed for a minimum turning radius of 3.8m as compared to 4.5m in 2011, providing better manoeuvrability. Driver effort has been reduced from 5kgf to 4kgf by reducing the scrub radius and the steering was made more responsive with a gear module of 1.5. Spring plungers have been utilised to maintain constant contact between the rack and pinion and they also prevent the rotational movement of the steering rack.

The composites team designed several components using carbon fibre, glass fibre and PU foam. The steering wheel core was developed with PU foam and glass fibre sandwich. A separate electronics box was incorporated that allows separate driver interface modules without changing the core. The foam used on the handles is soft for better grip. The steering wheel is also equipped with carbon fibre paddles for gear shifting.

Brakes

In 2011, our braking system was under designed and this made it difficult for us to clear the Brake Test at the FSG competition. This year, the team has redesigned the entire system to ensure effective braking. The brake callipers have been upgraded from 2 piston to 4 piston callipers – Wilwood GP310 with a piston diameter of 1.25”. The master cylinders have also been upgraded with a bore diameter of 0.55” at the front and 0.75” at the rear. The rear wheel hubs have been redesigned using 2 series Aluminium as opposed to mild steel last year thus resulting in a weight reduction of 800grams. The pedal box has also been redesigned keeping in mind driver ergonomics and a reduced overall weight. The new spherical bearing master cylinders occupy less space, enabling more compact packaging. The pedal box also offers drivers of different builds adjustability with the pedals because of the adjustable pedal stoppers. The base plate and the pads on the pedals are reinforced with carbon fibre to make them stronger yet keep their weight low.

Powertrain

The team decided to use a naturally aspirated Honda CBR 600 F4imotorcycle engine due to its high power to weight ratio,its ease of availability and since the team isfamiliar with its working and maintenance.

AMoTeC M400 ECU is used to control the engine parameters. The user friendly interface makes it easy for tuning and also easy for diagnosing and troubleshooting issues, if any. On running the car on a chassis dynamometer, the ignition advance and injection pulse widths were varied to obtain optimum lambda and power output. The ECU also helps in data acquisition from various sensors such as wheel speed sensors, oil pressure sensors and gear position sensors.

The team has used a Reverse Engineering methodology to develop a new gear shifting sequence. The shifting pattern has been modified from 1-N-2-3-4-5-6 as in a motorcycle to N-1-2-3-4-5. This has been done to enable faster shifts between N, 1 and 2.

The new shifter drum was designed by studying the profile of the stock shifter drum and modifying the original profile. This was done by 3D scanning the stock shifter drum first and then making a prototype of the new shifter drum through rapid prototyping. The new drum was tested in a static condition to validate the design.

The 6^{th} gear was eliminated from the gearbox as the maximum speeds required(~120kmph) in the competition are easily achieved with the 5^{th} gear, allowing a weight reduction of 340gms of rotating mass.
A fuel tank has been developed from carbon fibre for weight reduction and to avoid aluminium welding as in the case of previous designs.

Electronic gear shifting is implemented with the Kliktronic electronic shifter being used for its fast shifts(0.15-0.3sec), reliability and ease of installation and maintenance.

Air Intake and Exhaust -

The air intake and exhaust system aims at creating the right balance between power, volume, simplicity and aesthetics. A flat power band over a range of 8,000-12,000 engine rpm distributes the optimum car performance over a larger domain. A 1.5 litre airbox provides sufficient air along with crisp throttle responses. The airbox is manufactured by SLS using Duraform PA and post cured to withstand temperatures of upto 90 degrees Celcius. SLS allows flexibility of design hence complex shapes can be fabricated at relatively low costs. The airbox is designed to generate optimum flow of air which was validated by Flowizard flow analysis. The subsonic restrictor further adds to optimum flow of air.

The exhaust system with a 4-2-1 arrangement was preferred over a 4-1 arrangement as flue gases were got rid off easily with the first arrangement. A series of Ricardo simulations were carried out which finally led to a 16 inch primary, 8 inch secondary and 30 inch tertiary exhaust runner lengths. A free flow muffler was preferred over reactive muffler as it provided considerably low back pressures and complied with our maximum noise restrictions.

Cooling

The main aim of the cooling system is to maintain the engine at an optimum temperature range of 85-90 degree Celsius. The NTU method has been used to calculate the amount of heat rejected. A Davis Craig pump is used to give desired flow rate which is not attained by a mechanical pump. The flow of air over the radiator is enhanced with the help of an 8 inch light weight Davis Craig fan. A carbon fibre shroud is built around the fan to channelize the flow of air through the radiator. The Aluminium radiator comprises 25 tubes for the free passage of water. Solid aluminium tubing has been used between the radiator and the engine. These tubes reject heat from the coolant while the coolant passes through them thus making the cooling system more effective.

Drivetrain

To transmit the power from the engine to the wheels, the team has opted to use a light weight Drexler Motorsport LSD. The Drexler gives variable setup possibilities as compared to the previously used Torsen Differential. The differential is directly mounted to the engine. This makes the packaging more compact and also eliminates the rear box on the chassis resulting in a lowered chassis weight. There are shackle plates fitted in the assembly with a resolution equivalent to half of the chain pitch thus allowing easy chain tensioning. Tripod CV joints are used to transmit power smoothly over varied operational angles.

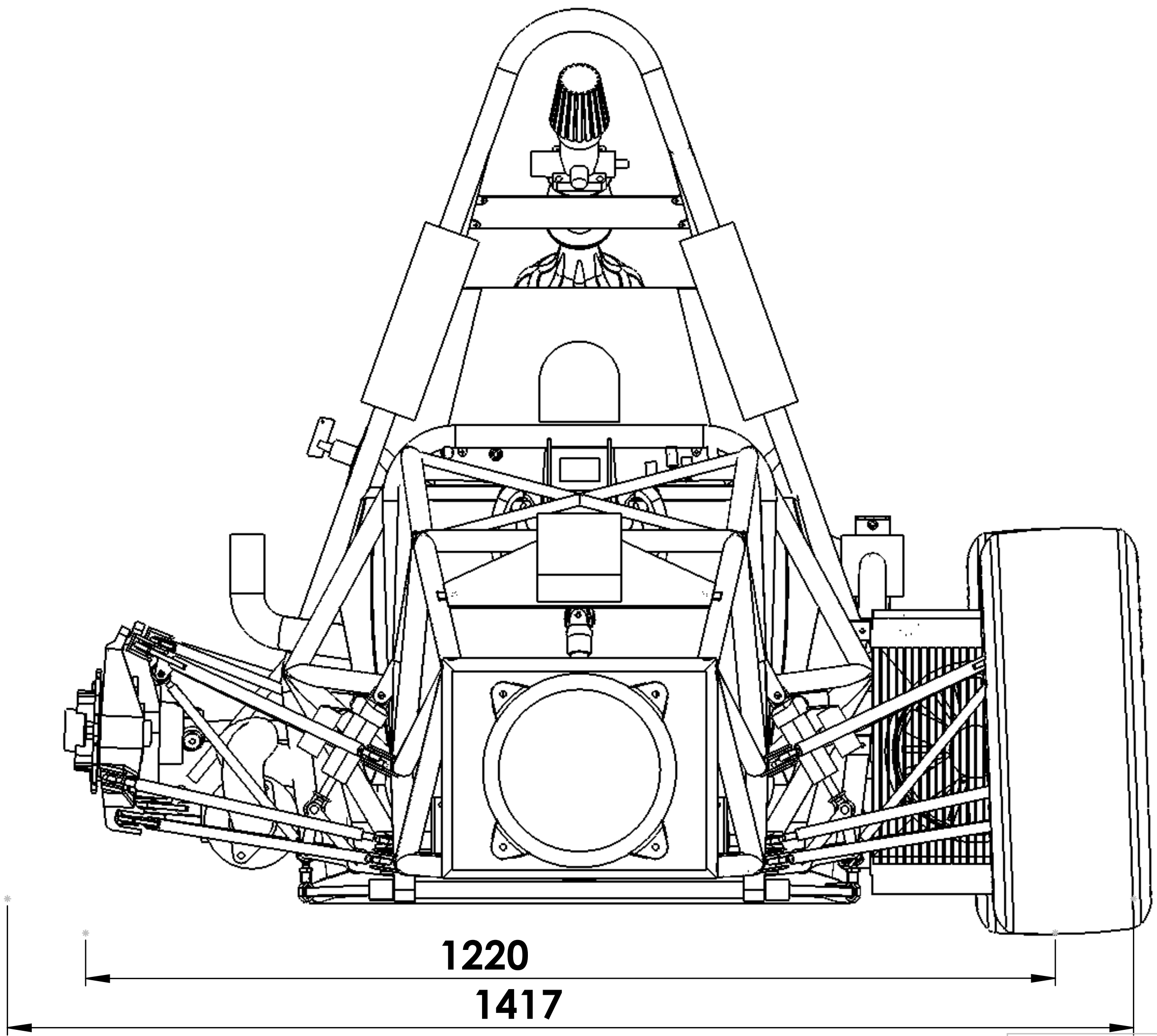
Electronics

This year the team is using a self-designed data acquisition system. The number of channels was increased from 4 to 18 to incorporate a higher number of sensors that will be beneficial for data collection during vehicle testing. The sensors were then calibrated with the DAQ. By increasing the number of channels, the baud rate was compromised.

On the driver interface front, an LCD has been incorporated. The LCD used is a character LCD. It displays fuel level, gear position, battery strength, vehicle speed and the distance travelled. RPM shift lights have been included on the steering wheel. The RPM output of the MoTeC ECU was found to be a varying frequency wave hence a frequency to voltage converter (LM-2917) was used. The lights themselves are driven by a driver circuit – LM 3914.

There were quite a few changes in the wiring this year. For concealment, we used heat shrinks instead of wire sleeves. This change was made since the wires snapped in the wire sleeves. With heat shrinks there was no such problem. The relays have been repositioned and are now mounted on the firewall. This made trouble shooting easier. Except for the power relays (starter motor, fuel pump and kill) the others have been replaced. A lighter alternative was found with the same specifications hence they were used for gear position (2), MoTeC, cooling fan and pump. Instead of a fuse box, we are using individual fuses for ease in trouble shooting.

The electrical systems on the vehicle are powered by a 2.5 kg light-weight, high capacity Lithium Ion battery.



ALL DIMENSIONS IN mm

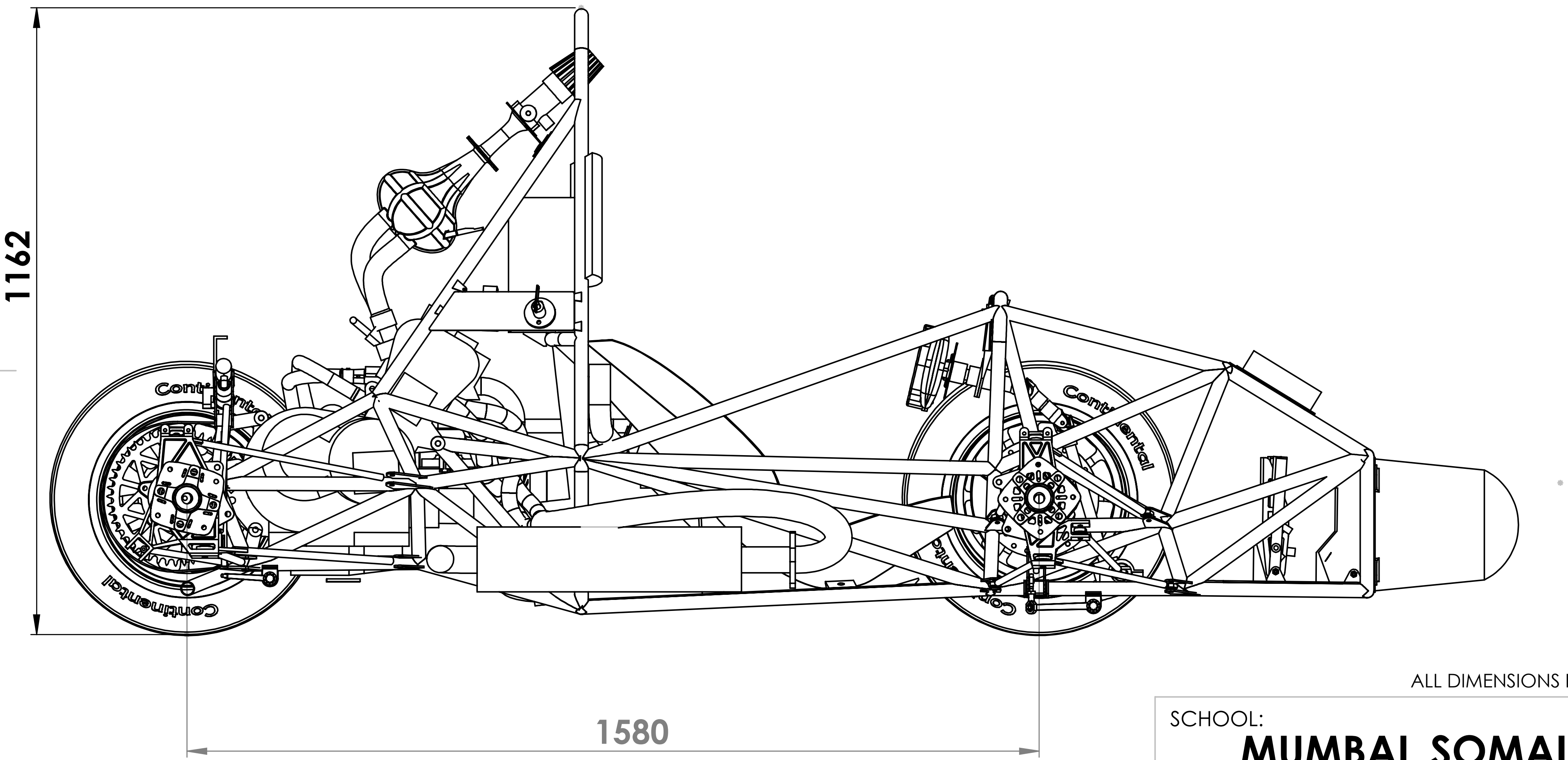
SCHOOL:

MUMBAI_SOMAIYA

DESCRIPTION: FRONT VIEW

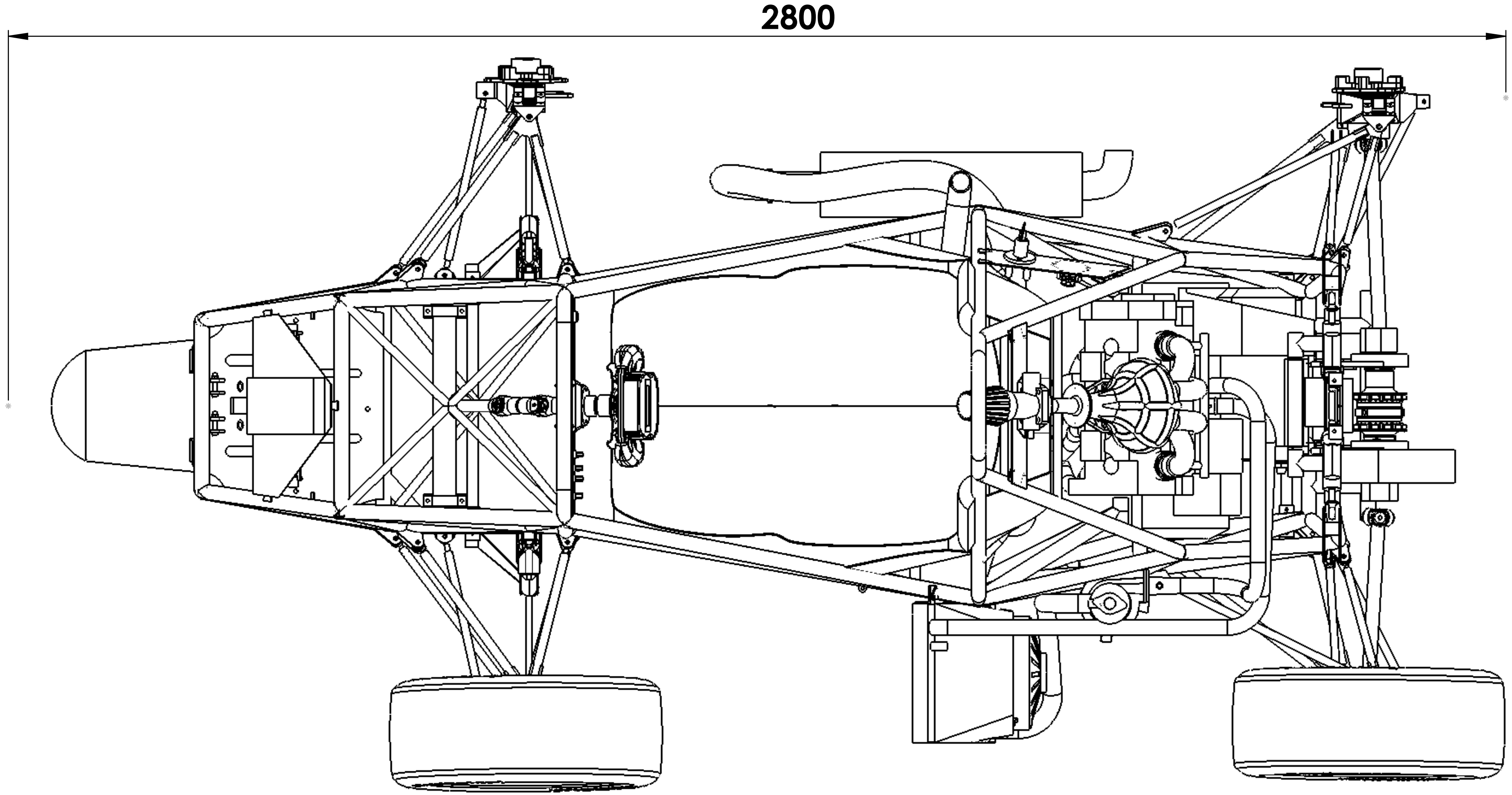
ORION RACING INDIA

CAR #27



ALL DIMENSIONS IN mm

SCHOOL: **MUMBAI_SOMAIYA**	
DESCRIPTION: SIDE VIEW	
ORION RACING INDIA	**CAR #27**



ALL DIMENSIONS IN mm

SCHOOL:

MUMBAI_SOMAIYA

DESCRIPTION: TOP VIEW

ORION RACING INDIA

CAR #27

Scanned Data

Rapid Prototype