ION Racing 2017

We create engineers of the future

FOREWORD

This is the 2017 magazine from ION Racing UiS. It is a great pleasure to take you deeper into our organization to learn about what we do, and why we do it.

The content is aimed towards giving the reader a deeper look into the year that has passed; how the 2016/2017 school year started out for us, the challenges we faced, and how we dealt with them. It will also give a deeper technical view on the result of our work, what we do on a daily basis, and how we work with our partners.

Hope you all like it!

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WHAT IS FORMULA STUDENT?

Formula Student is designed to test future engineers in all areas of work. It's not only about how well the car drives on the track, but many of the points are gathered through your team's design, business plan, and knowledge about your product and the marked.

The competitions are held at a number of locations around the globe. Since its founding, ION Racing have participated at Formula Student UK at Silverstone every summer. FS UK have about 150 participating teams each year.

On a world basis, Formula Student have been going on since 1981, and in all those years it has tested the next generation of bright minds and prepared them for the working life like nothing else ever could.

The event itself consist of 3 static and 5 dynamic events. Every event counts and you are assigned points based on how well the event is executed. The maximum amount of points you can get is 1000 points, the static events amounts to 325 points and the dynamic events can score you up to 675 points.

The static events consist of Engineering Design, Cost Analysis and Business Presentation. This is where the teams are tested in theoretical knowledge, what could have done differently and reasons why the final solutions were chosen. The dynamic events are Acceleration, Skid Pad, Autocross, Fuel Economy and Endurance. These events are out on the track and the goal is to test the car and its drivers to find out which car has the better acceleration, grip, maneuverability and fuel consumption.

ION RACING 2017

THE CHALLENGES

What are the elementary needs for participating in Formula Student? What are the elementary needs for building a racecar?

1. The people

You need students who are not only willing, but eager, to take on this challenge. And the university must be willing and eager to support it. People who want to learn, experience and achieve.

2. The time

The first thing we teach to new members in ION Racing is that everything takes time.

Even if you are just making a change to a drawing, the computer freezes. So instead of seconds it takes minutes. Even if you are just going to fasten the bolts of your suspension system you discover that you are running out and have to order more. So instead of hours it takes days. Even if you are just sending all your parts to production you discover that the machine park have burned down. So instead of weeks it takes months. Good luck keeping your timeline.

3. The money

This is true now more than ever. When the Norwegian oil market suddenly became less profitable, it changed everything. When the industry was facing major cut backs, we experienced that it was simply not a priority to contribute to the funding of a non-profit project

THE SUCCESS

Despite these barriers, we have had a good year, with growth and many achievements!

1. The team

Even though many are scared to participate in such a demanding project, unsure if they have what it takes, we have managed to get together a strong team. Bright, young students who want to do something legendary during their education.

2. Time management

The fact that we have so little time to complete the project each year is countered simply, but not easily; with long and efficient work hours.

3. Sponsorship

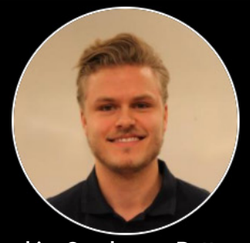
Even though the marked is bad, it is not impossible. The 2017 team have risen to new levels when it comes to marketing, and we have managed to secure more sponsors than any year previously. Our budget, though limited, have not hindered us.

THE TEAM

The Board

Olaf Nornes Kvamsøy
Team leader

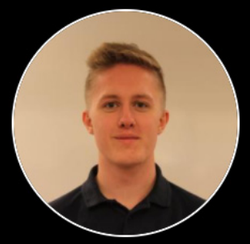
Helge Vassbakk
Chief Electrical Engineer



Joakim Sandanger Pettersen
Chief Mechanical Engineer

Truls Mentzoni Skoglund
Supply Chain Manager

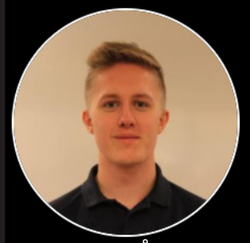
Magnus Ljostveit
Head of Finance



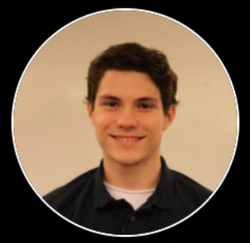
Magne Årdal
Head of Marketing

Olav Risa
HMS

Marketing



Magne Årdal
Head of Marketing



Jan Alexander Bjerke
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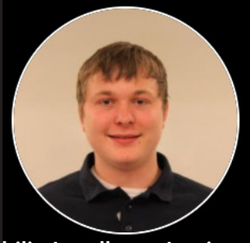
Nora Fotland
Sponsor Relations

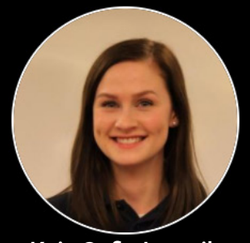
Trym Ullestad
Blog and Magazine

Monocoque



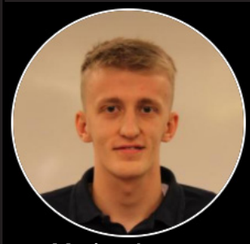
Philip Lundberg Jamissen
Group Leader

Joakim Sandanger Pettersen
Monocoque Design/SES



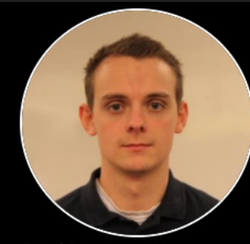
Kaja Sofie Lamvik
Inserts

Karoline Kverneland
Ergonomics



Marius Aasen
Main and Front hoop

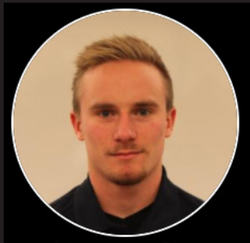
Trgygve Pollen
Assembly



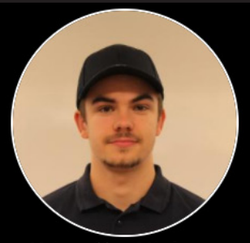
Olaf Nornes Kvamsøy
Monocoque production/SES

Eivind Vinnes
Sidepod Design

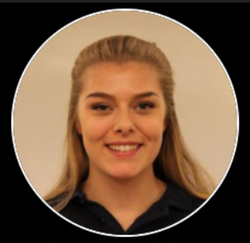
Suspension



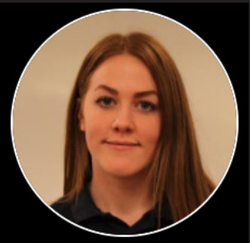
Truls Mentzoni Skoglund
Group Leader



Kristoffer Nielsen
Drivetrain



Maren Lodden
Dampers and ARB



Mia Katrin Risan
Brakes and Pedalbox

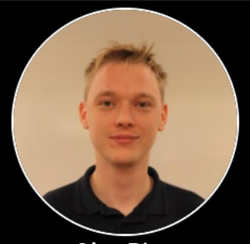
Audun Brønseth
Suspension

Thea Emilie Finn
Rims

Erik Benjamin Bruns
Wheel Hub

Tor Inge Berge
Coach

Battery



Olav Risa
Group Leader

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BMS

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High Voltage

Anders Helle
Big Boss

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Motorcontroller

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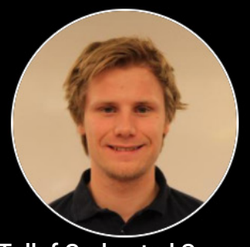
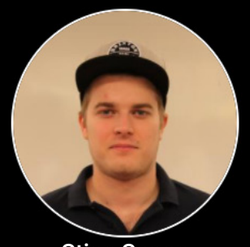
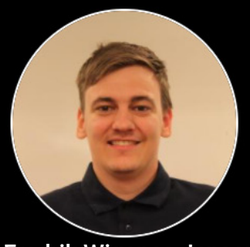
Svein Grøttå Ree
Group leader/ECU/Wire Harness/Misc. electronics



Tellef Goderstad Sunne
ECU/Wire Harness/ Misc. Electronics



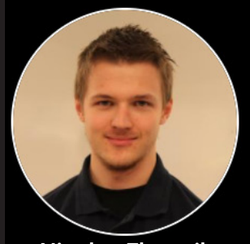
Stian Sagen
TSAL/Shutdown Circuit



Fredrik Wigsnes Jensen
µC programming/Sensor analytics

Aleksander Ferkingstad
Coach

Software



Nicolas Fløysvik
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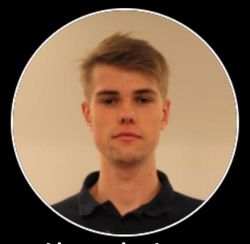

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Stian Trondsen
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Note - we do recommend following us on Facebook especially, as it is our most active and informative channel

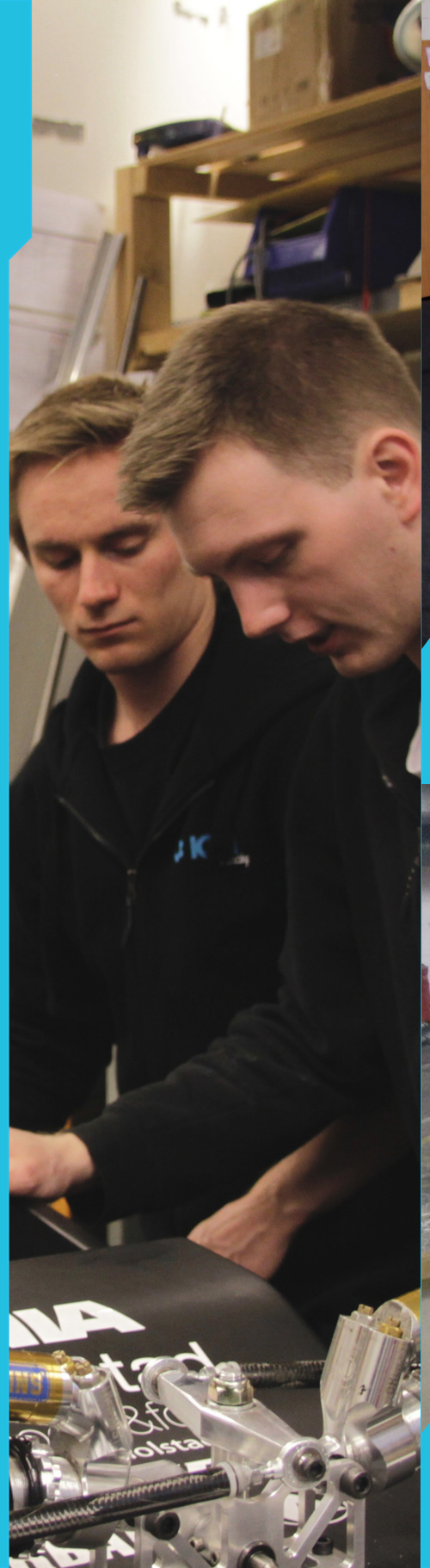
THE SOCIAL ASPECT

Being part of ION Racing often takes up huge portions of time, where you have to prioritize efficient work over binge watching Netflix. Luckily, working with ION Racing is usually a fun and social activity. There is joking and laughter all the way, and there is always someone there!

Our premises includes a workshop were you can fulfill the full range of your engineering desires, powerful computers to work with any kind of digital tool, a number of seating alternatives, varying in comfort, and a kitchen fully equipped with freezer, fridges, microwaves and cutlery.

In other words, all members can spend full day working with the project in comfort and company!

Sometimes we put work aside completely, and enjoy a round of teambuilding. Such events is important, because being a member should always be fun, and you should never feel alone. Your teammates are someone you spent a large amount of time with, and you get to know them very well as the year passes. By the time the year have passed completely and you have returned from the competitions, you have made friends for life!



A evening of relaxation and board games.

December 2016

Go kart is a great teambuilding, as it is both fun and let's us decide between possible drivers.

November 2016

THE ART OF MACHINING

One of the most fun and creative things a mechanical engineer can do is design and make metallic constructions. In this, ION Racing once again shows its relevance. Our car has a large portion of metal parts, where complete constructible accuracy is essential.

Our members are from an early start trained in CAD design and start drawing up the part that is their responsibility. As autumn stretches on, the final designs comes in. By the time New Year's Eve has passed, the members have already started working on them in the shop, or if they are too advanced for the university equipment, we are looking for companies that can do the construction. Luckily we have both experienced guidance to help us, and many helpful sponsors.

Our parts are many and varied. Through the years, members have worked with steel, iron, titanium, magnesium and, most of all, aluminum. Weight, size, value and complexity varies greatly. Most of them are essential.

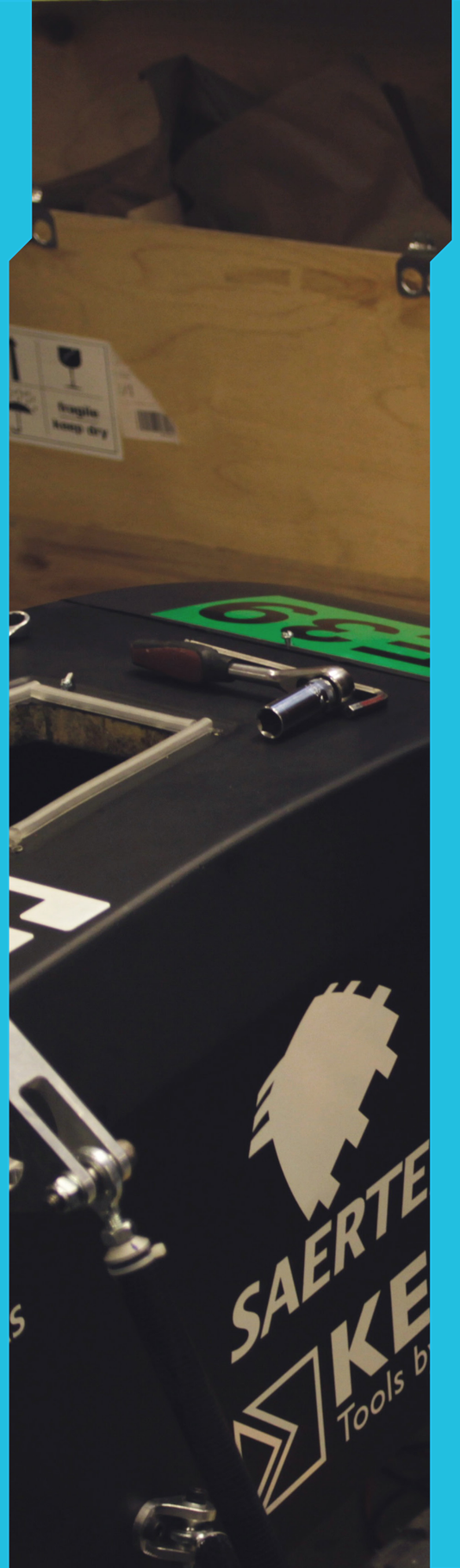
Here follows a few examples of metal work, we hope you find them as impressive as we do:

PARTNERSHIP

ION Racing is, like all Formula Student teams, a non-profit organization. This means of course that we depend on funding and other types of help. We are lucky enough to get a considerable amount from the university, without which we could not keep the project running. But far from our entire budget comes from the school, we also have a large number of sponsors. We have spent a lot of time to secure these firms and companies, by proving that we are worth investing in.

All who help us will get something in return, everything from some advertising to driving our cars. We do believe however, that the biggest reason for most of them is that they truly want to help, and are willing to contribute into creating the next generation of clever engineers.

We recognize every contribution we get, and we will never forget it!



Embla beeing loaded out of the trailer that is kindly lent to us by Tredal.

This trailer is used every time we set up stand, or participate at events. We even took it to Formula Student UK.

Silverstone, July 2016

Salte AS visited us to talk about spark eroding. It is a higly usefull technique, and as they are one of very few who truly knows it, we are very lucky to have them.

The lecture was in a public UiS auditorium, and was open to everyone.

March 2017

Several members visited IKM Electro to learn about the technical details of designing your own electrical engine.

ION Racing is building our 4th electrical car. One of our future goals is to actually design and build the motor we use ourselfs, and get a thesis about it at the same time.

January 2017

INTERVIEW WITH ARILD NETLAND

Regional director at Norsk Scania AS, Stavanger

Scania is a company that is primarily working with the transport industry. They deliver heavy trucks and buses for companies all over the world. Norsk Scania AS sell 1600-1800 trucks every year and around 100 buses. The branch in Stavanger is the third largest in Norway and houses 40 employees.

Is there anything exciting that Scania are working on that you would like to talk about?

Nowadays we are working towards greener product solutions, wanting to minimise pollution to the atmosphere. We are working on cars that log fuel usage, emissions and other statistics in real time that you can view on your phone. This can make users more aware of their impact on the world and could help detect problems in your vehicle.

Why did you choose to support ION Racing?

Scania is focusing more and more on cleaner transport and figured that a cooperation with ION Racing would be beneficial. We think that since ION are building an electric race car, we can provide a little motivation to help students think greener.

ION Racing gives their students experience in putting theory into practice, is it important for you that newer staff has had such experience?

It most certainly is. We can see that it is very beneficial for students of engineering to have experience if they perhaps want to join our research and development team. We have already seen that you guys at ION Racing are hardworking and we are impressed by your dedication so we would love to cooperate with you in the future.

INTERVIEW WITH SVEIN W. KRISTIANSEN

Manager at Smed T. Kristiansen AS

Smed is a machining company that primarily deliver machined parts to the offshore industry. They are experts in water jet cutting which will precisely and quickly cut steel leaving a very clean edge. They also cut with lasers which is even faster and with the accuracy and precision of laser light makes it perfect for thinner sheet metals. They also do bending and welding, making them a very versatile machine shop.

Smed has been a sponsor for ION Racing for the fifth year in a row, why have you been supporting us for so long?

When I was studying, there were no student projects like there are now. We feel it is important for students to be able to work on these projects and get the experience of working on something from start to finish. That is why we support ION Racing as well as UiS Subsea and Mars Institute Student Chapter.

Do you think that student projects help with preparing students for work?

Absolutely. Working with these projects, students get to know how it feels to solve real problems. It was shocking how few skills you learn in school that you get to use at work. Being engaged with these projects and working on them from start to finish really teaches you something valuable.

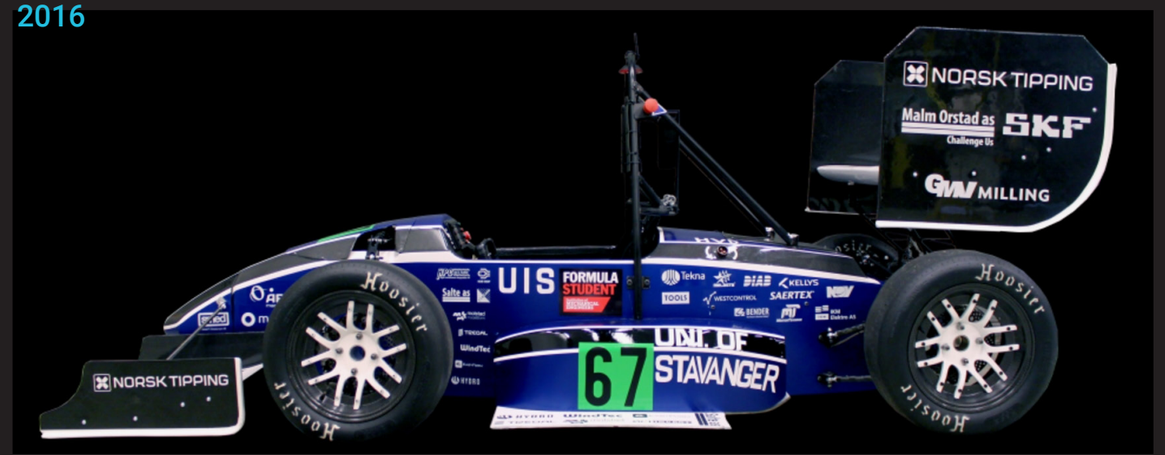
Is practical experience something you look for when hiring?

It will at least get you high up on the list of applicants. If it came down to two people of similar qualifications, the one that has actively gone out and gotten practical experience under their belt will get the job.

GARAGE

Embla

2016



Mjølnir

2015

The Mean Engineering Machine II

2014

The Mean Engineering Machine

2013

Lille Trille

2012

UNVEILING

For the biggest part of ION Racing history it has been tradition to have a large ceremony at the end of the school year were we unveil the car we have made that year. This year was no exception!

Our aim for the 2017 unveiling was to arrange an event that would be both flattering to the team and our results, as well as educating for the audience. In the aftermath of the ceremony, we felt very pleased with the result.

We had a variety of speakers at the unveiling, all of whom had interesting things to say.

From the university:

Marit Boysesen, rector, on the importance of practical experience in education and ION Racing's role at UiS.

Hirpa Lemu, ION Racing's UiS contact, on our beginning and growth.

Sponsors:

Tuan Williams, vice-president at NITO UiS

Ingar Bergeland, CTO at Westcontrol AS

Anna Johansson, marketing manager at Altair Nordic

Note: All sponsors talked about what they do, how they help ION Racing, and the use they see in the Formula Student competition.

From the team:

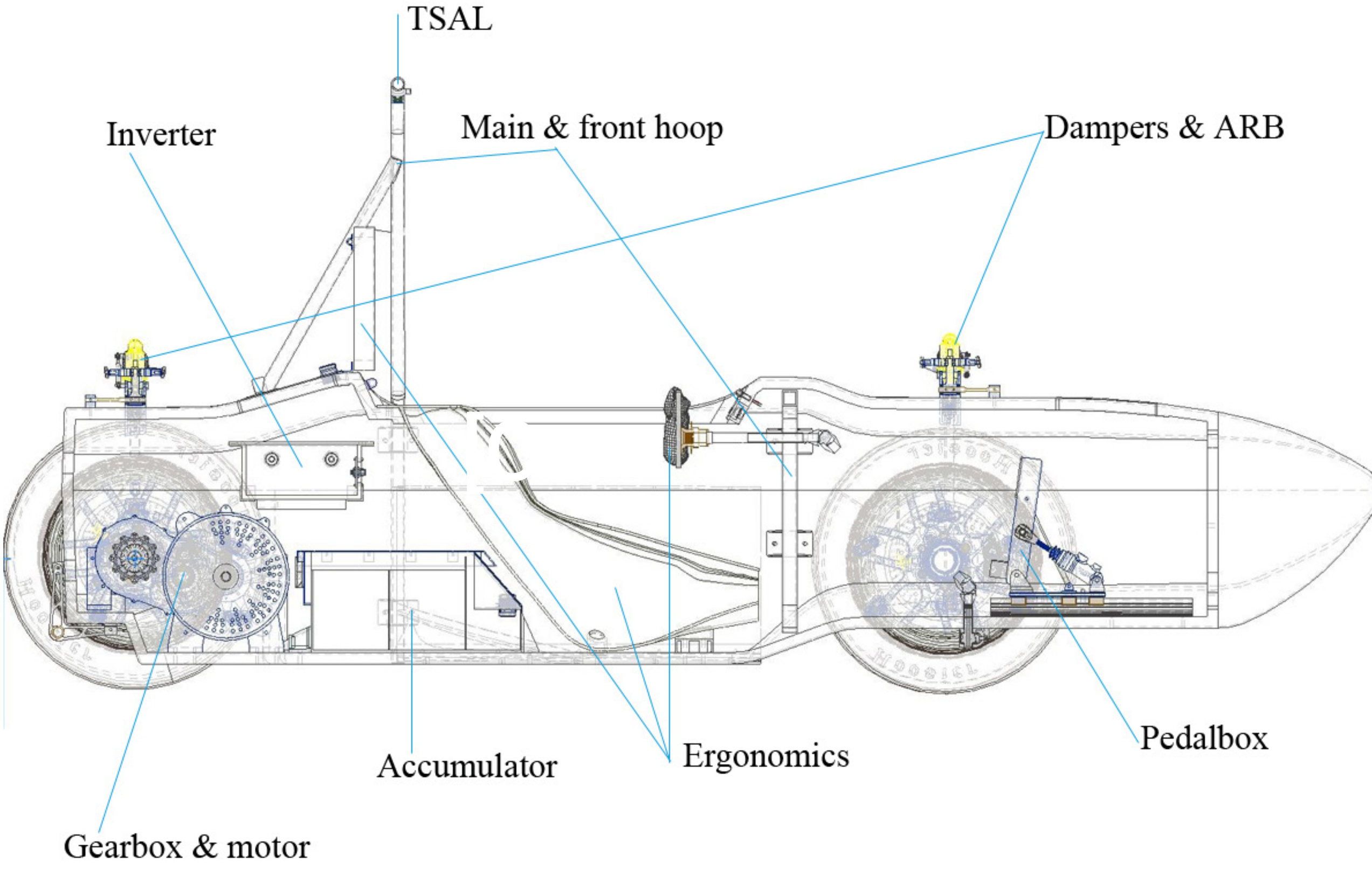
Olaf Kvamsøy, 2017 team leader, on this year's team, our challenges and our success.

Joakim Pettersen, 2017 CTO machine dpt, on the car itself.

FENRIR

2017

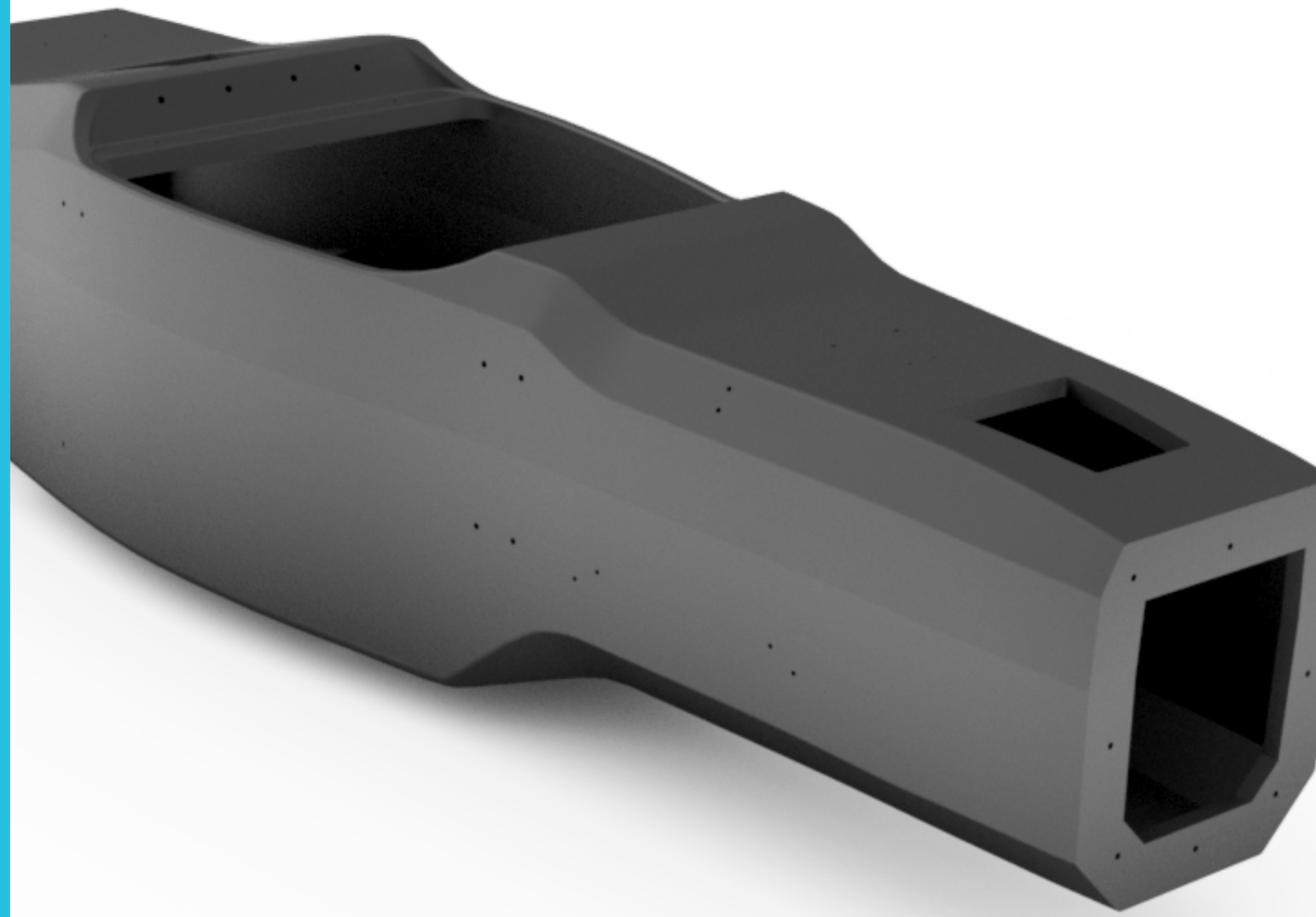

FENRIR
sparco
sparco
Uni of Stavanger
TE connectivity
Salte as
SINUS
Calspan
SKF
E39
Altair
SAERTEX
KEIL
Tools by ARM
Hoosier
OZ RACING


TSAL
Inverter
Main & front hoop
Dampers & ARB
Accumulator
Ergonomics
Pedalbox
Gearbox & motor

MONOCOQUE

The monocoque was chosen as the chassis construction mainly depending on the chassis stiffness and the load distributing qualities of such a construction. In previous years the production of the monocoque has given difficulties in both total weight and in the precision of the attachment points. Correct placements of the suspension fasteners and the tractive system was a high priority through the design phase, as the team has realized the importance through previous errors. The packaging of the internal components was designed as tight as possible in order to achieve smaller area while still complying to every rule, and the reclined seating position combined with an angled accumulator helped with reducing the overall length and moving the driver into a better suited position.

The materials used are epoxy resin reinforced with both biased and unidirectional carbon fibre sheets in different high quality ranging from 12K and up, and the sandwich laminate with PVC foam core build moment of inertia to achieve the desired stiffness. The torsional stiffness of the monocoque is simulated to be 3496,4 N-m/deg through simulation in Abaqus CAE. To achieve the most correct results possible the simulation was based on lamina properties retrieved from physical testing, which gives properties of the unique combination between the epoxy resin and the different carbon fibre types.



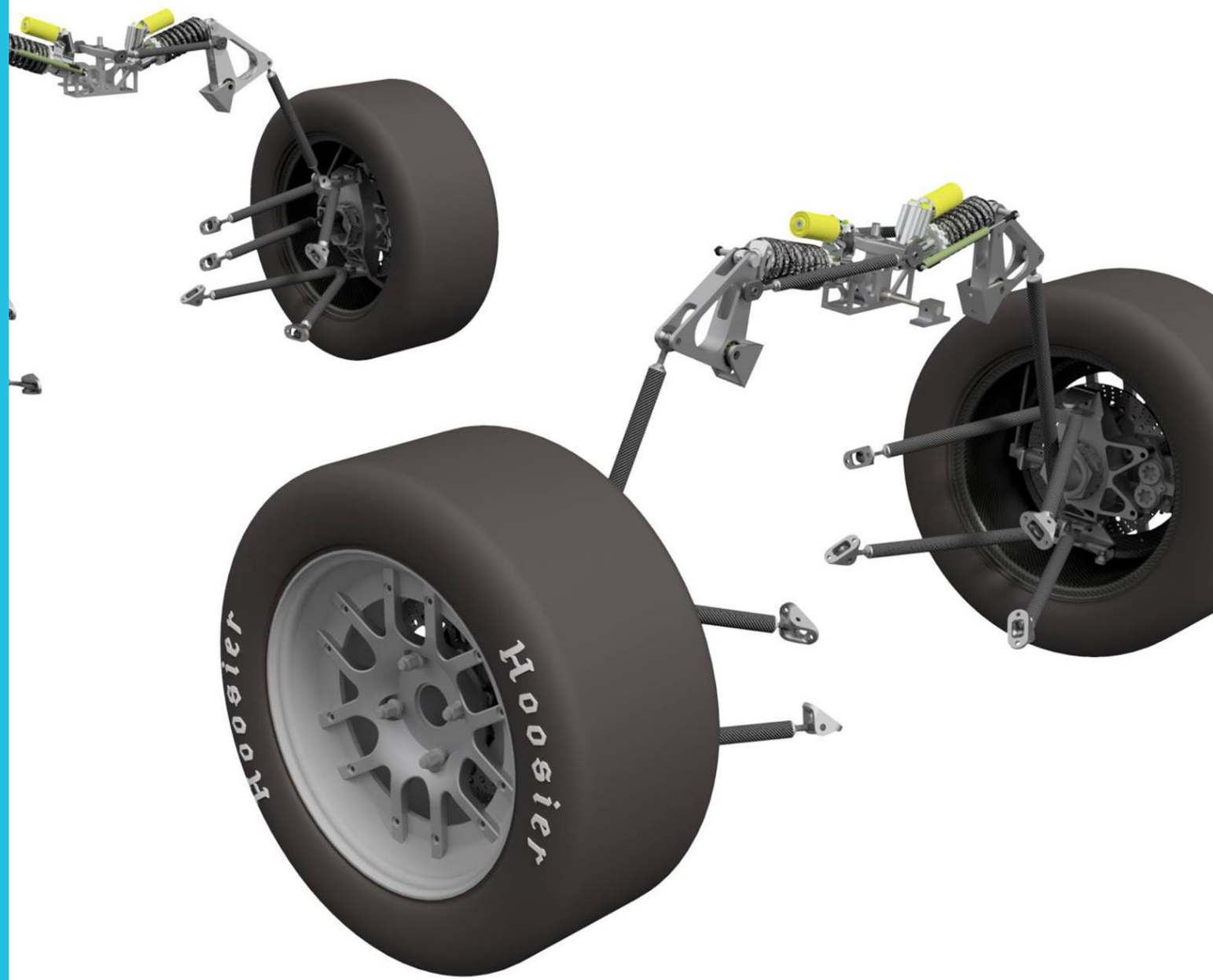
SUSPENSION

The suspension setup utilises double wishbones. The suspension geometry were chosen based upon calculations and simulation in optimum kinematics. Load cases were found using optimum lap-time and optimum-tire. The a-arms consists of carbon fibre rods for weight reduction and connected by machined aluminium parts to ensure accurate placement and geometry. The double wishbones is a short-/long-arm setup to stabilize the roll center.

The 2017 upright is constructed of aluminium 7075 T6. To statically adjust the camber, shims are added to the top fastening bracket of the upright. Lap time simulation and tire data were used for calculating the reaction forces on the upright.

For the anti-roll bar system the bell crank is situated vertically on the top side of the car, with a push-rod connected to the lower wishbone in the front, and connected to the upper wishbone in the rear. Dampers are situated in lateral direction on top of the car, alongside with a z-bar anti-roll system. For every rod used for the suspension and anti-roll system, we have chosen the previously used concept of filament winded carbon fiber tubes. Inserts for these tubes have been threaded with regular threads and links threads to simplify adjustability of the rods.

Regarding the motion ratio for wheel travel/ displacement in dampers, the bell crank will provide a motion ratio of 1.03:1 in the front, and 1.04t:1 in the rear. We have chosen Öhlins TTX 25 MKII dampers, with several coil springs in storage for the possibility of adjustment. The torsion bar for the anti-roll system is made from titanium grade 5.



BRAKES & ERGONIMICS

This year's car has a hydraulic braking system that consists of two single master cylinders – one controlling the front wheels, the other controlling the rear wheels. The front master cylinder has a 5/8" bore size, while the rear master cylinder has a 7/10" bore size. They are connected with a balance bar. The master cylinders are, through brake lines, connected to fixed brake callipers at each wheel. The brake callipers at the front wheels have four pistons, each piston with a diameter of 25 mm. The brake callipers at the rear wheels have two pistons each, also with a diameter of 25 mm. The brake callipers clamp on brake discs at each wheel. These brake discs are machined from S355J2+N carbon steel with 220 mm diameter, and are mounted to the hub. They are ventilated with drilled holes throughout.

To improve the ergonomics, 3D scanning technology were used for designing the steering wheel handle and seat. They were then imported into CAD-software for final adjustments for machining purposes and to fit the car. For individual fit to each of the drivers foam inserts are used in the seat.

The seat is molded in carbon fiber using a machined form. The steering wheel frame is molded in carbon fiber and a ultem 3d-printed handle is glued on.

GEARBOX

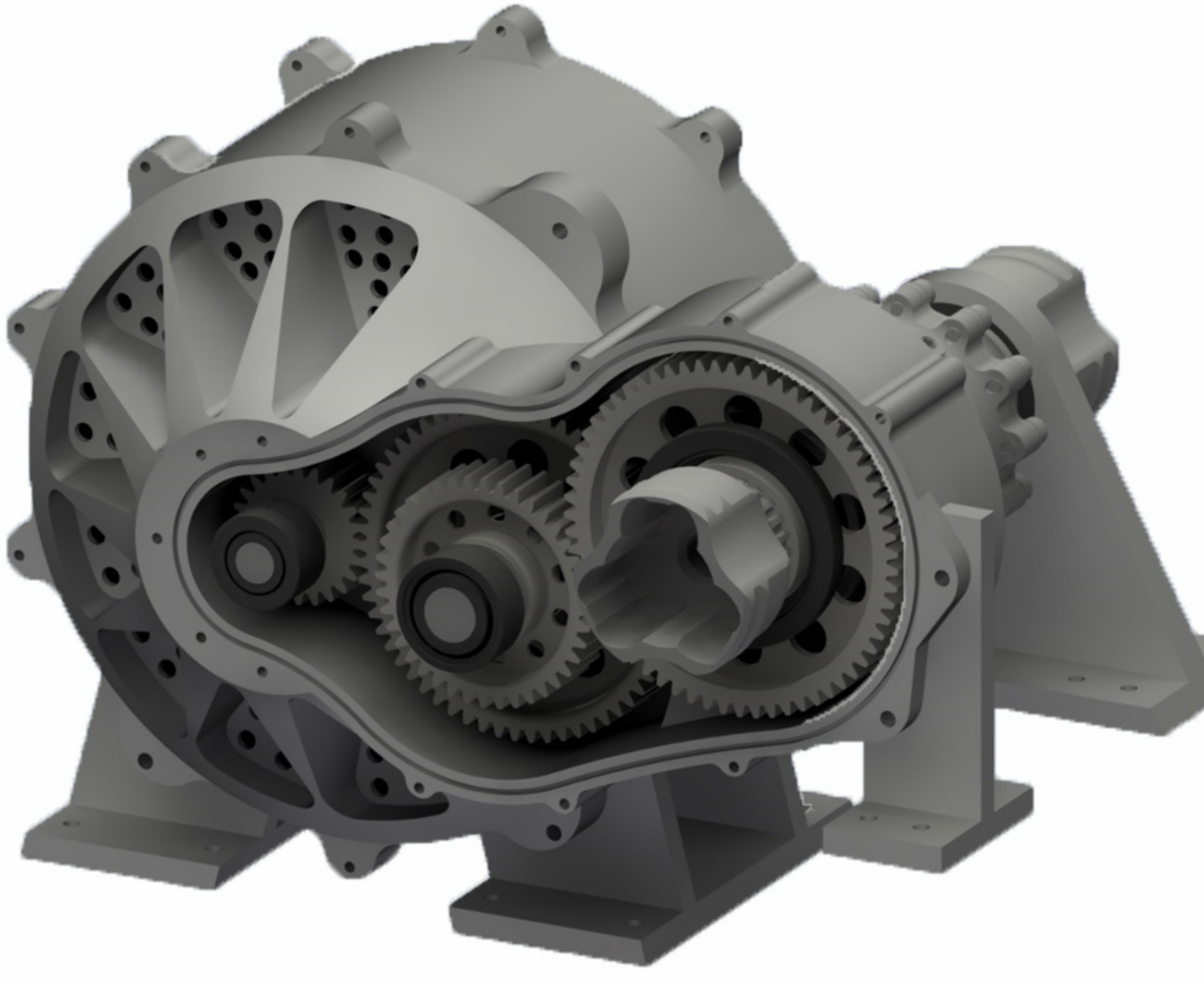
This year's gearbox takes the motor torque of 240 Nm and puts out 945 Nm at the wheels. This gives 4.1 Nm/kg excluding the weight of the driver. It does this using a gear ratio of 3,9375 that is carefully selected through calculations and the utilization of lap time simulation software. With these parameters, the Enstroj motor operates in its most effective RPM range while providing the 2017 race car with adequate acceleration and top speed.

Inside the gearbox there are 4 spur gears placed on 3 shafts, working together to decrease the number of revolutions and increase the torque. Spline connections are used throughout the system to make assembly and disassembly less time consuming and damaging to the components.

Spur gears were selected due to the fact that they transfer forces solely in one direction, thus lowering the required complexity of the gearbox itself. The following noise was considered a non-issue. The casings are crafted in aluminium 6082 T6 and proved through simulations to have sufficient strength in their respective load cases.

The gears are made of a high grade tool steel with extreme properties. This allows for thinner gears while still resisting the applied loads. The enclosure containing the gears is filled with a performance gearbox oil and is sealed using radial shaft seals as well as an o-ring. The shafts are constructed of the martensitic steel, S165M, recommended by a steel supplier for this application.

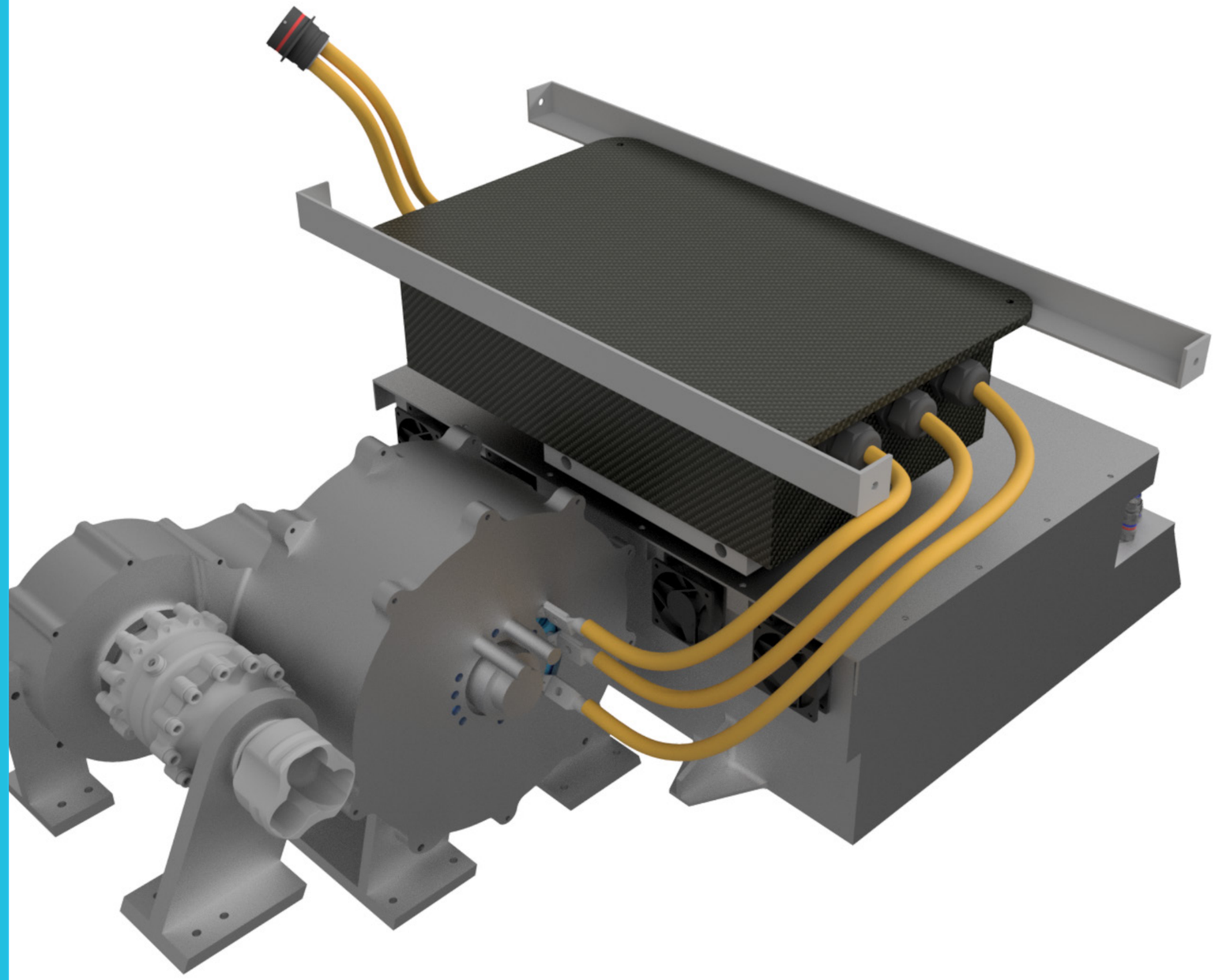
The limited slip differential from Drexler receives the torque and speed from the 4th gear and supplies it to the two driveshafts. It is designed to withstand 1200 Nm of torque. Being a limited slip differential, the Drexler component controls the torque difference of the rear wheels and keeps it below a set value. The component has different settings which can be used to adjust the performance of the vehicle directly.



DRIVETRAIN

The drivetrain are powered by the Enstroj Emrax 228 MV, a three-phase AC permanent magnet, synchronous motor. The motor is controlled by a in-house designed Voltage Source Inverter (VSI). The VSI is designed for a 400V input, to deliver peak power surges of 84.21kW and a continuous power consumption of 20.1 kW. Insulated gate bipolar transistor technology are used for the switching transistors because of the low collector to emitter voltage drop and low gate current. The gate-driver card is in-house designed utilising a 1ED020I12-B2 gate driver IC from Infineon which are current boosted using a bipolar transistor totem-pole configuration. The VSI protects against over-current, short circuit in legs, over-voltage, under-voltage, over-temperature inside the enclosure, over-temperature in IGBT's and over-temperature in the motor.

The control system consists of a self designed Electronic Control Unit (ECU) which collects data from the sensors in the vehicle. The sensor data is logged for later analysis in the team-designed analysis software. The ECU uses the speed sensors mounted on the upright to run a anti-slip algorithm before sending the torque request over CAN-bus to the VSI. To ease assembly and create better documentation the entire wire harness was modeled in CAD. To increase robustness the entire wire harness is fully heat shrunken .



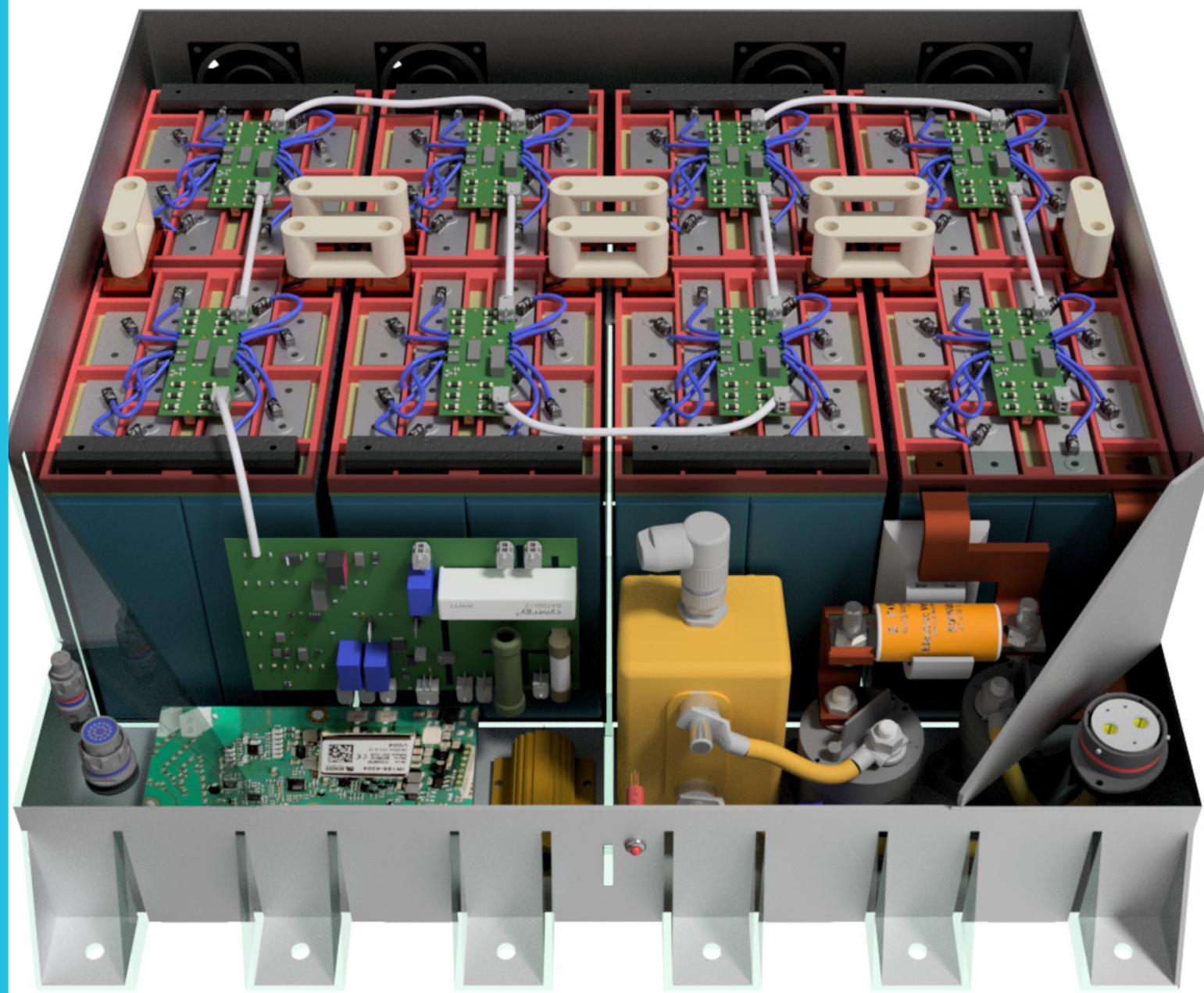
ACCUMULATOR & COOLING

The Accumulator container is a 400V system with 288 High-density Lithium Polymer battery cells. With 3P96S configuration the Accumulator provides the car with 7,46KWh. The design separates the cells in 8 equal sections with 3P12S configuration and energy at 3,78MJ. Lithium-Polymer battery cells has been chosen on behalf of their high power to weight ratio 173.8Wh/Kg and high discharge rates.

Our self designed battery management system (BMS) uses linear technology's LTC 6804-2 IC to provide constantly monitoring of the battery cell conditions. The BMS controls an air-cooling system consisting of four fans. This system is dependent on the cell temperature to ensures the accumulator from overheating. The BMS communicates with the ECU via CAN-Bus and battery system status can be monitored in pit via telemetry.

The accumulator casing consists of aluminium and provides both thermal conductivity and reliable structure. Accumulator High voltage connector provides an integrated interlock which ensures a reliable and safe system.

The motor and Voltage Source Inverter (VSI) is water cooled using one loop. It consists of one pump, one radiator and are connected using silicone hoses. The VSI cooling-block is in-house designed and produced which were simulated in Autodesk CFD for pressure drop and cooling. The accumulator is air cooled. Two fans are mounted in the back of the monocoque blowing out the hot air from the accumulator.



FORMULA STUDENT UK 2017

The last part of any Formula Student schoolyear is always the competition itself. ION Racing have competed at Silverstone this year, like all the years before. We arrived Tuesday 18th July and came back Monday 24th July.

The weather was mostly rain, which made the camp muddy. The opportunity for having fun in the sun was, in other words, quite lessened from the year before. This however only made it easier for the members to focus on the tasks that had to be done, and everyone contributed to the workload.

Here is a short summary of the different parts of the competition:

1 – Scrutineering

When it opened on Thursday ION Racing were fist in line. Most of the stickers were earned without much problem; Tech, Chassis, Tilt and Brake. The delays came from Electrical; were there were several small problems we had to attend to, Noise; were we had to change our RTDS to make sure it was loud enough to be allowed, and safety; were we had to argue to get some of our bolts accepted. All of this did unfortunately claim more time than we had wished, and it is the part of FSUK 2017 that is most disappointing to us.

2 – Static events

Friday was the day for static events, and while half the team continued work with the car the rest went face to face with the judges – expert in their fields. It's difficult to say exactly what the judges though, but we feel we did well in general. Cost and design were well planned ahead, and we ended with a score we are quite pleased with. Business was not as well planned as we would have liked, partly because the business team were changed up a few weeks before the competition. We still feel we did acceptable considering the circumstances.

3 – Dynamic events

The dynamic events started on Friday and lasted through the weekend. Unfortunately, due to the time requirements of scrutineering, we were not able to participate in the dynamic events on Friday and Saturday. However, on Sunday morning the car got it's final coveted sticker and we were cleared for the last and most important dynamic event.

And so ION Racing's 2017 team got the great pleasure of seeing Fenrir accelerate out on the Silverstone tracks – the first of our electric car to do so. The cheers were loud from the team, and the compliments of the commentators were gold to our ears.

Our total results stand as follows:

43rd place on Business Presentation

19th place on Cost

13th place on Design

32rd place in total

1 out of just 7 electric cars that were awarded points at endurance.

Prize from Mercedes AMG for "Best High Voltage Powertrain Implementation"

The last point is the one we are most proud of this year. When former engineers from Mercedes AMG's Formula 1 team, Patronas, say they are impressed by the drive system in our car, it's about the best compliment an engineering student can get.

All of this gave ION Racing the best results in our history, and even though we feel that we were extremely close to doing even better we are pleased because we overcame ourselves and grew – which is our number one goal.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