MAGAZINE 2021

Formula Student Germany

AN INTERNATIONAL DESIGN COMPETITION
OF SKILLS, SPEED AND SPIRIT

16TH - 21TH AUGUST 2021 | HOCKENHEIM

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A special thanks goes to the numerous volunteers who contributed significantly in the realisation of the fifteenth Formula Student Germany.

Editorial

Catharina Schiffter
EC Communications & Media

After more than two years it is finally time again - we open the gates of Hockenheim for the 15th Formula Student Germany! After cancelling FSG 2020 last summer with a heavy heart, the anticipation for this event has been all the greater! The last one and a half years were not easy for any of us. Not only in our private lives, but also in the FS community. Canceled events, lack of physical contacts, little perspective - that is we are even more impressed how every single team has mastered this difficult situation.

But now we need to look ahead. At least in most of the world the situation is improving and we too are happy to be able to stage our 15th competition this year on a reduced scale.

This magazine is all about this anniversary. Peppered with many impressions from the past 15 years, we do not only look into the past, but also into the future. In another article, we also look beyond our own backyard: to Formula Bharat in India.

Unfortunately, only a small number of team members are allowed to be on-site this year. Therefore, we tried to compensate the transfer of knowledge with some technical deep dives, at least to a small extent, in this magazine. We hope that these concepts will help to promote the exchange even during a small event. Furthermore, this year we have made the magazine more interactive - with additional video and reading material, which will be updated via the QR codes in the magazine during the FSG week.

Stay healthy and enjoy the read!

Nach zwei Jahren ist es endlich wieder soweit – wir öffnen die Tore in Hockenheim für die 15. Formula Student Germany! Nachdem wir schweren Herzens im letzten Sommer die FSG 2020 absagen mussten, ist die Vorfreude auf dieses Event umso größer gewesen! Die letzten anderthalb Jahre waren für jeden von uns nicht einfach. Nicht nur im privaten Umfeld, sondern auch in der FS Community. Abgesagte Events, fehlende physische Kontakte, wenig Perspektive – daher sind wir umso mehr beeindruckt, wie jedes einzelne Team diese schwierige Situation gemeistert hat.

Doch nun heißt es nach vorn schauen. Zumindest im Großteil der Welt verbessert sich die Situation und auch wir sind glücklich, dass wir in diesem Jahr in einem reduzierten Umfang unseren 15. Wettbewerb auf die Beine stellen können.

Dieses Magazin steht ganz im Zeichen dieses Jubiläums. Mit vielen Impressionen aus den letzten 15 Jahren gespickt, schauen wir nicht nur in die Vergangenheit, sondern auch in die Zukunft. In einem weiteren Artikel blicken wir zusätzlich über den Tellerrand hinaus: zur Formula Bharat nach Indien.

Da in diesem Jahr leider nur wenige Teammitglieder vor Ort sein dürfen, haben wir mit diesem Magazin versucht, den Wissenstransfer über einige technische Deep Dives zumindest in geringem Maße zu kompensieren. Wir hoffen, dass diese Anregungen helfen, den Austausch auch während eines kleinen Events zu fördern. Darüber hinaus haben wir in diesem Jahr das Magazin interaktiver gestaltet – mit zusätzlichen Video- und Lesematerial, welches über die QR Codes im Magazin im Laufe der FSG Woche aktualisiert wird.

Bleibt gesund und viel Spaß beim Lesen!

combustion formula student germany · driverless formula student germany · electric formula student germany

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15th FSG Competition
15. FSG Wettbewerb

A reflection on the past and an outlook into the future
Rückblick und Ausblick in die Zukunft

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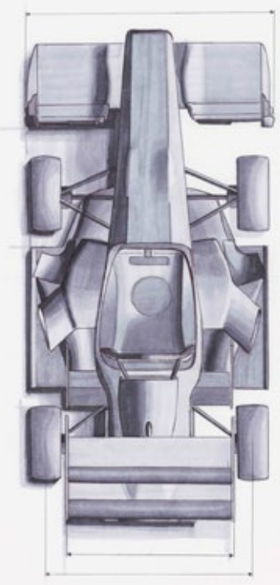
Tech Highlights

Current technical features developed by different Formula Student teams
Aktuelle technische Besonderheiten, die von verschiedenen Formula Student Teams entwickelt wurden



Introduction
Einführung

The Challenge

Formula Student Germany (FSG) is an international design competition for university students, based on the Formula SAE rules and guidelines. Teams from around the world have the task of designing a single-seated, formula car with either a combustion or electric drive train and to then manufacture a functional prototype. They can also decide if it will have autonomous features, enabling them to compete in the Formula Student Driverless competition. This year will be the last year in which combustion vehicles will also be registered. In the future, only electrically powered vehicles will participate. Therefore the driverless class will become more important. Along with these technical aspects, the teams must develop a viable business plan and a marketing concept for batch production of the vehicle. Therefore, the racecar must not only have manageable handling and possess good acceleration and braking ability, but must also be inexpensive to buy and run. Furthermore, other important aspects of the vehicle that must be developed include aesthetics, ergonomics, and use of off the shelf components. The vehicle designs are judged by experts from the automobile, motorsport and supply industry. The teams are then able to score points in various static and dynamic events, which will ultimately decide the overall ranking. The team with the best overall scores from the combination of design, financial planning, marketing strategy and performance on the track will win Formula Student Germany.

Practical Experience

FSG enriches the teaching content of a course of study with challenging and practical experience in the fields of manufacturing and production, whilst not neglecting the practice-oriented requirements relating to profitability and market relevance.

The aspects assessed by the competition correspond directly to the demands of the different branches of the industry for new product development, which is why they are not merely restricted to vehicle design. By working as an interdisciplinary team, the students learn firsthand how to combine the economic and technical goals of product development. At the same time, they gain expertise on how to defend the proprietary solutions and to assert these against competing developments

Herausforderung

Die Formula Student Germany (FSG) ist ein internationaler Konstruktionswettbewerb für Studenten, der sich an den Wettbewerb der amerikanischen Society of Automotive Engineers (SAE) anlehnt. Die Aufgabe für die Teams aus der ganzen Welt besteht darin, ein einsitziges Formel-Fahrzeug mit einem Elektro- oder Verbrennungsmotor zu konstruieren und einen fahrfertigen Prototypen herzustellen. Zudem können sich die Teams für die Implementierung von autonomen Funktionen in ihrem Fahrzeug entscheiden, was ihnen eine Teilnahme im Formula Student Driverless-Wettbewerb ermöglicht. Dieses Jahr wird das letzte Jahr sein, in welchem auch Verbrenner zugelassen werden. In der Zukunft werden ausschließlich elektrisch angetriebene Fahrzeuge teilnehmen. Dafür wird die Driverless Klasse an Bedeutung gewinnen. Parallel zu der technischen Entwicklung müssen die Teams einen tragfähigen Businessplan und ein Vermarktungskonzept für eine Kleinserienfertigung des Fahrzeugs entwickeln. Daher muss der Rennwagen nicht nur ein beherrschbares Handling, sowie gute Beschleunigungs- und Bremswerte haben, sondern auch günstig in der Anschaffung und im Unterhalt sein. Wichtige Nebenaspekte des entwickelten Fahrzeuges sind Ästhetik, Ergonomie und die Verwendung von Serienbauteilen. Bewertet werden die Fahrzeugkonzepte von Experten aus der Automobil-, Motorsport- und Zulieferindustrie. In verschiedenen statischen und dynamischen Disziplinen können die Teams wichtige Punkte sammeln, die letztlich über die Gesamtplatzierung entscheiden. Den Sieg der Formula Student Germany erringt das Team mit dem besten Gesamtpaket aus Konstruktion, Finanzplanung, Verkaufsargumentation und Rennperformance.

Praxisnahe Erfahrung

Die FSG bereichert die Lehrinhalte des Studiums um herausfordernde und praktische Erfahrungen in den Bereichen Konstruktion und Fertigung, ohne dabei die praxisrelevanten Voraussetzungen in Bezug auf Wirtschaftlichkeit und Marktrelevanz zu vernachlässigen.

Die im Wettbewerb abgefragten Aspekte entsprechen den Anforderungen verschiedener Industriebereiche hinsichtlich Produktneuentwicklungen und sind daher nicht nur für den Fahrzeugbau anwendbar. Durch die Arbeit in einem interdisziplinären Team lernen die Studenten die wirtschaftlichen und technischen Ziele einer Produktentwicklung in Einklang zu bringen. Dabei üben sie auch, ihre eigens entwickelten Lösungen verteidigen und gegenüber konkurrierenden Entwicklungen durchzusetzen.

An International Design Competition

Ein internationaler Konstruktionswettbewerb

Formula Student Combustion / Formula Student Electric

Formula Student Germany is an engineering design competition for students. As a team they work together to design and manufacture a prototype racecar, based on a hypothetical manufacturing contract. In order for the participating teams to be compared, their designs, plans and cars are judged by experts. Each team has the chance to win in total a maximum of 1,000 points over the course of static events, dynamic events and through proving the efficiency of their car. The team with the best overall combination of design, track performance, financial planning and marketing strategy will be a winner of FSG. In theory it is possible to win the overall competition without being the best in (or even being eliminated from) one or more events. Similarly, teams can win the top prize in one or more of the categories and still have no chance at an overall victory.

Die Formula Student Germany ist ein Konstruktionswettbewerb für Studenten, bei dem unter der Annahme eines fiktiven Konstruktionsauftrags der Prototyp eines Rennwagens entstehen soll. Um einen Vergleich der startenden Teams zu ermöglichen, werden die Konzepte, Planungen und Fahrzeuge von Experten bewertet. Insgesamt kann jedes Team in drei statischen und fünf dynamischen Disziplinen maximal 1000 Punkte erhalten. Den Gesamtsieg erringt das Team mit dem besten Gesamtpaket aus Konstruktion, Rennperformance, Finanzplanung und Verkaufsargumentation. Prinzipiell kann also auch ein Team den Gesamtwettbewerb gewinnen, das in einer oder mehreren Disziplinen nicht zu den Besten zählt oder sogar ausscheidet. Auf der anderen Seite können durch dieses Bewertungssystem auch Teams einen Titel in einer oder mehreren Disziplinen erringen, obwohl sie keine Chance auf den Gesamtsieg haben.

Static Events

The Formula Student Germany competition is designed to introduce the participating students to the interdisciplinary approach of today's automotive industry. This not only includes technical understanding, but also economic and communication abilities such as presentation techniques or financial planning skills. This is why the three static events demand collaboration across the team in the areas of design and layout, construction, marketing and pricing of a product. They also require specialised expertise from different technical and financial courses of study. The teams can win up to 325 points of the possible 1000 in the three static events, and each individual event is weighted differently. A panel of experienced experts from the automobile, motorsport, and supply industries judge the performance of each team.

Engineering Design – 150 points
At the start of the engineering design competition, the students must hand in an eight-page technical description of their car. It must show both their design and how the design will be applied to their chosen construction. On the basis of this document, the members of the jury will evaluate the layout, technical design, construction and implementation of the production of the actual vehicle. Then, there will be a discussion where the teams are questioned by the judges. These discussions focus on clarifying technical details, exploring the thinking behind the chosen design, as well as the corresponding technical understanding of the students. The evaluation will not only assess the quality of the technical solution in question but also the reasons behind it.

Cost and Manufacturing – 100 points
Cost is a decisive factor in the design of any product. In the cost analysis event, the teams must grapple with the calculative size of the vehicle, its components, and the necessary manufacturing steps and record all of this in a written cost report. The students must then answer questions from the judges relating to the cost report on their prototype. In addition to considering the thoroughness of the written report, the students' understanding of the manufacturing process and the total cost calculation will be assessed.

Business Plan Presentation – 75 points
Each team presents their business plan for the constructed prototype to a fictitious manufacturing company represented by judges. During a ten-minute presentation, the team must demonstrate why their design best fulfils the demands of their target group of amateur weekend racers and show how their design can be successfully marketed. The presentation will be followed by a five-minute discussion and question round with the judges. In this event the content, structure, and editing of the presentation, as well as the team's performance in delivering it, will be evaluated alongside their answers to the panel's questions.

Total: 325 points

The judges personally convinces themseves of the functionality of the design.

Die Judges überzeugen sich persönlich von der Funktionalität der Konstruktion.

▸ It is a safety topic when talking about getting quickly out the car.

▸ Eine Sicherheitsanforderung ist, schnell aus dem Auto aussteigen zu können.

▸ Statische Disziplinen

Der Formula-Student-Wettbewerb soll die teilnehmenden Studenten an die interdisziplinäre Arbeitsweise in der Industrie heranführen. Dazu zählen nicht nur technisches Verständnis, sondern auch wirtschaftliche und kommunikative Fähigkeiten, wie z. B. Präsentationstechniken oder Kompetenzen in der Finanzplanung. Daher wird in drei statischen Disziplinen sowohl die teamübergreifende Zusammenarbeit bei Konzept, Auslegung, Konstruktion, Vermarktung und Preisgestaltung eines Produktes als auch spezielles Fachwissen aus verschiedenen technischen und wirtschaftlichen Studiengängen gefördert und gefragt. In den drei statischen Disziplinen können die Teams maximal 325 Punkte erreichen, wobei die Einzeldisziplinen unterschiedliche Gewichtungen haben. Bewertet werden die Leistungen der Teams durch eine Jury aus erfahrenen Experten der Automobil- und Zulieferindustrie sowie dem Motorsport.

Engineering Design – 150 Punkte
Zu Beginn des Engineering Design-Wettbewerbs reichen die Studenten eine achtseitige technische Beschreibung zu ihrem Fahrzeug ein, um das Konzept sowie Besonderheiten der Konstruktion darzustellen. Die Juroren begutachten auf Basis der Unterlagen das technische Konzept, die Auslegung, Konstruktionen sowie Umsetzung in der Fertigung am realen Fahrzeug. Die Teams müssen ihnen dabei zu allen Fragen in einer Diskussion Rede und Antwort stehen. In den Gesprächen geht es um die Abfrage der technischen Details, die Hintergründe für die Wahl eines Konzepts und das dazugehörige technische Verständnis. In die Bewertung fließen also nicht nur die Qualität der vorliegenden technischen Lösungen ein, sondern auch die Gründe für die gewählten Lösungen.

Cost and Manufacturing – 100 Punkte
Die Kosten sind für Gestaltung eines Produktes ein entscheidender Faktor. Bei der Disziplin Cost Analysis müssen sich die Teams mit den kalkulatorischen Größen des Fahrzeugs, seiner Bauteile und der notwendigen Fertigungsschritte auseinandersetzen und diese schriftlich in einem Cost Report festhalten. Zu den eingereichten Unterlagen müssen sich die Studenten mit ihrem Prototypen einer Diskussion mit den Juroren stellen. Bewertet werden neben der Aufbereitung und Vollständigkeit des schriftlichen Reports auch das Verständnis der Fertigungsprozesse sowie der Gesamtpreis.

Business Plan Presentation – 75 Punkte
Mit ihrem Business Plan präsentieren die Teams einem potentiellen Investor oder Partner, vertreten durch die Juroren, ihren Geschäftsplan für den gebauten Prototyp. Die Teams stellen in einem zehnminütigen Vortrag dar, weshalb ihr Konzept am besten für die Zielgruppe geeignet ist und eine gewinnbringende Investition darstellt. Der Präsentation folgt eine fünfminütige Diskussions- und Fragerunde mit den Juroren. Bei dieser Disziplin werden Inhalt, Aufbau und Aufbereitung des Vortrags sowie der Auftritt der Teams ebenso bewertet wie die Antworten auf die Fragen der Juroren.

Gesamtpunktzahl: 325 Punkte

▸ Dynamic Events

The cars that the students design will not only be assessed when stationary. Their performance on the racetrack will also be put to the test. Each dynamic event tests different features of the vehicles. In addition to the maximum longitudinal and lateral acceleration, race performance, efficiency and endurance of the formula cars will be examined and evaluated. For the Acceleration, Skid Pad and Autocross events, each car starts with two drivers, each of whom is allowed two attempts. The best attempt is the one on which the car will be scored. A maximum of 675 points can be scored over the course of the four dynamic events and the efficiency event.

Acceleration – 75 points
The vehicle‘s acceleration from a standing start is measured over a 75 metre straight. In addition to traction, the correct engine design is especially important, either in terms of greater power or for the highest possible torque. The fastest cars cross the line in less than four seconds and can reach speeds of over 100 km/h by the end of the stretch.

Skid Pad – 75 points
During the Skid Pad event, the cars must drive a figure of 8 circuit lined with track cones, performing two laps of each circle. In each case, the second lap will be measured. The lap time gives a comparative value for the maximum possible lateral acceleration of the car. Most of the cars use aerodynamics to raise the contact pressure and thus, increase lateral acceleration. As with all the dynamic events, knocking over any of the cones results in a time penalty.

Autocross – 100 points
In the autocross event, the cars traverse a kilometre-long track with straights, curves, and chicanes. A fast lap time is a sign of high driving dynamics, precise handling and good acceleration and braking ability. Once again, time penalties occur for those who knock over any cones. The autocross rankings decide the starting positions for the endurance competition that follows.

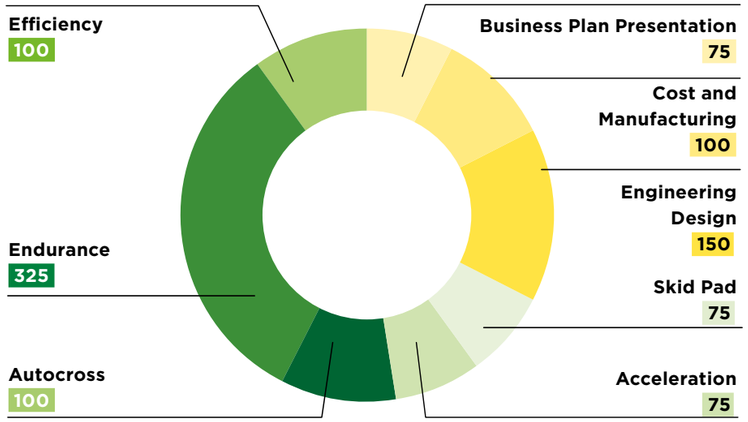
Endurance – 325 points
The endurance race represents almost a third of all available points and is consequently the most important event of the Formula Student Germany competition.The cars must demonstrate their capacity for endurance over a gruelling track distance of 22 km and all of the prototypes’ features are crucial for this event, from acceleration and handling to driving dynamics. The skill of the driver is also tested here, as they may only familiarise themselves with the track before the race by walking the length of the course (Course Walk). Each team gets just a single try and the drivers must be swapped at the halfway point. There can be up to four cars on the circuit at any given time and so overtaking manoeuvres must be performed frequently. Overtaking is signalled by a blue flag and is only permitted at specially marked sections of the track. A team will receive no points at the end if they are more than a third slower than the fastest team overall.

Efficiency – 100 points
During the endurance race, fuel consumption (FSC cars) or energy consumption (FSE cars) is precisely recorded. However, the absolute fuel and energy consumption is not what is used to calculate the efficiency score, but rather the consumption relative to speed. This is to prevent teams from driving particularly slowly in the endurance competition in order to score as highly as possible in the efficiency category.

Total: 675 points

▸ Participating driverless car in the disciplne Acceleration.

▸ Teilnehmendes autonomes Fahrzeug in der Disziplin Acceleration.



The points for FSC and FSE have the same distribution as the teams compete in 5 dynamic events and 3 static events.

Die Punkteverteilung für FSC und FSE ist identisch, da die Teams in 5 dynamischen und 3 statischen Disziplinen konkurrieren.

Dynamische Diszplinen

Die von den Studenten konstruierten Fahrzeuge werden natürlich nicht nur im Stand bewertet. Sie müssen ihre Performance auch auf der Rennstrecke unter Beweis stellen. In jeder dynamischen Disziplin werden andere Eigenschaften des Fahrzeugs getestet. Neben der maximalen Längs- und Querbeschleunigung werden auch die Rennperformance, Effizienz und Haltbarkeit der Formel-Rennwägen ermittelt und bewertet. Bei den Disziplinen Acceleration, Skid Pad und Autocross starten je Fahrzeug zwei Fahrer, die jeweils zwei Versuche haben. Gewertet wird das beste mit dem Fahrzeug erzielte Ergebnis. In den fünf dynamischen Disziplinen können maximal 675 Punkte erzielt werden.

Acceleration – 75 Punkte
Auf einer 75 Meter langen Geraden wird die Beschleunigung der Fahrzeuge aus dem Stand gemessen. Hier kommt es neben der Traktion vor allem auf eine richtige Auslegung des Getriebes und eine möglichst hohe Leistung, bzw. ein hohes Drehmoment an. Die schnellsten Fahrzeuge absolvieren diese Prüfung in einer Zeit unter vier Sekunden und erreichen am Ende der Messstrecke Geschwindigkeiten von mehr als 100 km/h.

Skid Pad – 75 Punkte
Beim Skid Pad durchfahren die Rennwagen einen mit Pylonen begrenzten Parcours in Form einer Acht. Jeder Kreisring wird zweimal umrundet. Gemessen wird jeweils die zweite Runde. Die Rundenzeit gibt einen Vergleichswert für die maximal erzielbare Querbeschleunigung der Fahrzeuge. Bei den meisten Fahrzeugen werden durch den Einsatz aerodynamischer Hilfsmittel der Anpressdruck und damit die Querbeschleunigung erhöht. Das Umstoßen von Pylonen wird mit einer Zeitstrafe belegt.

Autocross – 100 Punkte
Bei der Disziplin Autocross fahren die Rennwagen über einen etwa ein Kilometer langen Kurs mit Geraden, Kurven und Schikanen. Eine schnelle Rundenzeit ist ein Indikator für eine hohe Fahrdynamik, ein präzises Handling sowie gute Beschleunigungs- und Bremseigenschaften. Auch hier werden umgestoßene Pylonen mit einer Zeitstrafe geahndet. Die Platzierung im Autocross entscheidet auch über die Startreihenfolge im nachfolgenden Endurance-Wettbewerb.

Endurance – 325 Punkte
Das Endurance-Rennen stellt mit fast einem Drittel aller erreichbaren Punkte die Hauptdisziplin des Formula Student-Wettbewerbs dar. Über eine Renndistanz von 22 Kilometern müssen sich die konstruierten Rennfahrzeuge unter Dauerbelastung beweisen. Bei dieser Disziplin sind alle Eigenschaften der Prototypen wichtig, von der Beschleunigung bis zum Handling und der Fahrdynamik. Zusätzlich ist auch das Geschick der Fahrer gefragt, da die Strecke vor dem Rennen nur zu Fuß abgeschritten werden darf (Course Walk). Jedes Team hat einen einzigen Versuch, wobei nach der Hälfte der Distanz ein Fahrerwechsel erfolgen muss. Es sind bis zu sieben Fahrzeuge gleichzeitig auf der Strecke, wodurch es oft auch zu Überholvorgängen kommt. Diese werden von der Rennleitung veranlasst und finden in eigens dafür eingerichteten Überholzonen statt, an denen die Strecke breiter ist. Das langsamere Fahrzeug bekommt dafür von den Streckenposten durch blaue Flaggen signalisiert, dass es einen schnelleren Teilnehmer überholen lassen muss. Die Teams erhalten nur dann Punkte, wenn sie höchstens ein Drittel langsamer waren als das schnellste Team. Auch hier werden Pylonenfehler durch Zeitstrafen geahndet.

Efficiency – 100 Punkte
Während des Endurance-Rennens wird der Kraftstoffverbrauch (FSC-Fahrzeuge), bzw. der Energieverbrauch (FSE-Fahrzeuge) gemessen. Bei der Berechnung der Effizienz und der Punkte wird allerdings nicht der absolute Kraftstoff-/ Energieverbrauch gemessen, sondern der Verbrauch in Relation zur Geschwindigkeit. Dadurch wird verhindert, dass Teams während des Endurance-Wettbewerbs besonders langsam fahren, um eine möglichst hohe Punktzahl in der Efficiency-Disziplin zu erreichen.

Gesamtpunktzahl: 675 Punkte

The feeling of pure bliss when you cross the finish line.

Das Gefühl purer Glückseligkeit beim Überqueren der Ziellinie.

The complete FSG Competition Handbook 2021:

https://fsg.one/comp-handb-21

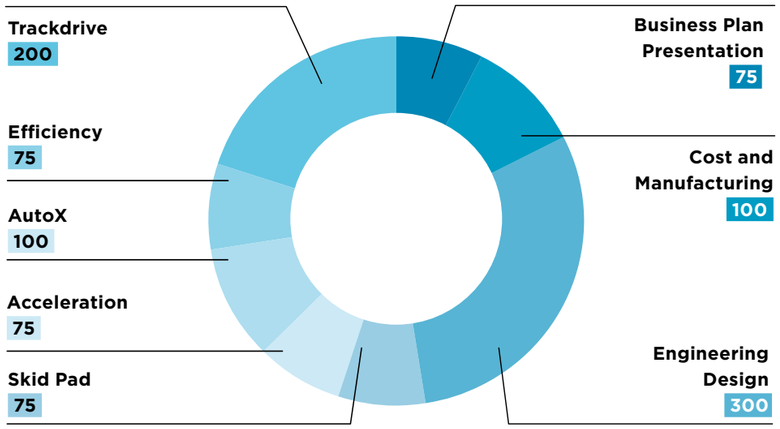
Formula Student Driverless (FSD)

As with the other two FSG competitions, the student racing teams at FSD compete with independently designed vehicles in dynamic and static disciplines. In contrast to FSC and FSE, the vehicles must cope with all dynamic disciplines completely autonomously with no driver sitting in the vehicle. In principle, however, "normal" driving with an FSD car is possible. The teams can freely select the type of drivetrain (electric or combustion), but must comply with the safety regulations of the respective vehicle category.

In the case of autonomous vehicles, the development focus shifts away from pure driving dynamics to an optimal adaptation of the autonomous vehicle system to the respective driving situation. FSG takes this into account when judging the FSD teams. This requires different static and dynamic disciplines, as well as a redistribution of the maximum achievable points. By maintaining as many disciplines as possible and maintaining the same maximum overall score, the comparability between all FSG competitions should at least be partially preserved.

Wie bei den anderen beiden FSG-Wettbewerben konkurrieren die Teams bei FSD mit eigens entwickelten Fahrzeugen in den dynamischen und statischen Disziplinen. Im Gegensatz zu FSC und FSE müssen die Fahrzeuge alle dynamischen Disziplinen komplett autonom bewältigen – ohne Fahrer im Fahrzeug. Prinzipiell ist jedoch „normales" Fahren mit einem FSD-Auto durchaus möglich. Bei der Wahl der Art des Antriebsstrangs (elektrisch oder Verbrenner) sind die Teams völlig frei. Die Sicherheitsvorschriften der jeweiligen Fahrzeugklasse müssen jedoch eingehalten werden.

Bei autonomen Fahrzeugen verschiebt sich der Entwicklungsschwerpunkt von reiner Fahrdynamik hin zu einer optimalen Auslegung der autonomen Fahrzeugsysteme auf die jeweilige Fahrsituation. Dies berücksichtigt FSG bei der Beurteilung der FSD-Teams, was Unterschiede bei den statischen und dynamischen Disziplinen sowie eine Umverteilung der erreichbaren Punkte pro Disziplin erfordert. Durch die Beibehaltung möglichst aller Disziplinen im Vergleich zu FSC und FSE sowie der selben maximal erreichbaren Gesamtpunktzahl bleibt die Vergleichbarkeit aller FSG-Wettbewerbe zumindest teilweise erhalten.



▸ The points for the FSD competition are more heavily weighted to the static disciplines.

▸ Bei der Punkteverteilung für FSD liegt mehr Gewicht auf den statischen Disziplinen.

▸ Static Disciplines

The Static Disciplines will give the teams the opportunity to gain almost 50 % of the points. These are critical for the teams in order to gain a competitive overall position.

Business Plan Presentation – 75 points and Cost Analysis – 100 points are identical to FSC and FSE.

Engineering Design – 300 points
The FSD Engineering Design event is considered more valuable for the teams as far as points. Not only will the design of the vehicle be judged, like it is in FSC and FSE, but the teams will also be judged on vehicle data from the dynamic disciplines.

Total: 475 points

▸ Statische Disziplinen

In den statischen Disziplinen können die Teams knapp 50 % der Punkte sammeln. Diese Disziplinen sind also entscheidend, um eine gute Gesamtposition zu erreichen.

Business Plan Presentation – 75 Punkte und Cost Analysis – 100 Punkte sind identisch zu FSC und FSE.

Engineering Design – 300 Punkte
Das FSD Engineering Design erhält in Bezug auf die erreichbaren Punkte ein größeres Gewicht und gewinnt damit an Bedeutung für die FSD Teams. Im Gegensatz zu FSC und FSE wird bei der Bewertung des Ingenieurswissens ein deutlicher Fokus auf die autonomen Systeme gelegt.

Gesamtpunktzahl: 475 Punkte

▸ Dynamic Disciplines

The Dynamic Disciplines make up the remaining points. In Formula Student Driverless, the Trackdrive replaces the Endurance event.

Acceleration – 75 points and Skid Pad – 75 points will also be held for FSD as described above, but as a driverless event.

Autocross - 100 points
As with FSC and FSE, the cars handling is demonstrated. The extra challenge for the autonomous cars is that they must drive around an unknown track.

Efficiency – 75 points
As in the case of the FSC and FSE, consumption-related points for the efficiency are also added.

Trackdrive – 200 points
The Autonomous Vehicles will race in a Track Race over 10 laps on a 300 to 500 metre long coned course.

Total: 525 points

▸ Dynamische Disziplinen

In den dynamischen Disziplinen können die Teams die restlichen Punkte einfahren. Bei der Formula Student Driverless ersetzt der so genannte „Track Drive" das Endurance-Rennen.

Acceleration – 75 points und Skid Pad – 75 Punkte
werden wie oben beschrieben ebenfalls für FSD beibehalten, jedoch ohne Fahrer.

Autocross - 100 Punkte
Wie bei FSC und FSE wird hier eine Runde auf einem Handlingparcours gefahren. Die unbekannte Strecke stellt für die autonomen Fahrzeuge eine besondere Herausforderung dar.

Efficiency – 75 Punkte
Wie bei FSC und FSE werden verbrauchsbezogene Punkte für den Verbrauch vergeben.

Trackdrive – 200 Punkte
Die autonomen Fahrzeuge werden in einem Track Race über 10 Runden auf einem 300 bis 500 Meter langen Kurs fahren.

Gesamtpunktzahl: 525 Punkte

▸ In this autonomous discipline, the precision of the sensors is crucial for success.

▸ In dieser autonomen Disziplin ist die Präzision der Sensoren erfolgsentscheidend.

Safety Regulations

Sicherheit und Regeln

Da alle Fahrzeuge Prototypen sind, müssen die Teams eine Reihe von Sicherheitsmaßnahmen und Regeln einhalten. Auf diese Weise wird zudem eine Chancengleichheit zwischen den Teams gewährt, die mit unterschiedlichen Voraussetzungen in Bezug auf Erfahrung, personelle Kapazitäten und finanzielle Ressourcen an den Start gehen. Das erfolgreiche Absolvieren des sogenannten Scrutineerings (technische Abnahme) ist die Grundvoraussetzung für die Zulassung eines Fahrzeugs zu den dynamischen Disziplinen. Für jeden erfolgreich absolvierten Check erhalten die Teams einen Aufkleber, der auf dem Fahrzeug angebracht werden muss. Bei FSC und FSE sowie FSD gibt es Unterschiede bei der Betriebssicherheit, die beim Scrutineering berücksichtigt werden müssen.

A series of safety measures and regulations must be observed for every prototype car competing. This is to ensure safety and a levelled playing field between the teams. It is important as all teams are at different levels, whether it is be different qualifications in terms of experience, personal ability or financial resources. Every car must pass Scrutineering (technical inspection and approval) in order to be allowed to participate in the dynamic categories. Teams are awarded various stickers for each safety check they pass. They must be placed at their car to show it has passed a particular test. For the FSC and FSE aswell as FSD series, there are also system-specific differences in terms of operation safety that have to be followed during scrutineering.

Accumulator (only FSE)
The ‘Accumulator’ is a technical term for the battery. It is built up of battery cells that can be connected in various series and parallel configurations. For the electrically powered Formula Student cars, the ‘Accumulator’ is the sole source of energy that enables the cars to drive. This is critical to safety if it is incorrectly designed or built.
To protect for this, it is checked before the teams may compete in the dynamic events. Overheating of the cells can lead to fire. A temperature-logging device is installed by the FSG scrutineers, to ensure that the monitoring of the cell temperature is accurate. The batteries are sealed once the inspection has been carried out. The teams must transport their ‘Accumulator’ on a specially designed trolley so that it can be moved away should there be any risk of the cells overheating.

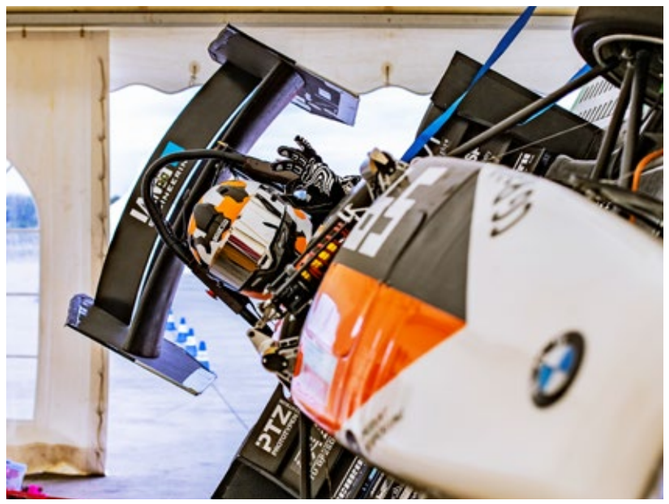
Batterie (nur FSE)
Der Akkumulator, kurz Akku, ist der technische Fachbegriff für die Fahrzeugbatterie. Diese besteht aus einer Vielzahl an Zellen, die in Reihe oder parallel geschalten sind. Für elektrische Formula Student Fahrzeuge ist der Akku die einzige Energiequelle, die das Fahrzeug antreibt. Daher ist der korrekte Aufbau des Bauteils essentiell für die Fahrzeugsicherheit.
Um eventuelle Fehlfunktionen und Ausfälle zu vermeiden, werden die Akkus vor den dynamischen Disziplinen genau geprüft. Bei Überhitzung der Zellen kann ein Brand entstehen, weswegen für die genaue Überwachung der Zelltemperatur durch die FSG Scrutineers Temperatursensoren angebracht werden. Der Transport der Akkus außerhalb des Fahrzeuges sowie das Laden muss auf speziellen Transportwagen geschehen, welche im Falle einer Überhitzung schnell abtransportiert werden können.

Electrical Scrutineering (only FSE)
During electrical scrutineering, the electrical safety of the electric car is tested. That means all systems required by the regulations are checked in regard to their functional capacity. For example, system checks include the insulation-monitoring device, correct operation of the signal light (the Tractive System Active Light, which displays the status of the high voltage system) and the sound that indicates that the vehicle is ready to race. In addition, general safety aspects are checked, such as whether the wires have been laid correctly mechanically and whether the high voltage energy storage device is assembled according to regulation.

Electrical Inspection (nur FSE)
Während der Electrical Inspection wird die elektrische Sicherheit der Elektrofahrzeuge überprüft, d.h. alle durch das Regelwerk vorgeschriebenen Systeme werden auf ihre Funktionsfähigkeit getestet. Zu den geprüften Systemen gehören u.a. die Isolationsüberwachung, die korrekte Funktionsweise des Signallichts (Tractive System Active Light, das die Aktivität des Hochvoltsystems anzeigt) und der Signalton, der die Fahrbereitschaft des Fahrzeugs signalisiert (Ready To Drive Sound). Es werden aber auch allgemeine Sicherheitsaspekte wie z. B. mechanisch einwandfrei verlegte Leitungen oder der regelkonforme Einbau des Hochvolt-Energiespeichers überprüft.

If a team has passed all tests, it can participate at the competition.
Wenn ein Team alle Tests bestanden hat, darf es am Wettbewerb teilnehmen.

Checking for leaks in the tilt table test.
Überprüfung auf Lecks beim Tilt Table Test.



The scrutineers must go through every point in their checklist.
Die Scrutineers überprüfen jeden Punkt auf ihrer Checkliste.

Tech and Safety (FSC and FSE)
For this inspection, all the components and accessories of the racecar that are considered relevant to safety according to the regulations are checked. These include the framework, wheel suspension, steering, braking, rims, and tires. Other details, such as the layout of the fuel lines, the fixture of the air intake system, the observance of appropriate cockpit size and the correct functioning of the kill switch are all checked. In addition to this, all drivers must show that when in a ready-to-race condition, i.e., strapped in to the driving seat wearing their full racing suit and helmet, they can exit their vehicle within five seconds.

Tilt Table (FSC and FSE)
The tilt table test checks whether any operating fluids are leaking and roll-over protection regulations are met. The car must be brought to the test in a ready to race condition, with all fluids and a full tank of petrol. The driver is strapped in and the car is set at an angle of 60 degrees. This corresponds to a lateral acceleration force of 1.7g. No fuel or other fluids are allowed to leak out at this angle. The race car only passes this test if the upper wheels remain on the floor.

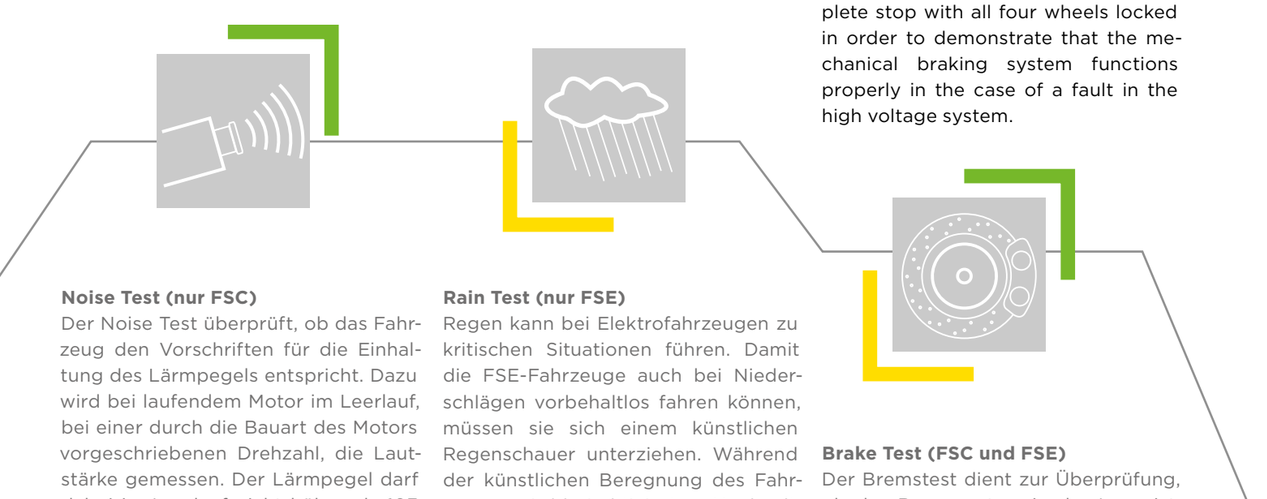
Tech and Safety (FSC und FSE)
Bei dieser Abnahme werden alle sicherheitsrelevanten Bau- und Zubehörteile des Rennwagens, die durch das Regelwerk vorgeschrieben werden, geprüft. Dazu gehören unter anderem die Rahmenstruktur, die Radaufhängung, Lenkung, Bremsen, Felgen und Reifen. Auch Details wie die Verlegung der Kraftstoffleitungen, die Befestigung des Ansaugsystems, die Einhaltung der Cockpitgröße oder die korrekte Funktionsweise der Notschalter werden geprüft. Zusätzlich müssen alle Fahrer zeigen, dass sie in einem fahrfertigen Zustand, d.h. voll eingekleidet und angegurtet, das Auto innerhalb von fünf Sekunden verlassen können.

Tilt Table (FSC und FSE)
Beim Tilt Table Test wird überprüft, ob keine Betriebsflüssigkeiten austreten und die Regularien zum Überrollschutz erfüllt werden. Die Fahrzeuge müssen startklar, mit allen Flüssigkeiten und vollgetankt, zum Test gebracht werden. Das Fahrzeug mit angeschnalltem Fahrer wird bis zu einem Winkel von 60 Grad geneigt. Dies entspricht einer Querbeschleunigung von 1,7 g. Bei diesem Winkel dürfen kein Kraftstoff oder andere Flüssigkeiten austreten. Nur wenn die oberen Räder auf dem Boden bleiben, besteht der Rennwagen den Tilt Table Test.

Noise Test (only FSC)
The noise test checks that the car complies with the provisions for the acceptable noise level. In order to measure the volume, the engine is run in neutral at a rotation speed. The speed depends on the type of engine. In neutral, the noise level must not exceed 103 dBC or be any greater than 110 dBC at a specified rotation speed.

Rain Test (only FSE)
Rain can lead to critical situations for electric cars. In order to be allowed to operate during rainfall with no reservations, the FSE cars must undergo an artificial rain shower. During the artificial rainfall, the car's high voltage system is activated and the appropriate components can be checked to see if they are sufficiently insulated and protected from water.

Brake Test (FSC and FSE)
The brake test checks whether a braking system is able to lock all four wheels of the car simultaneously and bring the vehicle to a controlled stop. However, since the FSE cars can also use their electric motor braking system, if the driver is operating an electric vehicle, in addition they must deactivate the high voltage system after accelerating and then come to a complete stop with all four wheels locked in order to demonstrate that the mechanical braking system functions properly in the case of a fault in the high voltage system.



Noise Test (nur FSC)
Der Noise Test überprüft, ob das Fahrzeug den Vorschriften für die Einhaltung des Lärmpegels entspricht. Dazu wird bei laufendem Motor im Leerlauf, bei einer durch die Bauart des Motors vorgeschriebenen Drehzahl, die Lautstärke gemessen. Der Lärmpegel darf dabei im Leerlauf nicht höher als 103 dBC und nicht höher als 110dBC bei der vorgeschriebenen Drehzahl sein.

Rain Test (nur FSE)
Regen kann bei Elektrofahrzeugen zu kritischen Situationen führen. Damit die FSE-Fahrzeuge auch bei Niederschlägen vorbehaltlos fahren können, müssen sie sich einem künstlichen Regenschauer unterziehen. Während der künstlichen Beregnung des Fahrzeuges wird bei aktiviertem Hochvoltsystem kontrolliert, ob die verwendeten Komponenten ausreichend isoliert und gegen Regen geschützt sind.

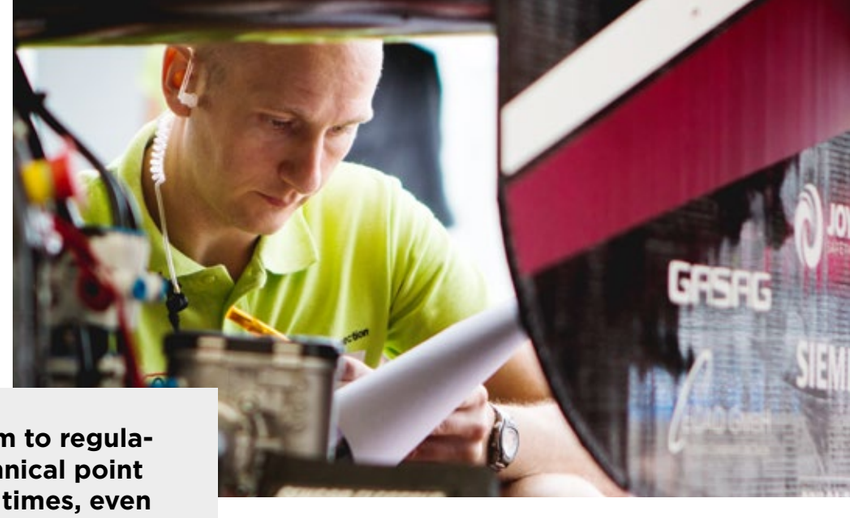
Brake Test (FSC und FSE)
Der Bremstest dient zur Überprüfung, ob das Bremssystem in der Lage ist, alle vier Räder des Fahrzeugs gleichzeitig zu blockieren und dadurch das Fahrzeug zu einem kontrollierten Stillstand zu bringen. Die FSE-Fahrzeuge können den elektrischen Antrieb auch zum Bremsen verwenden. Um eine einwandfreie Funktion des mechanischen Bremssystems bei einem Fehler im Hochspannungssystem nachzuweisen, muss der Fahrer nach dem Beschleunigen das Hochvoltsystem deaktivieren und anschließend mit vier blockierenden Rädern zum Stehen kommen.

Lucky team members who celebrate the done test procedure.

Glückliche Teammitglieder, die sich über das abgeschlossene Testverfahren freuen.

If a team fails any point of the inspection, they must fix the issue and return for re-inspection.

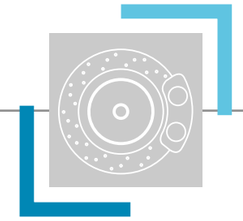
Wird auch nur ein Punkt bei der Inspektion nicht erfüllt, muss das Team das entsprechende Problem beheben und erneut zur Inspektion antreten.



"Vehicles must conform to regulations and, from a technical point of view, be safe at all times, even after passing scrutineering."

„Die Fahrzeuge müssen auch nach bestandenem Scrutineering zu jeder Zeit regelkonform und sicherheitstechnisch unbedenklich sein."

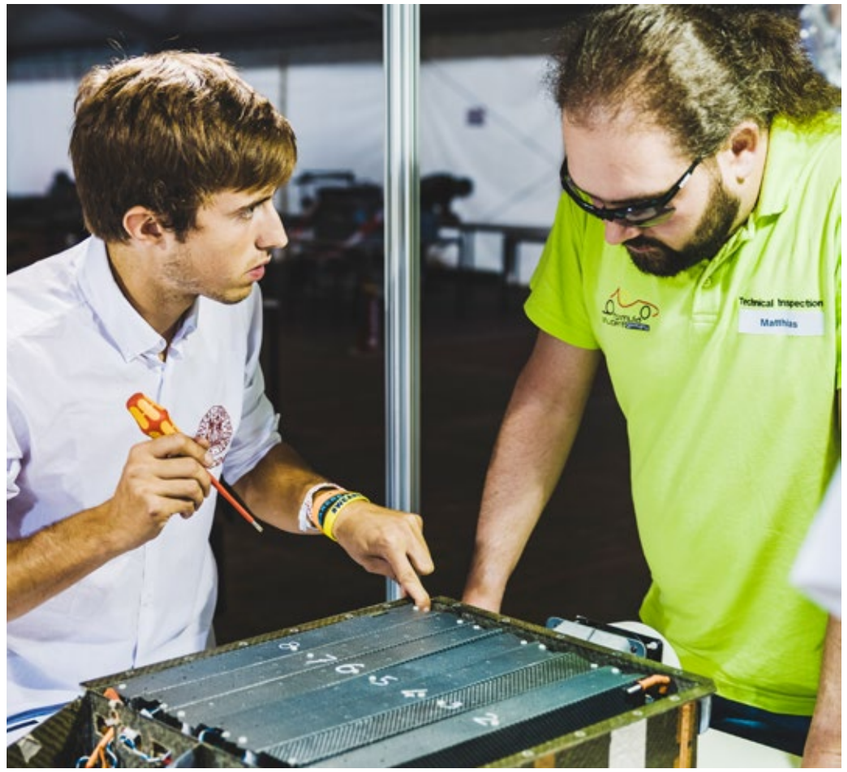
Brake Test (FSD)
Formula Student Driverless cars are equipped with an Emergency Brake System (EBS). This is actuated via the Remote Emergency System (EBS). This must be tested in order for the FSD cars to pass the brake test.



Brake Test (FSD)
Formula Student Driverless Fahrzeuge sind mit einem Notfallbremssystem (EBS) ausgestattet, welches durch eine Fernbedienung aktiviert werden kann. Um den FSD Brake Test zu bestehen, muss die Funktionsfähigkeit des EBS per Fernbedienung nachgewiesen werden.

Driverless Inspection (FSD only)
In order to guarantee the safety of the autonomous vehicles in the operation and handling for all parties concerned, the team must fulfill some special requirements. Each vehicle must be equipped with a so-called RES (Remote Emergency System), which fulfills two functions. By means of this remote control, the required emergency brake system (EBS) can be triggered and the vehicle can be stopped in emergency situations. At the same time, the RES control system enables the "Go" signal to be sent to the vehicle at the start of the dynamic disciplines. Furthermore, all FSD vehicles are equipped with different coloured signal lamps, which indicate the respective operating states of the vehicle. In autonomous mode, a yellow signal is illuminated, whilst a blue light indicates the status of the RES. These systems must be tested during the Driverless Inspection.

Driverless Inspection (nur FSD)
Um die Sicherheit der autonomen Fahrzeuge bei der Bedienung und Handhabung für alle Beteiligten zu gewährleisten, muss das Team einige besondere Anforderungen erfüllen. Jedes Fahrzeug muss mit einem sogenannten RES (Remote Emergency System) ausgestattet sein, das zwei Funktionen erfüllt. Mit dieser Fernbedienung kann das erforderliche Notbremssystem (EBS) ausgelöst und das Fahrzeug in Notsituationen angehalten werden. Gleichzeitig ermöglicht das RES-Steuerungssystem, dass das „Go" -Signal zu Beginn der dynamischen Disziplinen an das Fahrzeug gesendet wird. Darüber hinaus sind alle FSD-Fahrzeuge mit verschiedenfarbigen Signallampen ausgestattet, die die jeweiligen Betriebszustände des Fahrzeugs anzeigen. Im autonomen Modus leuchtet ein gelbes Signal, während ein blaues Licht den Status des RES anzeigt. Diese Systeme müssen während des Driverless Scrutineering getestet werden.



During E-Scrutineering the accumulator is checked extensively.

Während des E-Scrutineerings wird auch der Akku ausgiebig geprüft.

Adherence to the Rules

Vehicles must conform to regulations and, from a technical point of view, be safe at all times, even after passing scrutineering. The authorised technical experts or the race stewards can remove a car from the competition at any time in the case of a breach of regulation or safety requirements, for example, if a car is leaking fluids, is too loud, or if the insulation is not up to standard. The car cannot return to the competition until the fault has been repaired. Cars are also inspected again following the endurance race in order to exclude the possibility of a violation during the race. This is why the cars are placed in a parc fermé after the endurance competition, and the team members are not permitted to touch them until all the inspections have been successfully performed.

Geltungsbereich

Die Fahrzeuge müssen auch nach bestandenem Scrutineering zu jeder Zeit regelkonform und sicherheitstechnisch unbedenklich sein. Die offiziellen technischen Sachverständigen oder die Rennleitung können Fahrzeuge bei einem Verstoß gegen das Reglement oder die Sicherheitsanforderungen jederzeit aus dem Wettbewerb nehmen, z.B. wenn Flüssigkeiten austreten, das Fahrzeug zu laut oder die elektrische Isolation nicht gewährleistet ist. Die Fahrzeuge können erst dann wieder am Wettbewerb teilnehmen, wenn der Mangel behoben wurde. Nach dem Endurance-Rennen werden die Fahrzeuge erneut geprüft, um Regelverstöße während des Rennens ausschließen zu können. Hierfür werden die Fahrzeuge in einem „Parc-Fermé“ abgestellt und dürfen von den Teammitgliedern solange nicht mehr berührt werden, bis die letzte Abnahme erfolgt ist.

Flags

During the dynamic events, flags are used to communicate with the drivers. The various colours and patterns have different meanings, and all drivers must understand and obey any flag signal they receive during the competition. Infringements of flag signals can be penalised with various penalties, ranging from time penalties to disqualification.

Your session has started, enter the course!
Deine Fahrt beginnt. Fahr auf die Strecke!

Your session has been completed. Exit the course!
Deine Fahrt ist beendet.
Verlass die Strecke!

Pull into the passing zone to be passed by a faster competitor!
Fahr in die Überholzone, damit ein schnelleres Fahrzeug passieren kann!

Pull into the penalty box for discussion concerning an incident that may cause a time penalty!
Fahr in die Kontrollzone zur Diskussion eines Vorfalls! Ggf. Zeitstrafe!

Pull into the penalty box for a mechanical inspection of your car!
Fahr in die Kontrollzone für eine technische Untersuchung des Fahrzeugs!

Flaggen

Bei den dynamischen Prüfungen werden zur Kommunikation mit den Fahrern Flaggen eingesetzt. Die verschiedenen Farben und Muster haben unterschiedliche Bedeutungen. Alle Fahrer müssen die Flaggen kennen und beachten, wenn sie diese während des Wettbewerbs gezeigt bekommen. Verstöße gegen geschwenkte Flaggen können mit verschiedenen Sanktionen geahndet werden, die von Zeitstrafen bis zur Disqualifikation reichen können.

Come to an immediate safe controlled stop on the course! Pull to the side of the course.
Komm sofort kontrolliert zum Stehen.
Halte an dem Rand der Strecke.

Something is on the track that should not be there. Be prepared for evasive maneuvers to avoid debris or liquids!
Es ist etwas Unerwartetes auf der Strecke.
Sei bereit Flüssigkeiten oder Bruchstücken auszuweichen!

Something has happened beyond the flag station. No passing unless directed by the track marshals. Stationary: Danger! Slow down, be prepared to take evasive action. Waved: Great Danger! Slow down, evasive action is most likely required, be prepared to stop.
Etwas ist jenseits der Flagge passiert. Fahr nicht vorbei ohne Anweisung der Streckenposten. Flagge gehalten: Gefahr! Fahr langsam, sei bereit zum Ausweichen. Flagge geschwenkt: Große Gefahr! Fahr langsam, Ausweichen wird erforderlich sein. Sei bereit anzuhalten.

It is critical for safety that the students understand the meaning of the different flags.

Aus Sicherheitsgründen ist es essentiell, dass die Studierenden die Bedeutung der verschiedenen Flaggen kennen.

15th FSG Competition
15. FSG Wettbewerb

Written by Theresa Stach

As there was nothing else to write on, the first concrete tasks for FSG we documented on a beer mat. / Da keine andere Schreibunterlage zur Verfügung stand, wurden die ersten konkreten Aufgaben für die FSG auf einem Bierdeckel niedergeschrieben.

A reflection on the past and an outlook into the future of Formula Student Germany – from a pub to the Hockenheimring

It was a rainy evening on the 9th of July 2005 in Bruntinghorpe, England. Among others, Daniel Mazur, Ulf Steinfurt, Tim Hannig, Frank Röske, Rainer Kötke and Peter Jakowski from the FS Teams of Stralsund and Braunschweig sat together with Dr. Ludwig Vollrath, Managing Director at VDI in the Pub “The Plough” after finishing Formula Student UK.

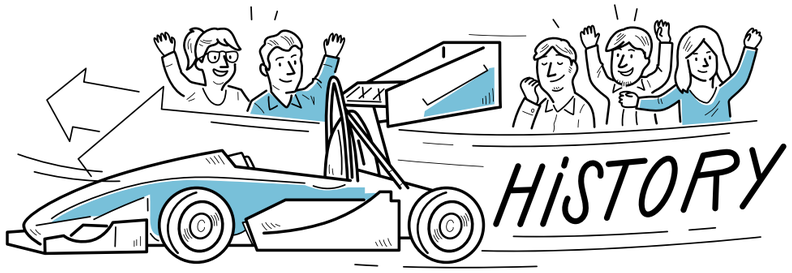
Inspired by the event’s atmosphere they sketched the idea of a Formula Student event in Germany.

As there was nothing else to write on they scribbled their idea on a beer mat! With this one beer mat the idea of FSG was born and the cornerstone was set for a competition that welcomes over 115 teams from 25 nations every year in Hockenheim.

Back in Germany, instantly everyone involved started to work on what was needed to set up an event like this. Already in the same year, a pre-event took place on the premises of Porsche Leipzig with a total of 11 teams from Germany, Austria, Finland, and Italy. After such a successful launch it was clear that a full-fledged event would be held next year. However, a suitable venue had to be found. To meet all requirements at the same time and create a worthy setting for the event, only a Formula 1 racetrack seemed adequate. This is how FSG found its way to Hockenheim. Over the years, the Hockenheimring was established as the “home of FSG”. With the growing number of participating teams, it was also necessary to enlarge the group of volunteers. Today, we are happy to count over 400 volunteers as part of the FSG family that help to bring this unique competition to life. Furthermore, the community of partners grew substantially over years. Our partners, many of whom have been part of FSG for several years already, help to create a unique feeling during the week and support many teams on their journey throughout the year.

With time the competition evolved from the combustion class, the start of the electric era took place in 2010. Initially introduced as a test scenario “only”, it quickly became clear that Formula Student Electric would become one of the most significant, forward-looking developments and a permanent part of the FSG. Today many other competitions offer an electric class and we are happy to see the movement growing as over 300 teams worldwide have already gone electric.

A few years ago, a new development started to emerge within the automotive industry: autonomous driving. We saw the need to integrate this complex topic into the competition. In 2016 we announced the Driverless concept Award where we gave the teams the possibility to actively shape the form of Formula Student Driverless. In 2017, autonomous driving became a part of Formula Student with the official launch of the “Formula Student Driverless” class. Just like in the Electric class we see the number of “driverless” teams growing and it already amounts to 113 teams worldwide. Of these, around 60 teams have already been able to present a finished and fully functional racing vehicle at an event. Starting in 2022 the merge of the electric and driverless classes will give driverless an even more important role in the competition.



Rückblick und Ausblick in die Zukunft der Formula Student Germany – vom Pub auf den Hockenheimring

Es war ein regnerischer Abend am 9. Juli 2005 in Bruntinghorpe, England. Unter anderem saßen Daniel Mazur, Ulf Steinfurt, Tim Hannig, Frank Röske, Rainer Kötke und Peter Jakowski aus den FS-Teams Stralsund und Braunschweig nach Abschluss der Formula Student UK mit Dr. Ludwig Vollrath, Geschäftsführer beim VDI, im Pub „The Plough“ zusammen.

Inspiriert von der Atmosphäre des Events skizzierten sie die Idee eines Formula Student Events in Deutschland.

Da es keine andere Schreibunterlage gab, kritzelten sie ihre Idee auf einen Bierdeckel! Mit diesem einen Bierdeckel war die Idee der FSG geboren und der Grundstein für einen Wettbewerb gelegt, der jedes Jahr über 115 Teams aus 25 Nationen in Hockenheim begrüßt.

Zurück in Deutschland machten sich alle Beteiligten sofort an die Arbeit, um die erste Veranstaltung auf die Beine zu stellen. Bereits im selben Jahr fand auf dem Gelände von Porsche Leipzig ein Pre-Event mit insgesamt 11 Teams aus Deutschland, Österreich, Finnland und Italien statt. Nach einem solch erfolgreichen Auftakt war klar, dass im nächsten Jahr ein vollwertiger Wettbewerb stattfinden sollte. Allerdings musste zuerst ein geeigneter Veranstaltungsort gefunden werden. Um allen Anforderungen gerecht zu werden und gleichzeitig einen würdigen Rahmen für die Veranstaltung zu schaffen, schien nur eine echte Formel-1-Rennstrecke geeignet. So fand die FSG den Weg nach Hockenheim.

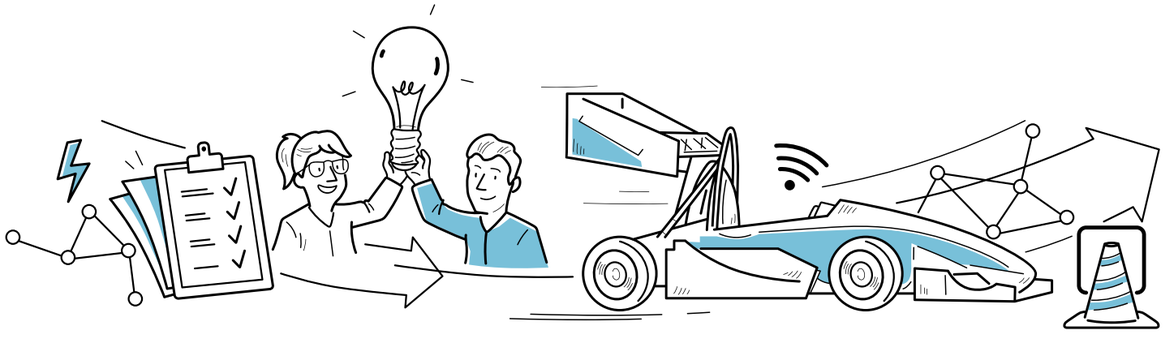
Im Laufe der Jahre etablierte sich der Hockenheimring als die „Heimat der FSG“. Mit der wachsenden Zahl der teilnehmenden Teams war es auch notwendig, den Kreis der ehrenamtlichen Helfer zu vergrößern. Heute freuen wir uns, über 400 Volunteers zur FSG-Familie zu zählen, die helfen, diesen einzigartigen Wettbewerb jedes Jahr aufs Neue zum Leben zu erwecken. Darüber hinaus ist das Netzwerk der Partner über die Jahre kontinuierlich gewachsen. Unsere Partner, von denen viele schon seit vielen Jahren Teil der FSG sind, helfen dabei, ein einzigartiges Gefühl während der Woche zu schaffen und unterstützen viele Teams während ihrer Saison.

Mit der Zeit hat sich der Wettbewerb weiterentwickelt: Neben der Verbrennerklasse startete die FSG 2010 die Elektro-Ära der Formula Student. Zunächst nur als Testszenario konzipiert, wurde schnell klar, dass die Formula Student Electric eine der bedeutendsten, zukunftsweisenden Entwicklungen und ein fester Bestandteil der FSG werden würde. Heute bieten viele andere Wettbewerbe eine Elektroklasse an und wir freuen uns, dass die Anzahl der Teams wächst, denn weltweit fahren bereits über 300 Teams elektrisch.

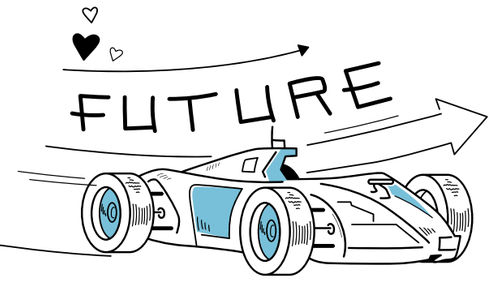
Vor einigen Jahren zeichnete sich eine neue Entwicklung in der Automobilindustrie ab: das autonome Fahren. Die FSG sah 2016 die Notwendigkeit, dieses komplexe Thema mit in den Wettbewerb zu integrieren. 2017 wurde das autonome Fahren durch die offizielle Einführung der neuen Klasse „Formula Student Driverless“ ein wesentliches Element des Wettbewerbs. Ähnlich wie in der Elektroklasse wächst die Zahl der Driverless Teams stetig und beträgt bereits 113 Teams weltweit. Davon konnten bereits rund 60 Teams einen fertigen und voll funktionsfähigen Boliden bei einem Event präsentieren. Ab 2022 wird durch die Zusammenlegung der Electric und Driverless Klasse das autonome Fahren eine noch wichtigere Rolle im Wettbewerb einnehmen.

For FSG, the main idea is to create a platform for students to experiment with new technologies and gain skills and knowledge in working with cutting-edge developments. Since the beginning of FSG we have constantly evolved. We drive to create the best environment possible for students to become open-minded, creative and skilled race car engineers, business managers, software developers, marketing experts or entrepreneurs, making tomorrow's reality a little better and more sustainable.

Für die FSG steht folgender Gedanke im Vordergrund: Wir möchten eine Plattform für Studierende schaffen, die es Ihnen ermöglicht mit neuen Technologien zu experimentieren sowie Wissen und Können im Umgang mit zukunftsweisenden Entwicklungen zu erwerben. Seit den Anfängen der FSG entwickeln wir uns ständig weiter. Wir streben danach, die bestmögliche Umgebung für Studierende zu schaffen, um aufgeschlossene, kreative und qualifizierte Renningenieure, Business Manager, Softwareentwickler, Marketingexperten und Entrepreneure zu werden, um so die Realität von morgen ein bisschen besser und nachhaltiger zu machen.



Let's have a look into the future with Dr. Ludwig Vollrath and Steffen Hemer: /
Blicken wir in die Zukunft mit Dr. Ludwig Vollrath und Steffen Hemer:



Dr. Ludwig Vollrath

Founding member and contributor of Formula Student Germany since Day 1

Gründungsmitglied und Vorantreiber der Formula Student Germany seit Tag 1

Ludwig, where do you think FSG is heading?
From the very beginning, the automotive industry has been characterized by constant change. The challenges in the current period are high – new types of vehicle and mobility concepts are being developed and brought to market maturity at high speed.

Vehicle development and production are now taking place entirely in an international context – future mobility concepts demand and encourage new partnerships outside the traditional automotive industry. This is also reflected in our competition. Therefore, we organize a "World Council Meeting" at the Hockenheimring each year. In our view it is important for the different competitions to exchange ideas with each other, address common problems and develop ideas for cooperation.

For me, every year at FSG, it's "Welcome to the future". Formula Student Germany is where the engineers and innovators of the future gather. FSG keeps pace with technological progress and, while presenting the students with challenges, we give them the necessary "equipment and tools" for the future.

What influence did the Corona pandemic have on the development of Formula Student?
The pandemic has highlighted the need to increasingly integrate virtual components into the competition. These will also be used more and more in the future. The FSG Academy's online events have provided a way for students around the world to participate in knowledge transfer this year. The response has been great.

But let me emphasize, the DNA of the Formula Student Community is the physical meeting on site, the competition at the events around the globe, the exchange between students and experts from the industry. FSG is committed to continuing to shape this in the future.

For me, every year at FSG, it's "Welcome to the future".
Für mich heißt es jedes Jahr bei der FSG „Willkommen in der Zukunft".

Ludwig, wo geht aus deiner Sicht die Reise für die FSG hin?
Von Beginn an war und ist die Automobilindustrie durch steten Wandel geprägt. Die Herausforderungen in der jetzigen Zeit sind hoch. Neuartige Fahrzeug- und Mobilitätskonzepte werden mit Hochdruck entwickelt und zur Marktreife gebracht.

Dabei findet die Fahrzeugentwicklung und -produktion nunmehr vollständig im internationalen Kontext statt - künftige Mobilitätskonzepte fordern neue Partnerschaften außerhalb der klassischen Automobilindustrie. Dies spiegelt sich auch in unserem Wettbewerb wider. Nicht ohne Grund legen wir mit unserem „World Council Meeting" auf dem Hockenheimring Wert darauf, dass sich die Wettbewerbe untereinander austauschen, gemeinsame Probleme ansprechen und Ideen zur Zusammenarbeit entwickeln.

Für mich heißt es jedes Jahr bei der FSG „Willkommen in der Zukunft". Bei der Formula Student Germany versammeln sich die Ingenieure und Innovatoren der Zukunft. Die FSG geht mit dem Technologiefortschritt mit und stellt die Studenten zwar vor Herausforderungen, gibt ihnen aber zugleich das nötige „Rüst- und Werkzeug" für die Zukunft mit.

Welchen Einfluss hat(te) Corona auf die Entwicklung der Formula Student?
Die Pandemie hat die Notwendigkeit aufgezeigt, verstärkt auch virtuelle Komponenten in den Wettbewerb zu integrieren. Diese werden auch in Zukunft mehr und mehr zum Einsatz kommen. Die Online Veranstaltungen der FSG Academy haben einen Weg aufgezeigt über den in diesem Jahr weltweit Studierende an dem Wissenstransfer teilnehmen konnten. Die Resonanz ist großartig.

Doch ich darf betonen, die DNA der Formula Student Community ist das physische Treffen vor Ort, der Wettbewerb auf den Events rund um den Globus, der Austausch von Studierenden und Experten aus der Industrie. Die FSG hat sich dem Ziel verschrieben, dies auch künftig weiterhin zu gestalten.

Steffen Hemer

Responsible for Formula Student Driverless since 2015

Verantwortlich für die Formula Student Driverless seit 2015

Steffen, what makes Formula Student Germany special for you?
From my point of view, Formula Student is not directly about becoming an expert in a field - even though you can certainly gain a lot of practical knowledge in a field by participating. In the end, the main focus is still the big, challenging, non-artificial overall project with everything that goes with it and its realization. This is exactly what promotes teamwork, understanding for all subteams, seeing interconnections, and practicing project management.

What hurdles have you seen so far in the Driverless area and what areas are changing as a result of FSG's realignment towards merging the Electric and Driverless classes?
So far, it is still the case that old vehicles are approved and converting them. While this has made sense as a way of getting to grips with the issue, it has also meant that many teams have had to deal with completely different construction sites than those they actually wanted to deal with. This should be optimized in the future by merging the classes.
In addition, the know-how and support in the industry were still being built up. However, at the same time, this offers the teams the opportunity to participate in the topic from the very beginning and to gain a foothold with their growing expertise.

Especially the area of simulation will become much more complex in the future. For example, the DV topic now adds a whole environmental simulation including sensor simulation in real time, in which the control software (as part or completely) controls the virtual vehicle. Of course, this poses new challenges for some teams. However, we are committed to supporting the teams here, e.g. through the Academy. Finally, it is impressive how the exchange among the DV teams is going. We can observe that the teams have independently formed communities to exchange information on specific topics and help each other out. ARWo (Autonomous Racing Workshop), FSOCO (Formula Student Objects in Context), FS SIM (Formula Student Simulator) are just examples, and all came into being without any intervention.

In summary, from my point of view, we have found a good compromise between further integration of the driverless class and at the same time training students for the new challenges. I am optimistic that the DV Cup will continue to provide a showcase of the top results in the development of DV solutions. At the end of the day, every DV department, whether in FS or industry, probably faces similar challenges.

Especially the area of simulation will become much more complex in the future.

Besonders der Bereich Simulation wird in Zukunft deutlich komplexer.

Steffen, was macht die Formula Student Germany für Dich aus?
Aus meiner Sicht geht es bei der Formula Student nicht direkt darum, Experte in einem Fachgebiet zu werden – auch, wenn man durch die Teilnahme sicher sehr viel praktisches Wissen in einem Bereich erlangen kann. Letztendlich ist der Hauptfokus immer noch das große, herausfordernde, nichtkünstlich-aufgesetzte Gesamtprojekt mit allem was dazu gehört und dessen Umsetzung. Genau das fördert Teamwork, Verständnis für die anderen Bereiche, Schnittstellen- und Projektmanagement.

Welche Hürden hast Du bisher im Bereich Driverless gesehen und welche Bereiche verändern sich durch die Neuausrichtung der FSG hin zur Zusammenführung der Electric- und Driverless-Klasse?
Bisher ist es noch so, dass Altfahrzeuge zugelassen sind und die Möglichkeit besteht, diese umzubauen. Das ist zwar zum Herantasten an die Thematik sinnvoll gewesen, hat aber auch dazu geführt, dass sich viele Teams um ganz andere Baustellen kümmern mussten als um jene, mit welchen sie sich eigentlich beschäftigen wollten. Dies soll durch die Zusammenführung in Zukunft optimiert werden.
Hinzu kommt, dass auch das Know-how und der Support in der Industrie bisher noch im Aufbau waren. Jedoch bietet dies den Teams gleichzeitig die Möglichkeit sich von Anfang an der Thematik zu beteiligen und mit ihrer wachsenden Expertise Fuß zu fassen.

Besonders der Bereich Simulation wird in Zukunft deutlich komplexer. Durch das DV-Thema kommt nun zum Beispiel auch eine ganze Umweltsimulation inklusive Sensorsimulation in Echtzeit, in der die Steuersoftware (als Teil oder komplett) das virtuelle Fahrzeug steuert, hinzu. Natürlich setzt dies einige Teams vor neue Herausforderungen. Wir sind jedoch bemüht, die Teams hier, z.B. durch die FSG Academy, zu unterstützen. Nicht zuletzt ist es beeindruckend, wie der Austausch bei den DV-Teams läuft. Wir können beobachten, dass sich die Teams selbständig in Communities zum Austausch zu speziellen Themen zusammengeschlossen haben und gegenseitig weiterhelfen. ARWo (Autonomous Racing Workshop), FSOCO (Formula Student Objects in Context), FS SIM (Formula Student Simulator) sind nur Beispiele und alle ohne Zutun entstanden.

Zusammenfassend, haben wir aus meiner Sicht einen guten Kompromiss zwischen der weiteren Integration von DV und gleichzeitig der Ausbildung der Studenten für die neuen Herausforderungen gefunden. Ich bin optimistisch, dass auch der DV-Cup weiterhin eine Präsentation der Top-Ergebnisse in der Entwicklung von DV-Lösungen bieten wird. Letzten Endes steht vermutlich jede DV-Abteilung, ob in der FS oder in der Industrie, vor ähnlichen Herausforderungen.

This year the FSG event is different from what we are used to it – therefore we want to inform you via every possible digital channel. Stay tuned and have a look!

@FormulaStudentG
Twitter: Receive quick updates in abbreviated form.
https://fsg.one/tw

formulastudentgermany
Instagram: Get inspiration via picture and videos.
https://fsg.one/ig

@FSGeV
Facebook: Be informed daily by a brief summary of the highlights.
https://fsg.one/fb

formulastudenttv
Youtube Live-Stream:
The most important races will be broadcasted live.
▸ **Our tipp:** Do you already know our Youtube Playlist?
The best way to reminisce about previous highlights.
https://fsg.one/yt

live.formulastudent.de
Live Events: Look forward to FSG academy, virtual shows, Q&A sessions as well as sponsor events – the best way to experience the Formula Student spirit remotely.
https://live.formulastudent.de

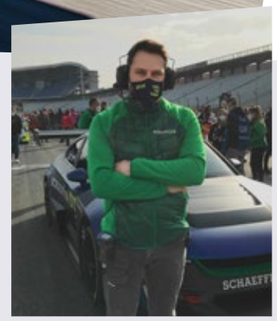
https://fsg.one/in

https://fsg.one/photos21

Pioneering achievement in motorsport

Christian Engelhardt (23) has been a big fan of motorsport since childhood. As a result, his desire for professional involvement in motorsport was already clear to him at an early stage.

With this goal in mind, he embarked on an integrated degree program in the Mechatronics department at Schaeffler in 2016. During his three-year course, he was able to gain practical experience in the "CURE Mannheim" Formula Student Team at DHBW Mannheim alongside the practical phases in the company. He has been working in the "Technical Development Motorsport" area at Schaeffler since October 2019.



Christian Engelhardt
Systems Engineer for electric drives at Schaeffler
Systemingenieur für elektrische Antriebe bei Schaeffler

Pionierleistung im Motorsport

Christian Engelhardt (23) ist schon seit seiner Kindheit ein großer Motorsportfan. Ihm war deshalb früh klar, dass er auch beruflich Kontakt mit dem Motorsport haben wollte. 2016 hat er deshalb sein duales Studium bei Schaeffler im Fachbereich Mechatronik begonnen. In seinem dreijährigen Studium konnte er neben den Praxisphasen im Betrieb auch Praxiserfahrung im Formula Student Team „CURE Mannheim" der DHBW Mannheim sammeln. Seit Oktober 2019 ist er bei Schaeffler im Bereich „Technische Entwicklung Motorsport" tätig.

What were your tasks within the team?
During my active participation in Formula Student, I was able to perform a wide variety of tasks. In the first year, I was responsible for the development of the high-voltage cabling in the vehicle, and subsequently developed the steering system for the next generation of vehicles. In my last season, I was responsible for all technical departments as Technical Project Manager.

What were the most challenging situations you faced during your active Formula Student participation?
As "CURE Mannheim" was only founded in 2016, we were unable to draw on completed vehicle developments from previous years. Therefore, for us as a team, participating in a Formula Student competition without any prior experience was a challenging event.
For me personally, technical project management presented the biggest challenges. Managing the requirements of all team members while simultaneously developing technically sound solutions, remaining flexible, and still keeping to the schedule, was not always an easy task.

What do you currently do at Schaeffler?
I work as a systems engineer for electric drives in the area of "Technical Development Motorsport". In this role, I am responsible for the development of electric powertrains in motorsport, including their testing and integration in the respective vehicles.

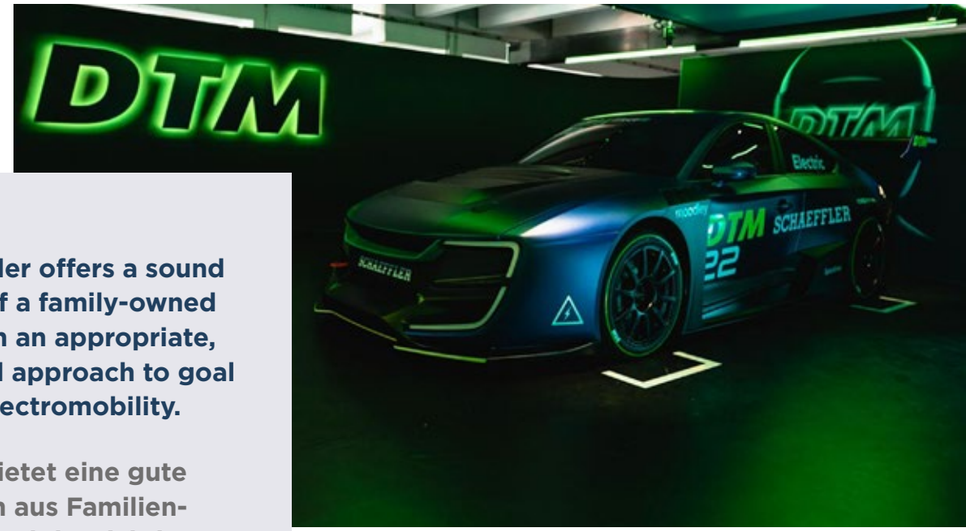
Can you tell us anything about your last major project?
Most recently, I was project supervisor for the DTM Electric Democar, which was introduced in fall 2020 as part of the DTM season finale. My tasks included coordinating all vehicle construction tasks, technical development, and subsequent vehicle testing, as well as project management.

Welche Aufgaben hattest du im Team?
Während meiner aktiven Zeit bei der Formula Student konnte ich verschiedenste Aufgaben ausführen. Im ersten Fahrzeugjahr war ich für die Entwicklung der Hochvoltverkabelung im Fahrzeug zuständig, im Anschluss habe ich für die nächste Fahrzeuggeneration das Lenksystem entwickelt. In meiner letzten Saison war ich als technische Projektleitung für alle technischen Fachbereiche verantwortlich.

Was waren die herausforderndsten Situationen während deiner aktiven Zeit bei der Formula Student?
Da „CURE Mannheim" erst 2016 gegründet wurde, konnten wir auf keine fertigen Entwicklungen von Vorjahresfahrzeugen zurückgreifen. Für uns als Team war es deshalb herausfordernd ohne Vorerfahrungen an einem Formula Student Wettbewerb teilzunehmen.
Für mich persönlich gingen die größten Herausforderungen mit der technischen Projektleitung einher. Die Bedürfnisse aller Teammitglieder zusammenzubringen und zeitgleich technisch gute Lösungen zu erarbeiten, flexibel zu sein und dennoch den Zeitplan einzuhalten war teilweise nicht immer einfach.

Was machst du aktuell bei Schaeffler?
Ich bin als Systemingenieur für elektrische Antriebe im Bereich „Technische Entwicklung Motorsport" tätig. Hier bin ich für die Entwicklung elektrischer Antriebsstränge im Motorsport verantwortlich. Dazu zählt auch deren Erprobung und Integration in die jeweiligen Fahrzeuge.

Kannst du etwas über dein letztes großes Projekt erzählen?
Zuletzt war ich Projektverantwortlicher für das DTM Electric Democar, welches im Herbst 2020 im Rahmen des DTM-Saisonfinales vorgestellt wurde. Zu meinen Aufgaben



"Schaeffler offers a sound combination of a family-owned enterprise with an appropriate, market-oriented approach to goal setting in electromobility."

Schaeffler bietet eine gute Kombination aus Familienunternehmen und der richtigen, marktorientierten Zielsetzung hin zur Elektromobilität."

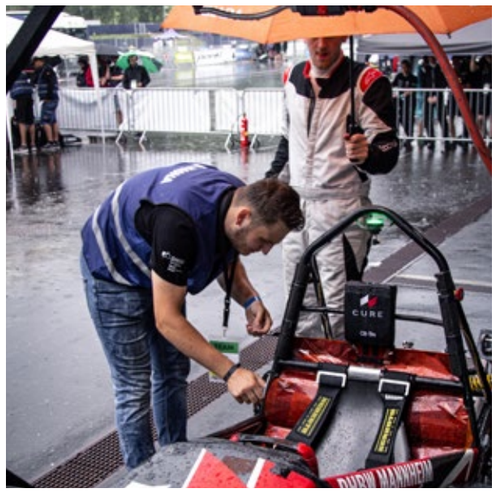
What experiences from your Formula Student participation can you incorporate into your working life?
During my time with "CURE Mannheim", I acquired a great deal of technical expertise, which I can apply repeatedly in everyday professional life. In addition, Formula Student gave me the opportunity to develop my personal skills and gain practical experience. The role of Technical Project Manager, in particular, enabled me to achieve continuous gains, not only in my capacity for teamwork and in terms of self-confidence, but also in my inherent flexibility and resilience, which has prepared me optimally for my current role at Schaeffler.

In your view, what makes Schaeffler an attractive employer?
Schaeffler offers a sound combination of a family-owned enterprise with an appropriate, market-oriented approach to goal setting in electromobility. The high level of commitment to motorsport also makes Schaeffler a particularly attractive employer in my view. For me, technical developments for various racing series are not the sole key players here, but also topics such as diversity in motorsport.

zählten unter anderem die Koordination aller Aufgaben im Fahrzeugaufbau, die technische Entwicklung und anschließende Fahrzeugerprobung, sowie das Projektmanagement.

Welche Erfahrungen kannst du aus deiner Teilnahme bei der Formula Student in deinem Arbeitsleben integrieren?
Durch meine Zeit bei „CURE Mannheim" konnte ich mir sehr viel technisches Fachwissen aneignen, welches ich in meinem beruflichen Alltag immer wieder einsetzen kann. Zudem hatte ich durch die Formula Student die Möglichkeit, mich persönlich weiterzuentwickeln und Praxiserfahrungen zu sammeln. Vor allem durch die Position als technische Projektleitung konnte ich meine Teamfähigkeit, mein Selbstbewusstsein aber auch die eigene Flexibilität und Belastbarkeit kontinuierlich stärken, was mich sehr gut auf meine aktuelle Position bei Schaeffler vorbereitet hat.

Was macht Schaeffler für dich zu einem attraktiven Arbeitgeber?
Schaeffler bietet eine gute Kombination aus Familienunternehmen und der richtigen, marktorientierten Zielsetzung hin zur Elektromobilität. Auch das hohe Engagement im Motorsport macht Schaeffler für mich zu einem besonders attraktiven Arbeitgeber. Nicht nur die technischen Entwicklungen für verschiedene Rennserien, sondern auch Themen wie Diversität im Motorsport spielen für mich eine große Rolle.



Learn more about this project!

Pioneer's Journey: The DTM Electric's way to its world premiere in Hockenheim

Lerne mehr über das Projekt!

Pioneer's Journey: Der Weg des DTM Elektro-Rennwagens zu seiner Weltpremiere in Hockenheim.

https://youtu.be/mQ5UGFexF5A

Awards 2021

Results:

http://fsg.one/results

	Formula Student	Combustion	Electric	Driverless
OVERALL	1st Place Overall	SAT	SAT	SAT
	2nd Place Overall	SAT	SAT	SAT
	3rd Place Overall	SAT	SAT	SAT
DYNAMICS	Acceleration Winner	FRI	FRI	FRI
	Autocross Winner	FRI	FRI	FRI
	Endurance Winner	SAT	SAT	–
	Skid Pad Winner	FRI	FRI	FRI
	TrackDrive Winner	–	–	FRI
	Most Fuel/Energy Efficient Car	SAT	SAT	FRI
STATICS	Business Plan Winner	FRI	FRI	FRI
	Cost and Manufacturing Winner	FRI	FRI	FRI
	Engineering Design Winner	FRI	FRI	FRI
SPECIAL AWARDS	FSD Daimler AI Autonomous	–	–	FRI
	FSG Siemens Digital Twin Engineering Excellence Award		FRI	

STATUS/STAND: 26.07.2021

Schedule 2021

https://today.formulastudent.de

Mon, 9th of August

13:00	C D E	Technical Inspection-, Registration- & Entrance Order Available	V	Website

Wed, 11th of August

19:00 - 20:00	C D E	Team Welcome	V	Live Stream

Thu, 12th of August

08:15 - 17:05	D E	Cost Analysis, Engineering Design	V	Virtual
09:30 - 14:30	C	Business Plan Presentation	V	Virtual
16:15	C	Announcement of Business Plan Finalists	V	Website
17:00 - 18:00	C	Business Plan Presentation Finals	V	Live Stream
18:30	D E	Announcement of Cost & Design Finalists	V	Website
19:00 - 19:30	D E	Cost Finals	V	Virtual
19:30 - 21:30	D E	Engineering Design Finals (not public)	V	Virtual

Fri, 13th of August

08:15 - 13:45	C	Cost Analysis, Engineering Design	V	Virtual
09:30 - 16:30	D E	Business Plan Presentation	V	Virtual
15:45	C	Announcement of Cost & Design Finalists	V	Website
16:15 - 16:45	C	Cost Finals	V	Virtual
16:45 - 18:45	C	Engineering Design Finals (not public)	V	Virtual
18:15	D E	Announcement of Business Plan Finalists	V	Website
19:00 - 20:00	D E	Business Plan Presentation Finals	V	Live Stream

Mon, 16th of August

08:00 - 08:30	D	Registration + Entrance for 20 Teams	11+8	South Stand, Pits
08:30 - 23:59	C D E	Pits available	8	Pits
10:00 - 10:30	E	Registration + Entrance for 19 Teams	11+8	South Stand, Pits
11:00 - 19:30	D E	Accumulator Inspection	8	Pits
11:00 - 19:30	D E	Mechanical Inspection	8	Pits
12:00 - 22:00	D E	Accumulator Workshop available	2	Inspection Building
14:00 - 14:30	E	Registration + Entrance for 19 Teams	11+8	South Stand, Pits
16:00 - 16:30	C	Registration for 22 Teams	11+8	South Stand, Pits
16:00 - 21:00	C	Entrance for 22 Teams	8	Pits
21:30 - 22:00	C D E	FSG Daily Live Show	V	Live Stream

Tue, 17th of August

06:00 - 23:59	C D E	Pits available	8	Pits
08:00 - 18:00	C D E	Welding Station	8	Welding Station
08:00 - 20:00		Supervised Antigen Testing - see personal schedule	8	Pits
08:00 - 22:00	D E	Accumulator Workshop available	2	Inspection Building
08:30 - 19:00	C D E	Event Control	V	Helpdesk@
08:45 - 19:00	C D E	Technical Inspections (A, D, E, M & P), Tilt, Rain, Noise, Brake	3+8	Dynamic Area, Pits
09:00 - 19:00	D	Emergency Brake System (EBS) Test	3	Dynamic Area
13:00 - 19:00	C	Engine Test *	3	Dynamic Area
21:30 - 22:00	C D E	FSG Daily Live Show	V	Live Stream

Wed, 18th of August

06:00 - 23:59	C D E	Pits available	8	Pits
08:00 - 18:00	C D E	Welding Station	8	Welding Station
08:00 - 20:00		Supervised Antigen Testing - see personal schedule	8	Pits
08:00 - 22:00	D E	Accumulator Workshop available	2	Inspection Building
08:30 - 19:00	C D E	Event Control	V	Helpdesk@
08:30 - 19:00	C D E	Practice Track / Engine Test	3	Dynamic Area
08:45 - 18:30	C D E	Technical Inspections (A, D, E, M & P), Tilt, Rain, Noise, Brake	3+8	Dynamic Area, Pits
09:00 - 18:00	C D E	FSG Academy	V	Virtual
09:00 - 19:00	D	Emergency Brake System (EBS) Test	3	Dynamic Area
21:30 - 22:00	C D E	FSG Daily Live Show	V	Live Stream
22:00 - 22:30	C D E	Team Briefing	V	Live Stream

Thu, 19th of August

06:00 - 23:59	C D E	Pits available	8	Pits
08:00 - 18:00	C D E	Welding Station	8	Welding Station
08:00 - 19:00	C D E	Event Control	V	Helpdesk@
08:00 - 20:00		Supervised Antigen Testing - see personal schedule	8	Pits
08:00 - 22:00	D E	Accumulator Workshop available	2	Inspection Building
08:30 - 12:30	C D	Practice Track	3	Dynamic Area
08:30 - 12:30	C E	Skid Pad	3	Dynamic Area
08:30 - 19:00	C D E	Practice Track / Engine Test	15	North Stand
08:45 - 18:30	C D E	Technical Inspections (A, D, E, M & P), Tilt, Rain, Noise, Brake	3+8	Dynamic Area, Pits
09:00 - 12:00	D	Acceleration	12	Start/Finish Line
09:00 - 18:00	C D E	FSG Academy	V	Virtual
09:00 - 19:00	D	Emergency Brake System (EBS) Test *	15	North Stand
13:00 - 15:30	D	Skid Pad	3	Dynamic Area
13:15 - 16:30	C E	Acceleration	12	Start/Finish Line
16:00 - 16:25	D	Autocross Course Walk	3	Dynamic Area
16:30 - 19:30	D	Autocross	3	Dynamic Area
21:30 - 22:00	C D E	FSG Daily Live Show	V	Live Stream
22:00 - 22:30	C D E	Team Briefing	V	Live Stream

* on request

Schedule 2021

Fri, 20th of August

06:00 - 23:59	C D E Pits available	8	Pits
08:00 - 18:00	C D E Welding Station	8	Welding Station
08:00 - 19:00	C D E Event Control	v	Helpdesk@
08:00 - 20:00	Supervised Antigen Testing - see personal schedule	8	Pits
08:00 - 22:00	D E Accumulator Workshop available	2	Inspection Building
08:30 - 12:30	D Trackdrive	3	Dynamic Area
08:30 - 19:00	C D E Practice Track / Engine Test	15	North Stand
08:45 - 18:30	C D E Technical Inspections (A, D, E, M & P), Tilt, Rain, Noise, Brake *	3+8	Dynamic Area, Pits
09:00 - 18:00	C D E FSG Academy	v	Virtual
13:45 - 14:15	C E Autocross Course Walk	3	Dynamic Area
14:30 - 18:30	C E Autocross	3	Dynamic Area
20:00 - 21:30	C D E Awards Ceremony - Part I	15+v	North Stand, Live Stream
21:30 - 22:00	C D E Team Briefing	15+v	North Stand, Live Stream

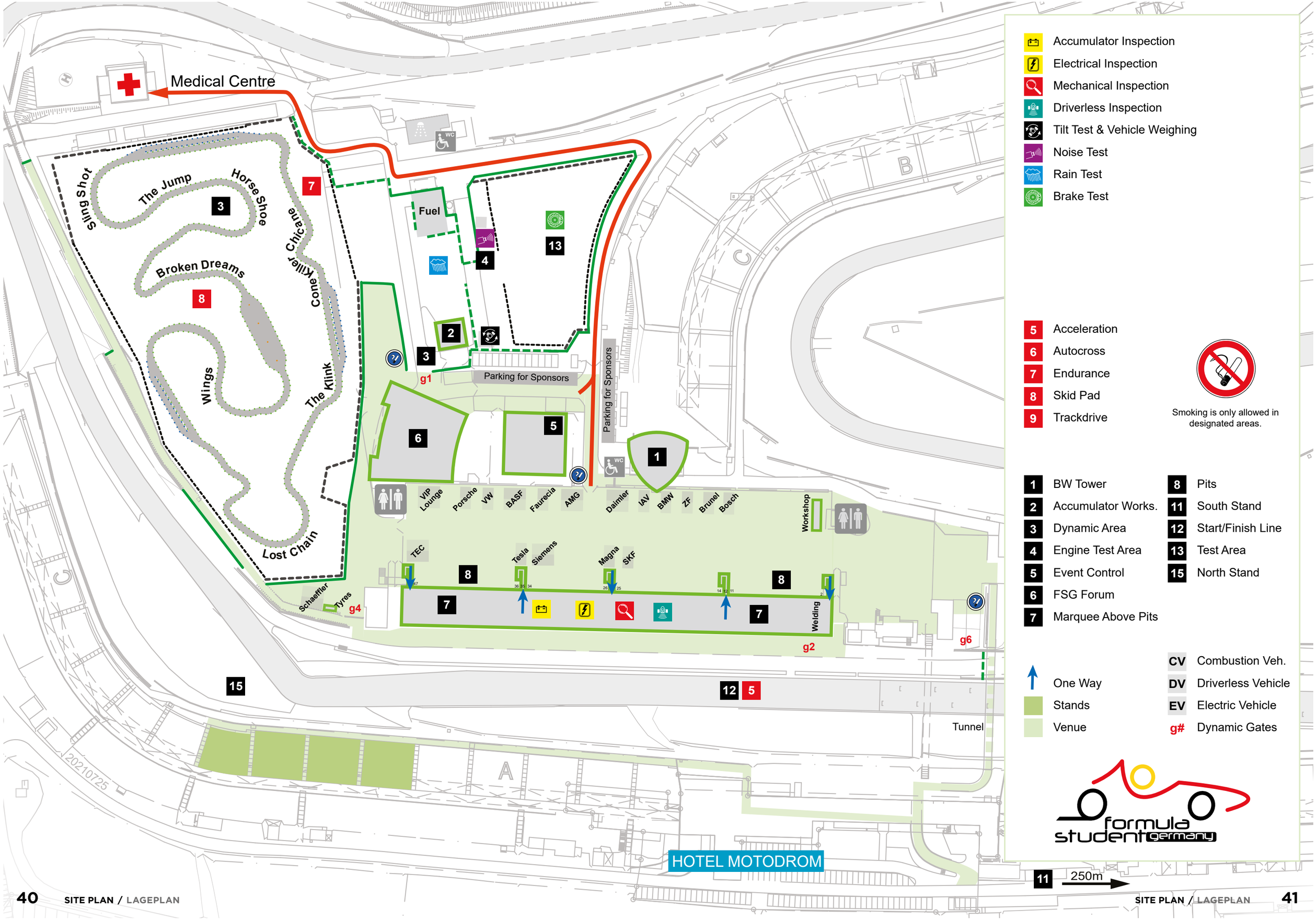
Sat, 21th of August

06:00 - 15:00	C D E Pits available	8	Pits
07:45 - 08:15	C E Endurance Course Walk	3	Dynamic Area
08:00 - 12:00	C E Practice Track / Engine Test	3	Dynamic Area
08:00 - 14:00	D E Accumulator Workshop available	2	Inspection Building
08:00 - 15:00	C D E Dismantling of Pits	8	Pits
08:00 - 19:00	C D E Event Control	v	Helpdesk@
08:30 - 14:30	C E Endurance	3	Dynamic Area
21:00 - 22:00	C D E Awards Ceremony - Part II	15+v	North Stand, Live Stream

Abbreviations
CV - Internal Combustion Engine Vehicle, DV - Driverless Vehicle, EV - Electric Vehicle
Technical Inspections (A, D, E, M & P): Accumulator-, Driverless-, Electrical- Mechanical- & Pre-Inspection

* on request

STATUS/STAND: 22.07.2021


Medical Centre
Sling Shot
The Jump
Horse Shoe
Chicane
Killer Cone
Broken Dreams
Wings
The Klink
Lost Chain
Fuel
Parking for Sponsors
Parking for Sponsors
VIP Lounge
Porsche
VW
BASF
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Accumulator Inspection
Electrical Inspection
Mechanical Inspection
Driverless Inspection
Tilt Test & Vehicle Weighing
Noise Test
Rain Test
Brake Test
5 Acceleration
6 Autocross
7 Endurance
8 Skid Pad
9 Trackdrive
Smoking is only allowed in designated areas.
1 BW Tower
2 Accumulator Works.
3 Dynamic Area
4 Engine Test Area
5 Event Control
6 FSG Forum
7 Marquee Above Pits
8 Pits
11 South Stand
12 Start/Finish Line
13 Test Area
15 North Stand
One Way
Stands
Venue
CV Combustion Veh.
DV Driverless Vehicle
EV Electric Vehicle
g# Dynamic Gates
formula student germany
250m

The Volunteers of FSG

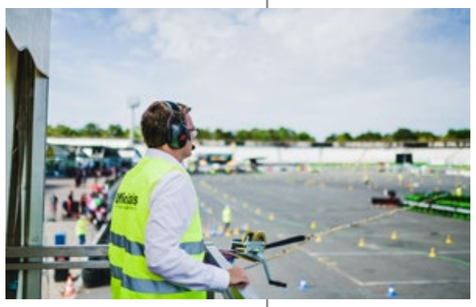
Die Ehrenamtlichen der FSG

It takes around 450 volunteers to bring Formula Student Germany to life every year. The team of volunteer's function like a well-oiled machine, tackling the ever-growing challenges of the annual event with honed skill and passionate dedication. The volunteers are divided into different groups according to their skill set.

For example, there are the scrutineers, the judges, the red shirts and the white shirts. These are people who handle the many tasks of planning, organising and running the event, as well as helping out and answering questions. The colour of their shirt will tell you what their role is at FSG.

Über 450 ehrenamtliche Helfer sind Jahr für Jahr an der Organisation und der Umsetzung der Formula Student Germany beteiligt. Wie eine gut geölte Maschine meistern sie mit Leidenschaft und Engagement die stetig wachsenden Herausforderungen, die das Event jedes Jahr aufs Neue mit sich bringt. Das eingespielte Team setzt sich aus verschiedenen Funktionsbereichen zusammen.

So gibt es beispielsweise die Scrutineers, die Juroren, die Red-Shirts und die White-Shirts, welche die Vielzahl an Aufgaben beim Planen, Organisieren und bei der Umsetzung vor Ort bewältigen und welche stets für Fragen rund um das Event zur Verfügung stehen. Anhand der Farbe ihres Shirts kann man leicht ihre Rolle bei der FSG erkennen.



white shirts

The **white shirts** are in charge of the yearlong task of planning the event and of ensuring that everything falls into place as it should on race day. They are the “go-to” people for sponsors, press, participants and visitors and they ensure that the competition runs without a hitch.

Die **White-Shirts** sind für die ganzjährige Planung der Veranstaltung und deren reibungslose Umsetzung an den Renntagen verantwortlich. Sie sind Ansprechpartner für Sponsoren, Medienvertreter, Teilnehmer und Besucher und stellen sicher, dass der Wettbewerb ohne Komplikationen verläuft.

red shirts

The **red shirts** have jurisdiction over event control and event support. The support team takes care of building up and taking down of every physical transformation that turns the Hockenheim Ring into Formula Student Germany. We need them to ensure that the event runs smoothly. They also act as the track marshals during dynamic events.

Furthermore, they are in charge of the event control team, serving as intermediaries between visitors, team members, sponsors and press, so that nobody on the FSG grounds can get left lost or stranded. The **red shirts** are the largest group of volunteers at FSG and are the ones who will do what it takes to overcome any challenges that might be faced during the event.

Die **Red-Shirts** sind für die Bereiche „Event Control“ und „Event Support“ zuständig. Das Support-Team kümmert sich um den Auf- und Abbau aller infrastrukturellen Bestandteile, die den Hockenheimring in die Formula Student Germany verwandeln. Sie sind die fleißigen Helfer, welche sicherstellen, dass das Event ohne Störungen verläuft. Darüber hinaus kommen die ehrenamtlichen Helfer als Streckenposten während der dynamischen Disziplinen zum Einsatz.

Zudem besetzen sie das Event Control-Team und bilden damit die Schnittstelle zwischen Besuchern, Teammitgliedern, Sponsoren und Medienvertretern. Sie sorgen dafür, dass niemand hilflos auf dem Gelände zurückbleibt. Die **Red-Shirts** stellen insgesamt die größte Gruppe ehrenamtlicher Helfer bei der FSG dar. Nur durch ihre Hilfe ist es überhaupt möglich, die vielseitigen und mitunter spontanen Herausforderungen während des Events zu meistern.

blue shirts

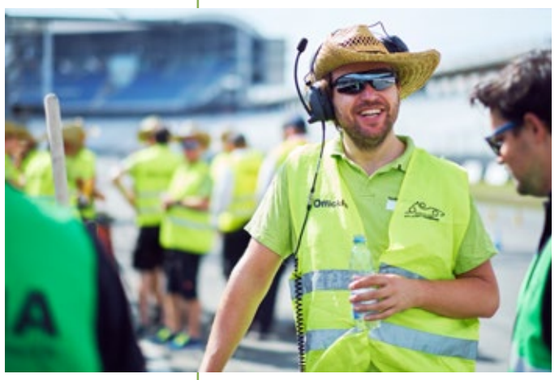
Since FSG is essentially a design competition, a team’s scoring in the static disciplines is a big factor in its overall standing. It is the job of the judges in their blue shirts to render these scorings. They look at the design, manufacturing quality and cost planning; they consider the economics of the project and whether the business plan is convincing. For this, they utilize their professional expertise, indispensable honesty and constructive criticism. Their feedback has resulted in the extensive improvements from the teams over the past years.

Da es sich bei der FSG im Wesentlichen um einen Konstruktionswettbewerb handelt, tragen die statischen Disziplinen in erheblichem Maße zur Gesamtwertung bei. Die in **blau gekleideten Juroren** bewerten die Entwicklung, Fertigungsgüte sowie das Kostenbewusstsein der Studenten. Sie betrachten die Wirtschaftlichkeit des Gesamtprojektes ebenso wie die Präsentation der detaillierten Geschäftspläne und nutzen dabei ihre Expertise und unvergleichlich ehrlich sowie konstruktive Kritik, welche bereits in vergangenen Jahren positiv zur Weiterentwicklung der Studenten beigetragen hat.

scrutineers

The **scrutineers** – the folks in **green** – are there to guarantee that all the vehicles are safe. They accomplish this by meticulously checking the cars for potential safety hazards and patiently assisting the teams with any technical problems (at the event as well as throughout the year). A team may not participate in the dynamic events with – out receiving the go-ahead from our **green shirted** volunteers.

Die **Scrutineers** – die „Leute in **Grün**“ – stellen die Sicherheit aller teilnehmenden Fahrzeuge sicher. Sie überprüfen die Boliden der Teilnehmer akribisch genau auf etwaige Sicherheitsmängel und stehen den Teams bei technischen Problemen mit ihrer Expertise helfend zur Seite (sowohl am Event selbst, wie auch während des Jahres). Als Team darf man ohne die Freigabe unserer **grün gekleideten** Helfer nicht an den dynamischen Disziplinen teilnehmen.



IT experts

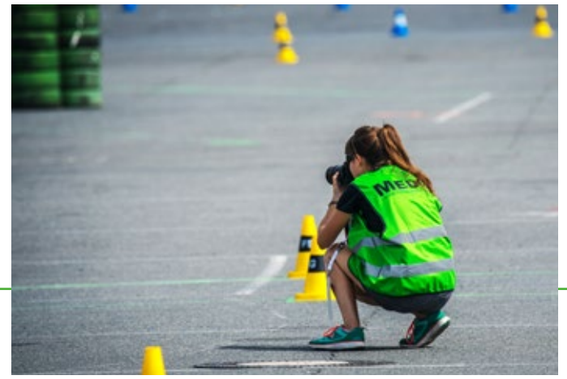
Behind the scenes we have the **IT experts**, who are tasked with timekeeping during the dynamic disciples as well as ensuring that all teams are given a fair and equal assessment. Not only this, but it is thanks to them that everyone at FSG can enjoy a high-speed Internet connection through – out the entire event site!

Ebenfalls oft im Verborgenen arbeiten unsere in schwarz gekleideten **IT Spezialisten**, welche für die Zeitnahme bei den dynamischen Disziplinen verantwortlich sind und sicherstellen, dass jedes Team eine faire und gerechte Bewertung erhält. Doch nicht nur das: Dank ihnen steht allen Anwesenden bei FSG über das gesamte Eventgelände eine Highspeed-Internet-Verbindung zur Verfügung!

media

Finally, we have the FSG **media team**, whose contributions through their video and image materials of exceptional quality and creativity, allow us to relive the most stunning and unforgettable moments of the event again and again, long af - ter the smoke from the tires of the race cars has cleared.

Zu guter Letzt leistet das ebenfalls in **schwarz gekleidete Media-Team** in Form von Videos und Bildern seinen Beitrag, und sorgt mit beeindruckender Kreativität und Qualität dafür, dass wir die schönsten und unvergesslichsten Momente des Events auch lange nachdem sich der letzte Rauch qualmender Reifen verzogen hat, noch einmal durchleben können.



After the two year long break, it is finally possible and a great pleasure for us to spread the incomparable FSG enthusiasm to all participants again. We are happy to be at your service with advice and assistance at this year's event!

Nach zwei Jahren Pause ist es uns endlich wieder möglich und ein großes Vergnügen die unvergleichbare FSG Begeisterung an alle Beteiligten weiterzugeben. Wir freuen uns, allen Teilnehmern und Partnern auch in diesem Jahr wieder mit Rat und Tat zur Seite zu stehen.

Formula Student Germany Team 2021

TIM HANNIG
Board (FSG e.V. Chairman)

DANIEL MAZUR
Board (GmbH Managing Director)

PHILIPP BANDOW
EC (Digital Officer)

STEFFEN HEMER
EC (FS-Driverless)

JOHANNES KRATZEL
EC (Event Support)

DR. JOCHEN SCHMIDT
EC (Dynamics)

DR. CHRISTIAN AMERSBACH
OT (FS-Driverless)

KONRAD BAYER
OT (Event Support)

RAPHAELA BIHR
OT (Business Plan Presentation)

MATTHIAS BRUTSCHIN
OT (Security & Event Support)

BARBARA DECKER-SCHLÖGL
OT (Event Support)

RAINER KÖTKE
Board (FSG e.V. Finance)

DR. LUDWIG VOLLRATH
Board (FSG External Relations)

SIMON DENSBORN
EC (Technical Inspection)

SEBASTIAN HOPPE
EC (Statics) & OT (Cost Event)

CATHARINA SCHIFFTER
EC (Communications & Media)

DR. SEBASTIAN SEEWALDT
EC (Rules)

SARAH BATTIGE
OT (Electrical Inspection)

CHRISTOPH BEISSWANGER
OT (Mechanical Inspection)

DANIEL BRONTSCH
OT (Cost Event)

MATTHÄUS DECKER
OT (Event Support)

MATHIAS GEBHARDT
OT (Electrical Inspection)

NICOLE GEIER
OT (Registration & Ticket Centre)

HINRICH GREFE
OT (Event Support)

JUDITH HENZEL
OT (Special Awards)

JENS KEGELMANN
OT (Business Plan Presentation)

ANKE LACHMANN
OT (VIP Lounge & Culina)

ANN-CATRIN LESCHNIEWSKI
OT (Event Control)

JOE MARTIN
OT (Design Event)

JOST PHILIP PÖTTNER
OT (Design Event)

YANNIC SCHRÖDER
OT (Timekeeping)

MARTIN STOLLBERGER
OT (Driverless Inspection)

ESTHER TROMP
OT (Event Management)

LEA VAUDLET
OT (Event Control)

ROBERT WEINGART
OT (Design Event)

DR. BJÖRN GERNERT
OT (IT)

SVEN GRUNDNER
OT (Back Office)

TANJA HOFMANN
OT (Security)

STEPHAN KRÜGER
OT (Pit Marshal)

PETER LEIPOLD
OT (Design Event)

FABIAN LIESCH
OT (IT & TK)

STIG MEJLBJERG
OT (Dynamics)

TORSTEN RILKA
OT (Scoring)

THERESA STACH
OT (Communications)

JENNIFER STRATMANN
OT (Communications)

JET TUITERT
OT (Mechanical Inspection)

PHILIPP VAUDLET
OT (Pit Marshal)

Judges

2021

Autonomous Design & Engineering Design

ALAKSHENDRA, Veer / **BREINLINGER**, Philipp / **BREMKAMP**, Joerg / **CZERWIONKA**, Paul / **D'HAEN**, Jonas / **DANGEL**, Manuel / **DECHIPRE**, Herve / **DECKERS**, Jean-Noel / **DENCKER**, Peter / **DENNY**, Michael / **DÖLLE**, Norbert / **ENDER**, Stefan / **EVANS**, David / **FISCHER**, Florian / **FLEMMING**, Erik / **FREITAG**, Christoph / **FRIES**, Benedikt / **GARDUNO**, Luis / **GIRARD**, Ian / **GOY**, Florian / **GREHN**, Alexander / **GREHN**, Alexander / **GUGENHEIMER**, Anton / **HALSDORF**, Georges / **HANIGK**, Martin / **HAUSER**, Mirko / **HERRMANN**, Sven Frieder / **HO**, Victor / **KALANKE**, Philipp / **KAUSSEN**, Martin / **KOHNS**, Lukas / **KÖNIG**, Thomas / **KRAUS**, Mike / **LIEBST**, Fabian / **LUSTIG**, Frank / **MATA**, Núria / **MENNENGA**, Björn / **MISSLER**, Christian / **MUR**, Lukas / **NOWICKI**, Daniel / **PADBERG**, Jochen / **PAWLITZKI**, Benz / **PHERSSON**, Luke / **PIRES**, Andrew / **PLAKHOTNICHENKO**, Andrei / **RAIHAN**, Dinar / **REZSNYAK**, Tamas / **RICHTER**, Alexander / **RUHDORFER**, Benedikt / **SAITO**, Takuya / **SAYOVITZ**, Steve / **SCHÖNBERG**, Christopher / **SERNÉ**, Ton / **STABROTH**, Waldemar / **STELZIG**, Michael / **STEPAN**, Sven / **TORGOVNIKOV**, Eugen / **TUEZKOE**, Andras / **VELA**, Nicolas / **WEBER**, Martin / **WILD**, Felix / **WITTWER**, Konrad-Fabian / **WÖHLER**, Konrad / **WUNSCHHEIM**, Lukas / **ZEISLER**, Jöran / **ZÖLS**, Thomas

Business Plan Presentation

AHR, Florian / **BACHLER**, Sophie / **BÖKER**, Bennet / **EICKHOFF**, Mathias / **FAHR**, Alexander / **FERKEN**, Reiner / **GREINER**, Alexander / **HAHN**, Thomas / **HERRMANN**, Jesko / **HERZHAUSER**, Erik / **HODGKINSON**, Philip / **HODGKINSON**, Raymond / **JACOB**, Carsten / **KEIM**, Sandra / **KINSKI**, Andreas / **LANGE**, Stephan / **LENZEN**, Thomas / **MAYER**, Fabian / **RAHNER**, Yannick / **REICHELT**, Carolin / **RICHTER**, Svenja / **SCHIFFTER**, Catharina / **SCHMIDLECHNER**, Matthias / **SCHNEIDER**, Tom / **SCHOLZ**, Thomas / **THELEMANN**, Corbinian / **TONI**, Flávio / **TRÜBSWETTER**, Ilona / **VADEHRA**, Bernhard Prem / **WEINELT**, Dieter

Cost and Manufacturing

GRUNDNER, Harald / **JIA**, Jin / **KASPER**, Dominik / **KÜHNE**, Alexander / **LEHR**, Mario / **LUNDBERG**, Alexander / **MEIER**, Peter / **METZGER**, Tobias / **NEUMANN**, Bernd / **OTTAVIANO**, Melissa / **PUSIC**, Zvonimir / **RÖSKE**, Frank / **SCHLEPPI**, Roman / **STRAUBERT**, Alexander / **WOLPERT**, Sven

Redshirts and Scrutineers 2021

Redshirts

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Scrutineers

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Communications & Media, Timekeeping & IT 2021

Communications & Media

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Timekeeping & IT

GARLICHS, Keno / **GERNERT**, Björn / **HAUFFE**, Björn / **LIESCH,** Fabian / **REIMERS**, Dennis / **SCHLICHTER**, Jan / **SCHRÖDER**, Yannic / **STAMPRATH**, Christoph / **TIMMERMANS**, Tristan / **VAN BALEN**, Johannes / **VAN LEEUWEN**, Tom

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* if without reference; excluding team profiles

Team profiles
Text and pictures provided by the teams (July 2021)

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Words from our Partners

BMW MINI ROLLS-ROYCE MOTOR CARS LTD

OLIVER FERSCHKE
Head of HR Marketing BMW Group

The BMW Group is very enthusiastic about its involvement in the Formula Student Germany. The challenges the teams face during the course of a season are also always faced by the BMW Group. We are, therefore, pleased when qualified participants from all over the world gain their first practical experience in the BMW Group.

Mit großer Begeisterung engagiert sich die BMW Group in der FSG. Die Herausforderungen, mit welchen sich die Teams im Laufe einer Saison konfrontiert sehen, beschäftigen auch uns bei der BMW Group immer wieder. Daher freuen wir uns, wenn qualifizierte Teilnehmer aus dem In- und Ausland ihre ersten Praxis-Erfahrungen in der BMW Group sammeln.

BASF
We create chemistry

PHILIP TRÜPER
Vice President, Business Management Transportation,
BASF SE

For BASF, scientific research and the consequently arising innovative strength are essential. We are focused on science education realizing that today's students will be the thinkers, innovators, visionaries and leaders of the future. We consider "Formula Student Germany" as a great opportunity to get in contact with ambitious and curious young people.

Für BASF sind wissenschaftliche Forschung und die daraus resultierende Innovationen essentiell. Wir konzentrieren uns auf die naturwissenschaftliche Bildung und erkennen, dass die Studierenden von heute die Denker, Innovatoren, Visionäre und Anführer der Zukunft sein werden. Wir sehen die „Formula Student Germany" als eine großartige Möglichkeit, mit ambitionierten und neugierigen jungen Menschen in Kontakt zu treten.

BOSCH
Invented for life

HEIDI STOCK
Human Resources Management - Talent Acquisition

At Bosch, our vision is to transform our products into smart assistants for all humans by using artificial intelligence – as we do with autonomous driving. Behind this vision stand associates with individual competences, mindsets and experiences – as diverse, as the teams of FSG. That's why we have supported FSG for many years.

Unsere Vision bei Bosch ist, mit künstlicher Intelligenz unsere Produkte zu intelligenten Assistenten der Menschen zu machen. Wie beim automatisierten Fahren. Dahinter stecken Mitarbeiter*innen mit individuellen Kompetenzen, Denkweisen und Erfahrungen – so vielfältig, wie die Teams der FSG, die wir jedes Jahr gerne unterstützen.

Brunel

MARKUS ECKHARDT
General Manager

Smart, autonomous, environmentally friendly: This is how we are shaping the future of mobility. For this, we need the talent, creativity and enthusiasm of FSG's budding engineers. Together, we share a passion for implementing forward-looking projects in engineering and IT. That is why Brunel has been supporting FSG since 2006.

Smart, autonom, umweltfreundlich: So gestalten wir die Zukunft der Mobilität. Hierfür benötigen wir das Talent, die Kreativität und Begeisterung der angehenden Ingenieure/-innen der FSG. Gemeinsam teilen wir die Leidenschaft für die Umsetzung zukunftsweisender Projekte im Engineering & der IT. Deshalb unterstützt Brunel die FSG bereits seit 2006.

DAIMLER

DR. MICHAEL HAFNER
Vice President MBOS Base Layer and MBUX,
Mercedes-Benz AG

The future of the automotive industry is electric and connected. We are aiming to take the lead in electric drive and car software. The creative minds in the FSG teams work with genuine commitment and passion. These are the talents that we want to support and promote in order to develop the best products.

Die Zukunft in der Automobilbranche ist elektrisch und vernetzt. Wir streben dabei die führende Position bei Elektroantrieben und Fahrzeug-Software an. In den Teams der FSG sind kreative Köpfe, die mit Herzblut und Leidenschaft bei der Sache sind. Genau diese Talente wollen wir unterstützen und fördern, um die besten Produkte zu entwickeln.

faurecia

ANDREAS MARTI
Faurecia Group Country HR Director Germany

FSG participants and automotive supplier Faurecia have a lot in common: a passion for innovation, ambition, determination and the courage to find unusual and creative mobility solutions. We are proud to be a sponsor of the FSG and look forward to exchanging ideas with the dedicated and talented teams. We wish everyone lots of success!

Die Teilnehmer der FSG und der Automobilzulieferer Faurecia haben vieles gemeinsam: Leidenschaft für Innovation, Ehrgeiz, Zielstrebigkeit und den Mut zu ungewöhnlichen und kreativen Lösungen. Wir sind stolz, als Sponsor der FSG dabei zu sein, und freuen uns auf den Austausch mit denengagierten und talentierten Teams. Wir wünschen Allen viel Erfolg!

automotive engineering iav

CHRISTIAN WILLENBERG
Employer Branding & HR Marketing

With over 8000 members of staff, IAV is one of the world's leading providers of engineering services to the automotive industry. The company can look back on more than 35 years of experience in developing innovative concepts and technologies for future vehicle generations. For further information about IAV, go to www.iav.com/en/careers

IAV ist mit über 8.000 Mitarbeitern weltweit einer der führenden Engineering-Partner der Automobilindustrie. Das Unternehmen entwickelt seit über 35 Jahren innovative Konzepte und Technologien für zukünftige Fahrzeuggenerationen.
Weitere Infos zu IAV erhalten Sie über unser Karriereportal www.iav.com/karriere

MAGNA

CLAUS HOFER
Director Total Rewards & Talent Europe, Magna International

Magna's innovation and technology are transforming vehicles and the future of mobility. We are committed to supporting the next generations and the education of future automotive pioneers. We believe in the development and nurturing of bold young minds in science, engineering, and technology.

Magna verändert durch Innovationen und Technologie die Zukunft des Automobils und der Mobilität. Wir engagieren uns in der Nachwuchsförderung und der Ausbildung zukünftiger Pioniere in der Automobilindustrie. Wir glauben an die Entwicklung und Unterstützung mutiger, junger Talente vornehmlich im Ingenieurswesen, in der Wissenschaft und Technik.

MAHLE

DR.-ING. PETER WIESKE
Director Corporate Advanced Engineering Mechatronics

The talented engineers at Formula Student share their passion for technology with us. Every year, new unique concepts emerge and find the appropriate stage at the Hockenheimring. We are happy to support the talents with the necessary resources and bring them a bit closer to their goal! Together we are successful. #StrongerTogether

Die Leidenschaft für Technologie teilen die talentierten Ingenieurinnen und Ingenieure bei der Formula Student mit uns. Jedes Jahr ergeben sich neue einzigartige Konzepte, die auf dem Hockenheimring die angemessene Bühne finden. Wir freuen uns die Talente mit den nötigen Ressourcen zu unterstützen! Gemeinsam sind wir erfolgreich. #StrongerTogether

MathWorks®

DR. VEER ALAKSHENDRA
Automotive Competition Technical Lead

Employing a Model-Based Design approach to the automotive design process enables teams to design, test, validate and share their models within one environment. Using industry-standard tools such as MATLAB and Simulink help students tackle real engineering problems. www.mathworks.com/fsg

Mit MATLAB und Simulink lösen Teams der Formula Student Germany reale, automobiltechnische Probleme. Studenten, die modell-basierte Entwicklung einsetzen, entwickeln schneller und besser. Modell-basierte Entwicklung (Model-Based Design) erlaubt Lösungen zu testen und zu validieren bevor diese im Fahrzeug eingesetzt werden. www.mathworks.com/fsg

PORSCHE

KONSTANZE MARINOFF
Director Recruiting & HR-Marketing

It's equally essential for Porsche and all Formula Student teams: To work with dedication, to fight for the best solution, day after day, to courageously explore new approaches and to face the competition with fairness and respect. We wish all participating teams exciting and successful days at the Hockenheimring.

Für Porsche, genauso wie für alle Formula Student Teams gilt: Mit Herzblut bei der Sache sein, Tag für Tag für die beste Lösung kämpfen, mutig neue Wege gehen und sich mit sportlicher Fairness dem Wettbewerb stellen. Wir wünschen allen teilnehmenden Teams spannende und erfolgreiche Tage am Hockenheimring und freuen uns auf den Austausch!

SCHAEFFLER

CORINNA SCHITTENHELM
Chief Human Resources Officer

Team spirit, commitment and passion for technology - these are the qualities that our employees and the Formula Student teams have in common. As a sponsor we are in close contact with the teams and support them with our know-how. The participants are welcome applicants for us. We pionieer motion.

Teamgeist, Engagement und Leidenschaft für Technik – das sind Eigenschaften, die unsere Mitarbeitenden und die Formula-Student-Teams verbinden. Als Sponsor stehen wir in engem Kontakt mit den Teams und unterstützen diese mit unserem Know-how. Die Teilnehmenden sind gern gesehene Bewerber*innen bei uns. We pioneer motion.

SIEMENS

OLIVER BECKER
Director Academic Business

Team spirit, an infectious enthusiasm and the impressive professionalism of all the teams – that is what distinguishes the FSG. Siemens Digital Industries Software is very proud of being the sponsor of this extraordinary competition since 2015 and is looking forward to the week in Hockenheim, which is a real highlight for us. Come and talk to us – it's worth it!

Teamgeist, eine ansteckende Begeisterung und die beeindruckende Professionalität aller Teams – das ist es, was die FSG auszeichnet. Siemens Digital Industries Software ist sehr stolz darauf, seit 2015 Sponsor dieses außergewöhnlichen Wettbewerbs zu sein und freut sich auf die Woche in Hockenheim, die für uns ein echtes Highlight ist. Kommen Sie mit uns ins Gespräch – es lohnt sich!

SKF®

MY LINH PHAM
Manager Talent Academy

Our vision: 'A world of reliable rotation'. To make this a reality, we are working on optimized solutions for a wide range of applications. It requires experience, knowledge, flexibility & creativity. This is exactly what the FS teams bring with them. At SKF, young engineers who think ahead are offered the chance to help shape the future.

Unsere Vision: "Eine Welt in zuverlässiger Rotation". Um sie zu verwirklichen, arbeiten wir an optimierten Lösungen für verschiedenste Anwendungen. Dafür sind Erfahrung, Wissen, Flexibilität & Kreativität nötig. Genau das bringen die FS-Teams mit. Jungingenieuren & IT'lern, die weiterdenken, bietet SKF die Chance, den Fortschritt mitzugestalten.

TE connectivity

ANDREA SCHMITT
Cluster Lead Automotive, EMEA Talent Attraction

TE Connectivity is happy to be part of your team! When it comes to creating reliable connections we've been in the race for decades. Education and innovation are key drivers for the future of our company – become one of our talents! We are looking forward networking with you at our orange show truck this year. For us, every connection counts.

TE Connectivity freut sich Teil eures Teams zu sein, denn wenn es darum geht zuverlässige Verbindungen zu schaffen sind wir Jahrzehnte im Rennen. Bildung und Innovation treiben unser Unternehmen - werde Teil davon! Wir freuen uns darauf uns mit Euch an unserem orangenen Showtruck in diesem Jahr zu vernetzten. Denn für uns zählt jede Verbindung.

ERIK DEMMLER
HR Director Giga Berlin, Human Resources

Tesla's mission is to accelerate the world's transition to sustainable energy. Tesla was founded in 2003 by a group of engineers who wanted to prove that people didn't need to compromise to drive electric - that electric vehicles can be better, quicker and more fun to drive than gasoline cars. Today, Tesla builds not only all-electric vehicles but also infinitely scalable clean energy generation and storage products.

Tesla steht für eine Mission: Die Beschleunigung des Übergangs zu nachhaltiger Energie. Tesla wurde 2003 von einer Gruppe von Ingenieuren gegründet, die beweisen wollten, dass Elektrofahrzeuge keinen Kompromiss bedeuten, sondern mehr Leistung, Beschleunigung und Fahrspaß als Benziner bieten können. Heute baut Tesla neben reinen Elektrofahrzeugen auch unbegrenzt skalierbare Stromerzeugungs- und Stromspeicherprodukte.

DIPL.-ING. CHRISTOF KERKOFF
VDI-Society Automotive and Traffic Systems Technologies

VDI, the Association of German Engineers, is proud to be a partner and sponsor for Formula Student Germany since the very beginning. This competition is a model for other programs we run to stimulate interest in the engineering profession and to lend a hand to the future generation, and our members follow it keenly every year.

Der Verein Deutscher Ingenieure (VDI) ist stolz darauf, die Formula Student Germany seit Ihren Anfängen als ideeller Träger und Sponsor zu unterstützen. Dieser Wettbewerb ist ein Vorbild für andere Programme, mit denen wir das Interesse für Technikberufe wecken, den Nachwuchs fördern und er begeistert unsere Mitglieder jedes Jahr aufs Neue.

CARSTEN HELBING
Chief Technical Officer, Volkswagen AG

Volkswagen is rethinking and redisgning mobility: eletric, digital, intelligent and sustainable. Therefore, we need top talents to enhance the development of mobility with us. We are looking forward to meet committed students at Formula Student and discuss innovations and career opportunities.

Wir wollen die Mobilität neu denken und gestalten: elektrisch, digital, intelligent und nachhaltig. Dafür brauchen wir Top-Talente, die mit uns die Entwicklung der Mobilität vorantreiben. Wir freuen uns, bei der Formula Student mit engagierten Studierenden über Innovationen sowie Karrierechancen ins Gespräch kommen.

MARTIN FRICK
Head of Talent Attraction

ZF is a global technology company, enabling the next generation of mobility and offering integrated solutions for vehicle manufacturers, mobility providers and start-up companies in the fields of transportation and mobility. We support Formula Student to give the participants early insights in our activities that shape the future of mobility.

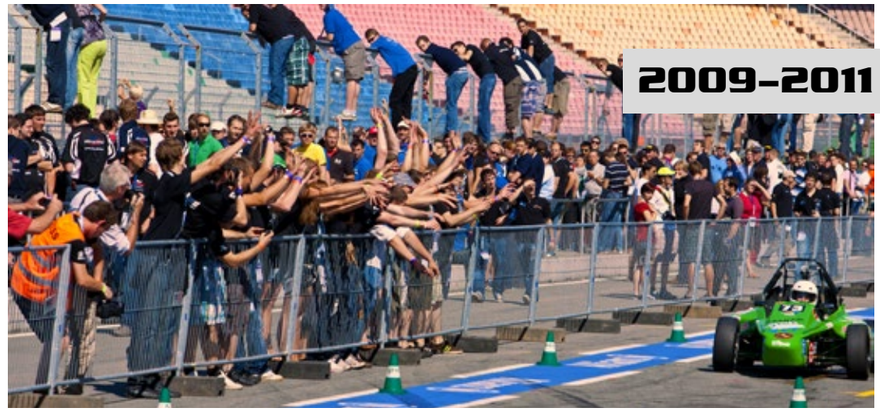
ZF ist ein weltweit aktiver Technologiekonzern. Mit seinem Technologieportfolio bietet ZF Lösungen für Automobilhersteller, Mobilitätsanbieter und neu entstehende Unternehmen im Bereich Transport und Mobilität. Bei der Formula Student engagieren wir uns, um den Teilnehmern Einblicke zu geben, wie wir die Mobilität der nächsten Generation gestalten.

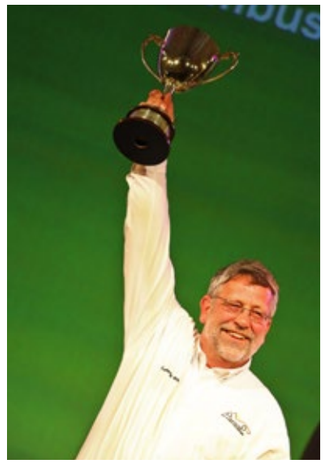
Impressions

last 15 years of
Formula Student Germany

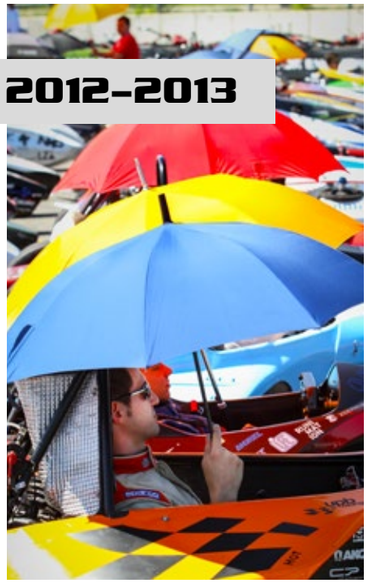
2006–2008

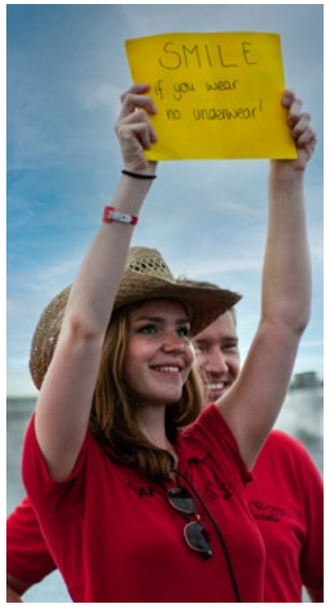
2009–2011



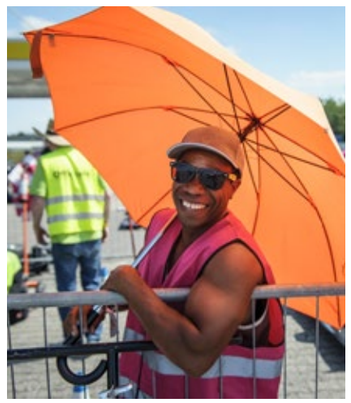


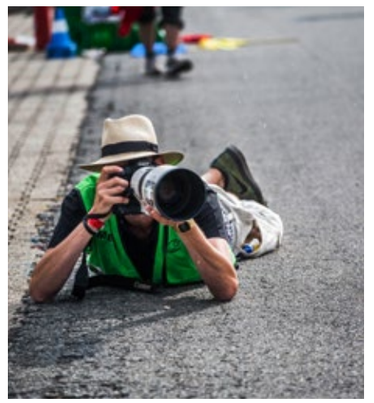
2012–2013





2014–2015





2016-2017

2018-2019

2019

The strategic relevance of the Formula Student

How Formula Student helps propelling technological advance in automotive industry

Ready to race into the future. /
Bereit in die Zukunft durchzustarten.

Die strategische Relevanz der Formula Student

Wie die Formula Student den technologischen Fortschritt in der Automobilbranche vorantreibt

Written by Catharina Schiffter

In today's world the technological change is exponential, with many industries being disrupted by the increasing speed of progress and new players entering the market. The automotive industry is no exception. Megatrends like electrification, autonomous driving, connected cars and the change of mobility behaviour will turn the automobile business upside down. New players across the globe have started to compete with traditional OEMs and establish new practices and ways to approach the development and the marketing of cars.

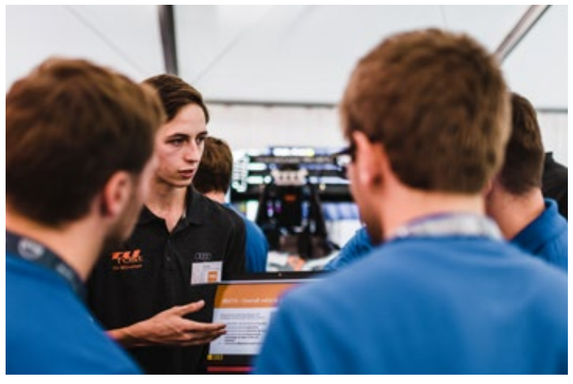
Besides these influences from other automotive players, other industries heavily influence the perception of the future car. For example, the smartphone has revolutionized the way customers perceive the value of a product. Nowadays, instead of buying a new vehicle every few years because it is outdated, the customer expects new features and support of the vehicle over it's lifetime. The relentless push of technological advance and the demand on shorter update cycles require engineers that handle complex and interconnected problems at an increasing speed more than ever.

In der heutigen Welt ist der technologische Wandel exponentiell. Viele Branchen werden durch die zunehmende Geschwindigkeit des Fortschritts und den Eintritt neuer Akteure in den Markt nachhaltig verändert. Die Automobilindustrie ist da keine Ausnahme. Megatrends wie Elektrifizierung, autonomes Fahren, Connected Cars und die Veränderung des Mobilitätsverhaltens stellen das Automobilgeschäft zunehmend auf den Kopf. Mobilitäts Start-Ups auf der ganzen Welt beginnen mit den traditionellen OEMs zu konkurrieren und etablieren neue Praktiken und Wege bei der Entwicklung und Vermarktung von Autos.

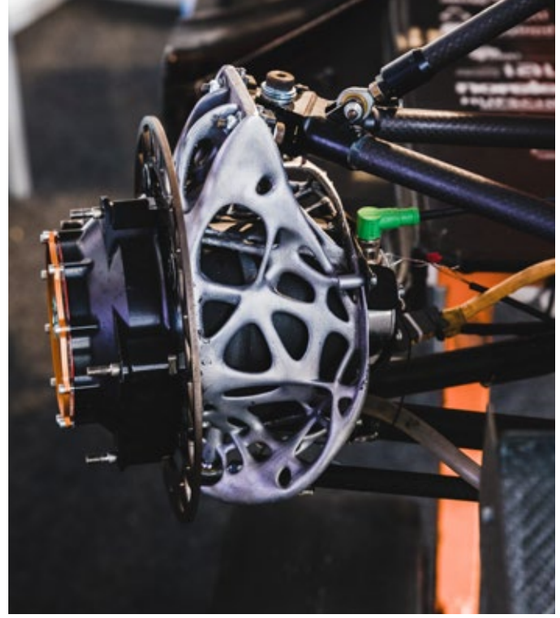
Neben den Veränderungen innerhalb der Automobilbranche beeinflussen auch andere Branchen die Wahrnehmung des zukünftigen Autos stark. Das Smartphone beispielsweise hat die Art und Weise revolutioniert, wie Kunden den Wert eines Produkts wahrnehmen. Anstatt alle paar Jahre ein neues Fahrzeug zu kaufen, weil es veraltet ist, erwartet der Kunde heute neue Funktionen und Unterstützung des Fahrzeugs über die gesamte Lebensdauer. Der unaufhaltsame Vorstoß des technologischen Fortschritts und die Forderung nach kürzeren Update-Zyklen erfordern mehr denn je Ingenieure, die komplexe und vernetzte Probleme mit zunehmender Geschwindigkeit lösen.

Software & data-driven development

The traditional automotive industry is used to evolutionary steps in mechanical engineering. Cars became more stable and comfortable to drive, quicker in acceleration and top speed, and safer through crash tests. Over the last decade this approach however clashed with the new world of data and the power of software engineering.
As mechanics reach their natural boundaries in many areas the differentiator of the future will not be powertrains but the tech stack of the vehicle. With software being the main success factor in the automobile, it is more important than ever to learn about the creation, testing and deployment of software in the real world. Formula Student teams went from simple CAN bus networks to highly complex E/E-architectures in their vehicles to handle sensor and driver inputs for maximum performance on the track. Being exposed to such highly complex systems is a great opportunity for students to foster coding skills, incorporate agile working methods, and implement systems engineering strategies. Competence in software is already one most requested qualification across the industry and Formula Student members excel in it.
Just like in the industry, FS Teams are increasingly implementing data driven engineering in their approach to building a robust design. With continuous data collection, analysis, simulation and validation the Teams improve their designs and seek more performance on the track. Digital twins of the cars are created, simulated, and optimized year over year. It does not only allow the improvement of the overall concept of the car through targeted measures but especially helps to understand fundamental correlations in the system. In the Engineering Design Event this knowledge helps to convince the Judges on a well- thought-through vehicle concept and the system understanding.



Presenting proof is key to successful argumentation. /
Es braucht Validierung um erfolgreich zu argumentieren.



Use of state-of-the-art technology. / Einsatz von hochmoderner Technologie.

Software- und datengetriebene Entwicklung

Die traditionelle Automobilindustrie ist an evolutionäre Schritte im Maschinenbau gewöhnt. Fahrzeuge wurden stabiler und komfortabler im Fahrverhalten, schneller in der Beschleunigung und Höchstgeschwindigkeit, und sicherer durch Crashtests. Im letzten Jahrzehnt prallte dieser Ansatz jedoch auf die neue Welt der Daten und der Macht der Softwareentwicklung. Da die Mechanik in vielen Bereichen an ihre natürlichen Grenzen stößt, wird das Unterscheidungsmerkmal der Zukunft nicht etwa der Antriebsstrang oder das Fahrwerk sein, sondern der Tech-Stack des Autos. Da Software zum Erfolgsfaktor im Automobil geworden ist, ist es wichtiger denn je, etwas über die Entwicklung, das Testing und den Einsatz von Software in der realen Welt zu lernen. Formula Studentteams sind von einfachen CAN-Bus-Netzwerken zu hochkomplexen E/E-Architekturen in ihren Fahrzeugen übergegangen, um Sensor- und Fahrereingaben für maximale Leistung auf der Rennstrecke zu verarbeiten. Der Umgang mit solch hochkomplexen Systemen ist eine großartige Gelegenheit für Studenten, ihre Programmierfähigkeiten zu fördern, agile Arbeitsmethoden anzuwenden und Systems-Engineering-Strategien umzusetzen. Kompetenz im Bereich Software ist bereits eine der meistgefragten Qualifikationen in der Industrie und Studenten in der Formula Student zeigen diese Fähigkeit in ihrer Arbeit im Projekt. Genau wie in der Industrie, implementieren FS-Teams zunehmend datengetriebene Entwicklung, um ein robustes Design zu entwickeln und sich kontinuierlich zu verbessern. Durch kontinuierliche Datensammlung, -analyse, -simulation und -validierung verbessern die Teams ihre Konstruktionen und streben nach mehr Leistung auf der Rennstrecke.
Digitale Zwillinge der Autos werden geschaffen und Jahr für Jahr optimiert. Dies ermöglicht nicht nur das Gesamtkonzept des Autos durch gezielte Maßnahmen zu verbessern, sondern hilft vor allem, grundlegende Zusammenhänge im System zu verstehen. Somit können die Teams im Engineering Design Event die Judges mit einem gut durchdachten, validierten Fahrzeugkonzept und umfassenden Systemverständnis überzeugen.

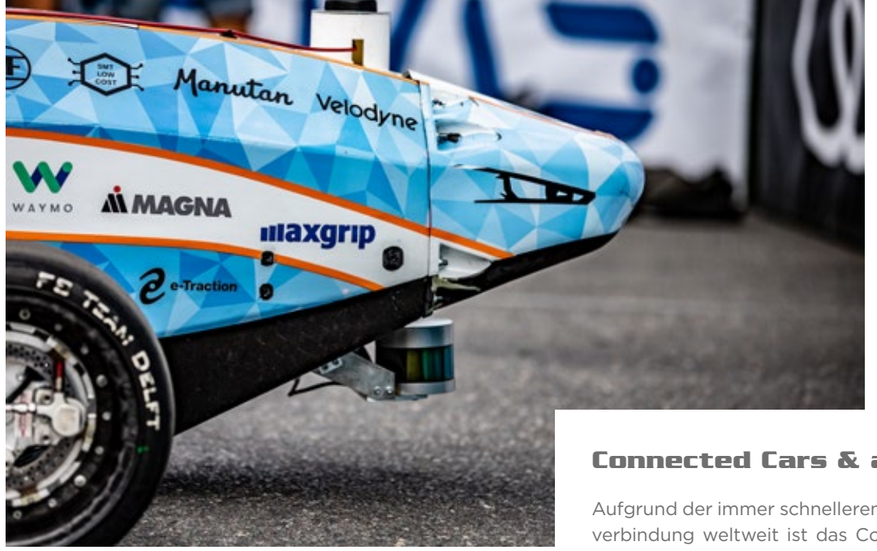
Electrification

When Formula Student Germany introduced the electric vehicle class back in 2010, there were only a few small production series electric vehicles available on the market. Cost of accumulators were so high and driving range so low, that these vehicles were not on par with their internal combustion engine counterparts. It took a decade of innovation from inside and outside the industry to drive down accumulator cost, increase range and incentivize charging networks. Nowadays, a much greater variety of electric vehicles of nearly all OEMs is available and there will be plenty more in the next years. Many students who worked on electric powertrains made their way into the industry and make use of their knowledge every day. Of course, a race car powertrain focuses on maximum performance on the track, however, all necessary components are fundamentally the same in passenger vehicles, trucks and busses. Students develop a great understanding of the entire drive system, incorporate their own ideas on batteries, motors, controllers, and cooling systems which makes them attractive to potential employers across the industry. Since the revolution of electric cars has just begun, there is an increasing demand in the skilled workforce for further innovations to improve electric cars and replace their combustion counterparts.

Elektrifizierung

Als die Formula Student Germany im Jahr 2010 die Elektroklasse einführte, gab es nur wenige elektrische Kleinserienfahrzeuge auf dem Markt. Die Kosten für Akkus waren so hoch und die Reichweite so gering, dass diese Fahrzeuge nicht mit ihren Konkurrenten mit Verbrennungsmotoren mithalten konnten. Es bedurfte eines Jahrzehnts der Innovation innerhalb und außerhalb der Branche, um die Kosten für Akkus zu senken, die Reichweite zu erhöhen und Anreize für Ladenetze zu schaffen. Heute gibt es eine viel größere Auswahl an Elektrofahrzeugen von fast allen OEMs und in den nächsten Jahren kommen immer mehr hinzu. Viele Studenten, die an elektrischen Antriebssträngen gearbeitet haben, sind nun in der Industrie tätig und nutzen ihr Wissen täglich. Natürlich steht bei einem Rennwagen-Antriebsstrang die maximale Leistung auf der Rennstrecke im Vordergrund, jedoch sind alle notwendigen Komponenten in PKWs, LKWs und Bussen grundsätzlich die Gleichen. Die Studenten entwickeln ein großes Verständnis für das gesamte Antriebssystem, bringen eigene Ideen zu Batterien, Motoren, Reglern und Kühlsystemen ein, was sie für potenzielle Arbeitgeber in der Branche attraktiv macht. Da die Revolution der Elektroautos gerade erst begonnen hat, gibt es einen steigenden Bedarf an qualifizierten Arbeitskräften für weitere Innovationen, die Elektroautos verbessern und zukünftig den Verbrenner ersetzen.

The challenge for the driver is to complete the track without hitting any pylons. /
Die Herausforderung für den Fahrer ist den Parcour ohne das Umwerfen von Pylonen zu meistern.



All set for Autocross. /
Bereit für Autocross.

Connected car & autonomous driving

With the rise of fast, stable and mobile network connectivity worldwide the connected car is the next massive change that the automobile world is experiencing. This game changer does not only allow the car to be smarter but opens the door to the world of digital ecosystems. A car as a connected device also enables the many use cases in the autonomous vehicle. After the revolutionary projections by many OEM's on (fully) autonomous vehicles in the mid 2020s only a few years ago, the direction shifted to an evolutionary implementation of ADAS (Advanced Driver Assistance Systems). FSG directly targets this development by merging the electric and driverless class. To learn the important fundamentals, Formula Student Driverless introduces every competing student to this highly complex task without the challenges of the environment/traffic. Whether it's the selection of the sensor set (camera, radar, or LiDAR), the fusion of different data streams, or the localization on the map/track, these challenges provide a valuable preparation for future jobs within the industry.

Apart from the technical expertise that students can gather during their work on a Formula Student car, soft skills are a vital part of the education as well. Being exposed to the team's organization and working ethic provides valuable lessons. Setting goals, delivering on deadlines, and learning day-to-day project management work can be transferred directly into any future job position after graduation. Being part of the Formula Student community is a great opportunity to excel into the initial steps of the professional career. Through technical expertise and soft skills, you can either start a successful business or join a company in the related field to drive innovation in technology forward. Formula Student provides a level playing field to learn and grow, helping students become better engineers and economists.

Connected Cars & autonomes Fahren

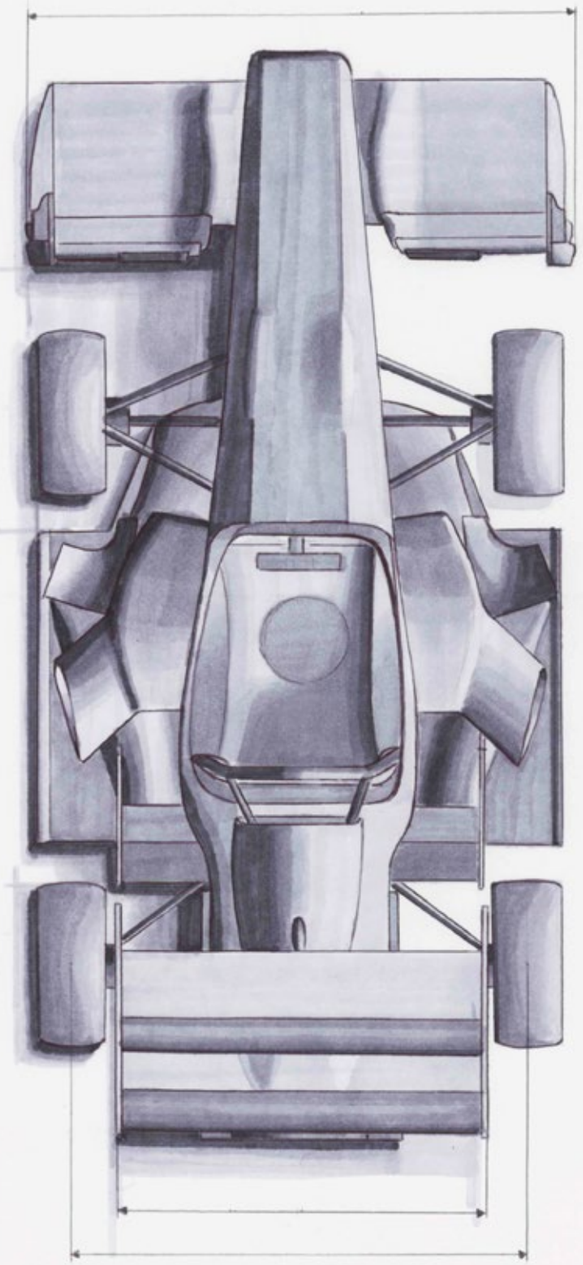
Aufgrund der immer schnelleren und stabileren Netzwerk- und Internetverbindung weltweit ist das Connected Car die nächste massive Veränderung, die die Automobilwelt erlebt. Dieser Game Changer macht das Auto nicht nur intelligenter, sondern öffnet die Tür zur Welt der digitalen Ökosysteme. Ein Auto als vernetztes Gerät ermöglicht auch die vielen Anwendungsfälle im autonomen Fahrzeug. Nach den revolutionären Projektionen vieler OEMs auf (voll-)autonome Fahrzeuge Mitte der 2020er Jahre vor wenigen Jahren, hat sich die Richtung hin zu einer evolutionären Implementierung fortschrittlicher ADAS-Systeme verschoben.

Die FSG setzt direkt an dieser Entwicklung an, indem sie die elektrische und fahrerlose Klasse zusammenführt. Um die wichtigen Grundlagen zu erlernen, führt die Formula Student Driverless jeden teilnehmenden Studenten an diese hochkomplexe Aufgabe heran, ohne beispielsweise die Herausforderungen des Verkehrs zu adressieren. Ob es um die Auswahl der Sensorik (Kamera, Radar oder LiDAR), die Fusion verschiedener Datenströme oder die Lokalisierung auf der Karte oder an der Strecke geht – diese Herausforderungen bieten eine wertvolle Vorbereitung auf zukünftige Jobs in der Branche.

Neben dem technischen Fachwissen, das die Studenten während ihrer Arbeit an einem Formula Student Fahrzeug sammeln können, sind auch Soft Skills ein wichtiger Teil der Ausbildung. Die Organisation und Koordination innerhalb eines Teams ist eine wertvolle Erfahrung. Das Setzen von Zielen, das Einhalten von Terminen und das Erlernen der täglichen Arbeit im Projektmanagement können direkt in jeden zukünftigen Job nach dem Studium übertragen werden. Teil der Formula Student-Community zu sein, ist eine großartige Möglichkeit, die ersten wichtigen Schritte für die berufliche Laufbahn bereits im Studium zu tun. Durch technisches Fachwissen und Soft Skills können sie entweder ein Unternehmen gründen oder in ein Unternehmen im verwandten Bereich einsteigen, um Innovationen in der Technologie voranzutreiben. Die Formula Student bietet jedem Studierenden eine „große Spielwiese", um Neues zu lernen, zu wachsen und bessere Ingenieur:innen bzw. Wirtschaftler:innen zu werden.

Tech Highlights

Written by Tim Schulte



Every year, thousands of aspiring engineers worldwide design and manufacture impressive assemblies for their Formula Student cars. For this purpose, not only are the latest manufacturing technologies and materials used, but the students also combine current development approaches from research with their own ideas to create new, innovative systems. Formula Student has always been the best environment for this: the project brings together young, ambitious people who strive for innovation in a strong team and want to develop individually. On the following pages, we would like to introduce you to some of the results of the teams' latest vehicle developments and are excited to see what ideas the teams will surprise us with again in the future. Assemblies will be presented by the teams from Dresden, Paderborn, Aachen, Hamburg and Freiberg.

Jedes Jahr konstruieren und fertigen tausende angehende Ingenieure weltweit beeindruckende Baugruppen für ihre Formula Student Autos. Hierfür wird nicht nur auf modernste Fertigungstechnologien und Materialien gesetzt, sondern von den Studierenden auch aktuelle Entwicklungsansätze aus der Forschung mit den eigenen Ideen verbunden, um neue, innovative Systeme zu schaffen. Die Formula Student ist hierfür seit jeher die beste Umgebung: Das Projekt verbindet junge, ambitionierte Menschen, die in einer starken Gemeinschaft nach Innovationen streben und sich persönlich weiterentwickeln möchten. Auf den folgenden Seiten möchten wir Ihnen einige Ergebnisse der letzten Fahrzeugentwicklungen der Teams näher bringen und sind gespannt, mit welchen Ideen uns die Teams auch in Zukunft wieder überraschen werden. Dabei werden Baugruppen von den Teams aus Dresden, Paderborn, Aachen, Hamburg und Freiberg präsentiert.

Team: **Elbflorace e.V.**

CLASS: EV
YEAR: 2019

Keyfacts:
-> Weight of 372 g
-> Stitching Time of 8 min

1

Mounted attachment to the vehicle. / Montierte Anbindung am Fahrzeug.

Usage of tailored fiber placement (TFP) for the fabrication of the front wing attachment

Verwendung von Tailored Fiber Placement (TFP) für die Herstellung der Frontflügelanbindungen

Introduction to TFP technology

Tailored Fiber Placement refers to a manufacturing technology for tailored reinforced textile products. It represents a further development of conventional embroidery technology and is an additive manufacturing process. Reinforcing fibers in the form of yarns or rovings are placed and fixed variably axially on a base textile. Either fixing threads or binders are used for this purpose during production. The flexible routing of the reinforcing yarns permits component design in line with the load path and thus increased utilization of the fiber properties, which in turn permits weight savings. Thus, the application of the reinforcing fibers, often carbon, can be carried out along the main stress directions after analysis of the force path by means of numerical simulations. Moreover, local stress peaks can be reduced, and specific properties significantly improved. The production of the window frame of the Airbus A350 can be cited as a significant industrial application example of TFP technology. Fixation by the sewing thread entails disadvantages, as it compresses the reinforcing fiber at the crossover points and leads to ondulations. Undulation refers to fiber curvatures, such as the regular, short-wave curvatures in conventional woven fabrics. The weft thread passes alternately over and under one or more warp threads. Ondulation leads to a decrease in the fiber-parallel strength of the fabric.

Vorstellung der TFP-Technologie

Tailored Fiber Placement bezeichnet eine Fertigungstechnologie für maßgeschneiderte Verstärkungshalbzeuge. Es stellt eine Weiterentwicklung der konventionellen Sticktechnik dar und gehört zu den additiven Fertigungsverfahren. Dabei werden Verstärkungsfasern in Form von Garnen oder Rovings variabel axial auf einem Basistextil abgelegt und fixiert. Hierzu werden während der Fertigung entweder Fixierungsfäden oder Binder genutzt. Der flexibel gestaltbare Verlauf der Verstärkungsfäden erlaubt ein lastpfadgerechtes Bauteildesign und damit eine erhöhte Ausnutzung der Fasereigenschaften, was wiederum Gewichtseinsparungen zulässt. So kann die Applikation der Verstärkungsfasern, oftmals Carbon, nach Analyse des Kraftverlaufs mittels numerischer Simulationen entlang der Hauptspannungsrichtungen erfolgen. So können lokale Spannungsspitzen reduziert und die spezifischen Eigenschaften signifikant verbessert werden. Ein bedeutendes Anwendungsbeispiel der TFP-Technologie in der Industrie ist die Fertigung des Fensterrahmens des Airbus A350. Die Fixierung durch den Nähfaden birgt jedoch auch den Nachteil, dass die Verstärkungsfaser an den Überkreuzungsstellen zusammengedrückt werden, was zu sogenannter Ondulationen führt. Ondulation bezeichnet Faserkrümmungen, wie beispielsweise die regelmäßigen, kurzwelligen Krümmungen in herkömmlichen Geweben. Der Schussfaden verläuft abwechselnd über und unter einem oder mehreren Kettfäden hindurch. Ondulation führt zu einer Abnahme der faserparallelen Festigkeit des Halbzeugs.

Application in the racing car of TU Dresden

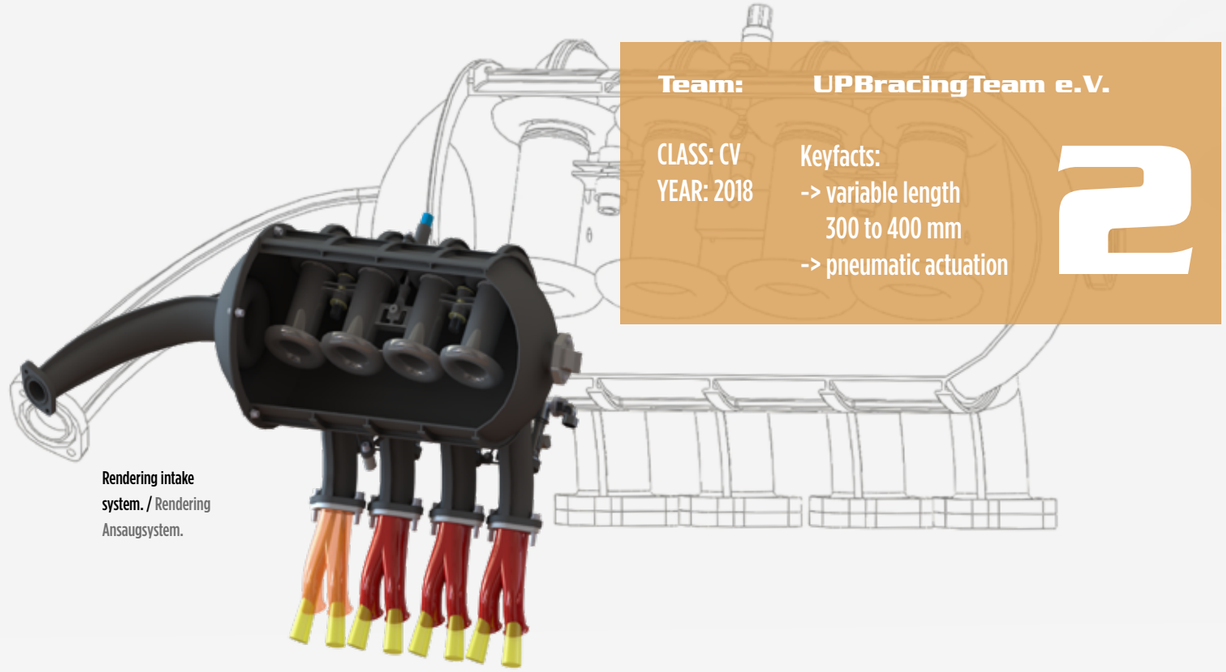
Elbflorace used TFP technology to design two attachments that connect the front wing to the monocoque chassis on both sides. Carbon inserts with variable hole patterns in the fiber composite component allow the entire wing structure to be adjusted in height relative to the chassis. Changes to the aerodynamic balance during testing can be performed as, for example, the ground effect and efficiency of the main element are affected. The structural design is based on a framework that exposes the individual members mainly to tensile and compressive stresses in order to make the best use of the fiber properties. In addition to the loads in different driving conditions, or/and load cases due to regulations, which lead to one-sided loading, should also be considered. Front wings usually have a very high efficiency, so they are exposed to proportionally low drag forces compared to high downforce forces. This force vector is crucial for the numerical design of the front wing connection. Also, the failure behavior must be considered and the interaction with the front crash element of the chassis should be checked. For this purpose, most teams foresee a specific predetermined breaking point in the connection, such as the targeted shearing of the bolted connection.

Anwendung im Rennwagen der TU Dresden

Elbflorace nutzte die TFP Technologie um zwei Anbindungen zu konstruieren, welche den Frontflügel auf beiden Seiten mit dem Monocoque Chassis verbinden. Vollcarbon Inserts mit Langloch im Faserverbundbauteil ermöglichen eine Höhenverstellung der gesamten Flügelstrukturen relativ zum Chassis. So können Änderungen an der aerodynamischen Balance während dem Testen vorgenommen werden, da beispielsweise der Bodeneffekt und die Effizienz des Hauptelements beeinflusst werden. Die Strukturauslegung beruht auf einem Fachwerk, welches die Einzelstäbe hauptsächlich Zug- und Druckspannungen aussetzt, um so die Fasereigenschaften optimal ausnutzen zu können. Dabei müssen neben den Lasten in verschiedenen Fahrzuständen, auch Reglement bedingte Lastfälle betrachtet werden, welche zu einer einseitigen Belastung führen. Frontflügel haben in der Regel eine sehr hohe Effizienz, weswegen sie anteilig jedoch nur geringen Widerstandskräften im Vergleich zu den Abtriebskräften ausgesetzt werden. Dieser Kraftvektor ist entscheidend für die numerische Auslegung der Frontflügelanbindung. Weiterhin sollte das Versagensverhalten nicht außer Acht gelassen und die Interaktion mit dem vorderen Crashelement des Chassis überprüft werden. Hierzu sehen die meisten Teams eine gezielte Sollbruchstelle in der Anbindung vor, wie beispielsweise dem gezielten Abscheren der Schraubverbindung.

▲ **Component after infusion with the VAP method.** / Bauteil nach der Infusion mit dem VAP-Verfahren.

◀ **Reinforcement pattern** / Verstärkungsmuster



Team: UPBracingTeam e.V.

CLASS: CV
YEAR: 2018

Keyfacts:
-> variable length
300 to 400 mm
-> pneumatic actuation

2

Rendering intake system. / Rendering Ansaugsystem.

Pneumatic variable-length intake manifold

Pneumatischer längenvariabler Ansaugstutzen

Why are variable-length intake manifold (VLIM) installed in IC engines?

The intake system of internal combustion engines has the task of providing the required combustion air with the lowest possible losses. The air should be distributed evenly to the individual intake ports of the cylinders and the flow velocity reduced, which inevitably leads to an increase in pressure (diffuser effect). For this purpose, it is important that the air path is uniform, which is why cross-sectional jumps or offsets at separation points must be avoided. In the intake chamber, gas-dynamic processes induced by the periodic piston movement occur, which are used specifically to increase the degree of delivery by appropriate design of the system. For example, when the intake valve opens, a vacuum wave is generated which returns at the end of the intake manifold as a positive pressure wave. This can prevent the air already drawn into the combustion chamber from flooding back into the intake tract (delivery rate) or even generate a boost by means of the overpressure

Warum werden längenvariable Saugrohre (VSR) in Verbrennungsmotoren eingebaut?

Das Ansaugsystem von Verbrennungsmotoren hat die Aufgabe mit möglichst geringen Verlusten die erforderlichen Verbrennungsluft bereitzustellen. Die Luft soll gleichmäßig auf die einzelnen Ansaugstellen der Zylinder aufgeteilt und die Strömungsgeschwindigkeit reduziert werden, was zwangsläufig zu einem Druckanstieg führt (Diffusorwirkung). Wichtig dafür ist der gleichmäßige Verlauf der Luftstrecke, weshalb Querschnittssprünge oder Absätze an Trennstellen zu vermeiden sind. Durch die periodische Kolbenbewegung induziert, treten gasdynamische Vorgänge in der Ansaugkammer auf, die durch entsprechende Gestaltung der Anlage gezielt zur Steigerung des Liefergrads verwendet werden. So entsteht beispielsweise beim Öffnen des Einlassventils eine Unterdruckwelle, die am Ende des Saugrohrs als Überdruckwelle wieder zurückläuft. Hierdurch kann ein Zurückfluten der schon im Brennraum angesaugten Luft in den Ansaugtrakt verhindert werden (Liefergrad) oder gar durch die Überdruckwelle eine Aufladung erzeugt werden (Luftaufwand). Dieser Resonanzeffekt ist geschwindigkeitsabhängig, weswegen bei herkömmlichen Verbrennungsmotoren ein Kompromiss zwischen fülliger Leistungskurve und hoher Leistung bei Nenndrehzahl gefunden werden muss. Ein variables Ansaugsystem verschafft hier Abhilfe: Ein langes Saugrohr führt zu hohem Luftaufwand bei niedrigen Drehzahlen, jedoch eben auch zu Leistungseinbußen, da die Wandreibung steigt.

wave (air consumption). This resonance effect is speed-dependent, which is why conventional internal combustion engines have to find a compromise between a rich power curve and high power at rated speed. A variable intake system provides a remedy here: A long intake manifold leads to high air consumption at low engine speeds, but also to a loss of power because wall friction increases. Conversely, the resonance of a short intake manifold is at high engine speeds, which results in high air consumption and, combined with high engine speed, in high power. This makes it possible to call up high torques even at low engine speeds and, in combination with the transmission stages, to optimize the drivability of the racing engine.

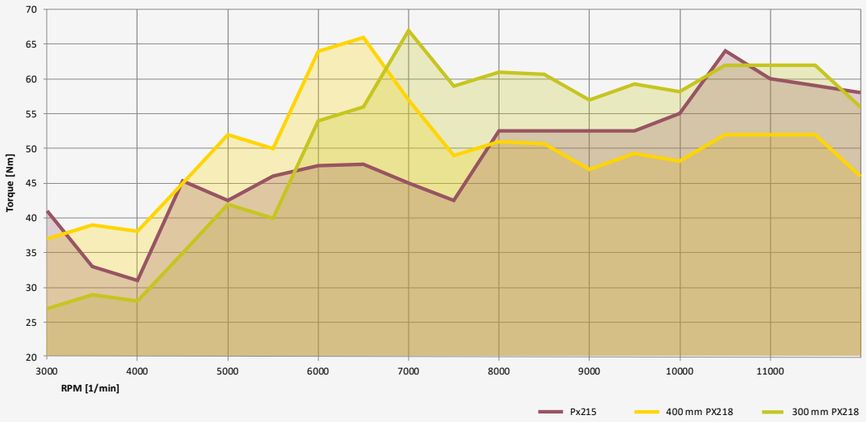
Integration into the Paderborn powertrain

UPB Racing's race car, which competes in the CV class of Formula Student, is powered by a transversely mounted Suzuki GSX-R 600 in-line four-cylinder engine. The airbox was additively manufactured and built up in layers of polyamide 6 using selective laser sintering (SLS). While the internal geometry was flow-optimized using CFD simulations and validated on the in-house engine test bench, longitudinal and circumferential stiffeners were added on the outside. They protect the structure from the high internal pressure and prevent buckling of the thin-walled shell both to ensure functionality and to keep possible negative influences of flow changes to a minimum. The suction tube length adjustment is realized by a pneumatic system, which can adjust a length of 300 and 400 mm. Using the data from the speed sensor on the crankshaft, an additional control unit can activate a valve with 24 V voltage on the basis of a previously applied map. Thereby a piston is pressurized with up to eight bar to increase the intake manifold length. The highlight of the piston is the integrated spring, which allows the intake manifold to be retracted without an additional pressure line. This significantly reduces system complexity and increases the reliability of the powertrain.

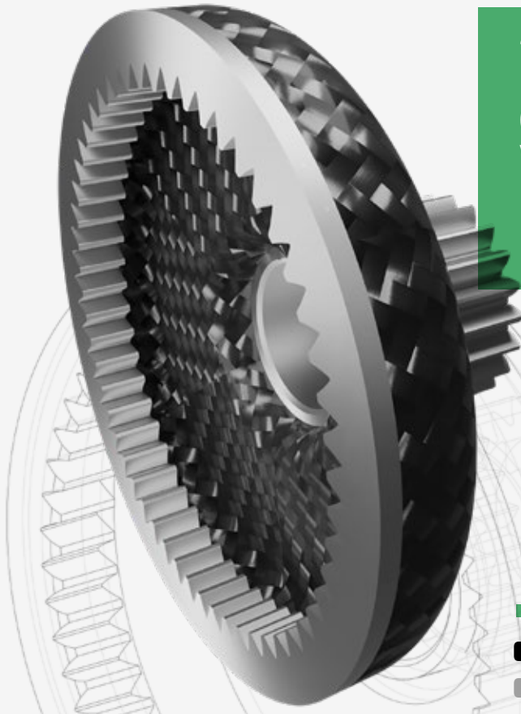
Umgekehrt liegt die Resonanz eines kurzen Saugrohrs bei hohen Drehzahlen, was sich in hohem Luftaufwand sowie kombiniert mit hoher Drehzahl in hoher Leistung auswirkt. Hierdurch lässt sich schon bei niedrigen Drehzahlen hohe Drehmomente abrufen und in Kombination mit den Getriebestufen die Fahrbarkeit des Rennmotors optimiert werden.

Integration in den Paderborner Antriebsstrang

Angetrieben wird der Rennwagen von UPB Racing, der in der CV Klasse der Formula Student startet, von einem quer eingebauten Suzuki GSX-R 600 Reihenvierzylinder. Die Airbox wurde hierbei additiv gefertigt und mittels Selective Laser Sintering (SLS) aus Polyamid 6 schichtweise aufgebaut. Die Innengeometrie wurde mittels CFD-Simulationen strömungsoptimiert ausgelegt und auf dem hauseigenen Motorenprüfstand validiert. An der Außenseite wurden Versteifungen in Längs- und Umfangsrichtung eingebracht. So wird die Struktur vor hohem Innendruck geschützt, und Beulen in der dünnwandigen Schale vermieden, um die Funktionalität sicherzustellen und mögliche negative Einflüsse Strömungsveränderungen gering zu halten. Die Saugrohrlängenverstellung wird dabei durch ein pneumatisches System realisiert, welche eine Länge von 300 und 400 mm einstellen kann. Auf Basis der Daten des Drehzahlsensors an der Kurbelwelle kann mittels eines Zusatzsteuergerätes ein Ventil mit 24 V Spannung angesteuert werden. Dieses wiederum beaufschlägt einen Kolben mit bis zu acht bar Druck, um so die Saugrohrlänge zu erhöhen. Hierfür wurde zuvor ein Kennfeld appliziert. Der Clou des Kolbens ist dabei die integrierte Feder, die das Zurückfahren des Saugrohrs ohne zusätzliche Druckleitung ermöglicht. Die Systemkomplexität wird hierdurch erheblich verringert und die Zuverlässigkeit des Antriebsstrang gesteigert.



Test bench results of different inlet lengths. / Prüfstandsergebnisse verschiedener Einlasslängen.



Team: Ecurie Aix e.V

CLASS: EV
YEAR: 2020

Keyfacts:
-> system weight of 75 g
-> gauge quality of Q3

3

CFRP-Hybrid-Gear-Set
CFK-Hybrid-Zahnradsatz

Hybrid structures in modern lightweight construction

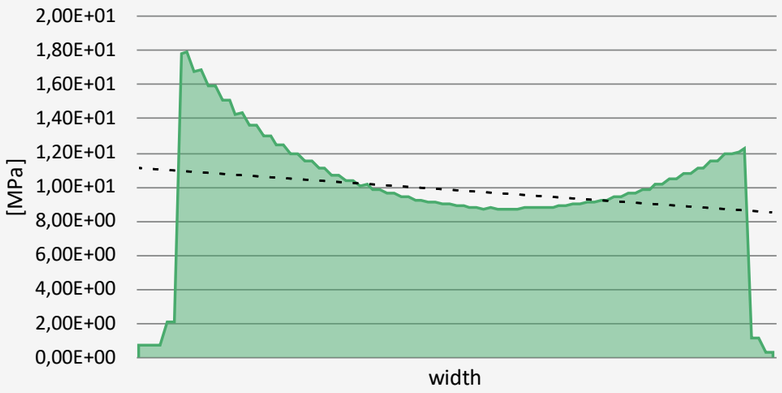
Lightweight construction has set itself the aim of realizing a structure with a minimum net weight as well as a certain durability and reliability under given boundary conditions. The associated problems concern the choice of a suitable design, lightweight materials and their joining technology, a design that is as precise as possible, and ultimately the realization in an advanced manufacturing technology. For this, on the one hand, the load must be known exactly and, on the other hand, the response of the materials used to the loads present, i.e. the material behavior, must be clear. Both are generally only possible within a variation range and must be intercepted by appropriate safety factors. Loads are superimposed by impacts, for example, and materials are subject to the usual quality fluctuations during production or processing. The ideal component would be one in which all areas are subjected to uniform, high stresses, since this would result in the best possible, with low material usage. Durable parts are naturally much larger and heavier than time-stressed parts, which is why this type of design is preferred. In motorsports, lightweight construction primarily serves to increase performance and optimize lap times, as it is one of the most sensitive vehicle parameters alongside mechanical grip or aerodynamic downforce. This is referred to as purpose-built lightweight construction. A lack of minimum

Hybride Strukturen im modernen Leichtbau

Der Leichtbau hat zum Ziel, unter gegebenen Randbedingungen, eine Struktur mit minimalem Eigengewicht sowie bestimmter Lebensdauer und Zuverlässigkeit zu realisieren. Die damit verbundenen Probleme betreffen die Wahl einer zweckgerechten Bauweise, leichter Werkstoffe und deren Fügetechnik, einer möglichst exakten Auslegung sowie letztlich die Realisierung in einer fortschrittlichen Fertigungstechnologie. Einerseits muss hierzu die Belastung genau bekannt sein und andererseits auch die Antwort der verwendeten Materialien auf die vorliegenden Belastungen, eben das Materialverhalten, verstanden werden. Beide Aspekte sind im Allgemeinen nur innerhalb eines Streubereiches möglich und müssen daher von entsprechenden Sicherheitsfaktoren abgefangen werden. Lasten werden beispielsweise durch Stöße überlagert und Werkstoffe unterliegen den üblichen Qualitätsschwankungen während der Produktion oder Verarbeitung. Ideal wäre ein Bauteil, in dem alle Bereiche gleichmäßig und hoch beansprucht werden können, um somit bestmöglicher und geringer Materialeinsatz betrieben wird. Dauerfeste Teile sind naturgemäß wesentlich größer und schwerer als zeitfeste Teile, weswegen diese Auslegungsart bevorzugt wird. Im Motorsport dient der Leichtbau primär der Performancesteigerung und Rundenzeitoptimierung, da er neben dem mechanischen Grip oder aerodynamischen

weights in Formula Student compared to conventional racing series therefore leads all too often to design decisions regarding the lightest concept, while otherwise heavier concepts with other advantages could be considered. In addition, in series development in automotive engineering, economy and ecological lightweight design are dominant and a compromise must be sought between technical and economic aspects. Composite construction, i.e. the purposeful combination of different materials according to their specific properties, is now being used more and more and offers several advantages over conventional differential construction. If the component has to meet several requirements, for example high tensile forces in one area and high wear resistance in another, hybrid combinations can prove their worth. Special technological and analytical problems, such as joining technology, must be weighed up beforehand. That is because the thermal incompatibility of the components in particular can lead to problems - residual stresses are induced by different thermal expansion. Weight-related evaluation criteria are introduced for material selection: The characteristic values here are by no means permanently constant. For example, stiffness is important for a small structural parameter (ratio of load to length), whereas strength is important for a large one. The component weight can be considered as a base or target value. A stiffness (base) can be specified, and the smallest weight (target) required, or the greatest stiffness (target) can be aimed for with a constant weight (base). Costs and strengths can also be compared.

Abtrieb zu den sensitivsten Fahrzeugparametern gehört. Daher spricht man von Zweck-Leichtbau. Ein Fehlen von Mindestgewichten in der Formula Student im Vergleich zu herkömmlichen Rennserien führt daher umso öfter zu Designentscheidungen hinsichtlich des leichtesten Konzeptes, während sonst auch schwerere Konzepte mit anderen Vorteilen ausgewählt werden würden. In der Serienentwicklung im Automobilbau sind außerdem Spar- und Öko-Leichtbau dominierend, weswegen zwischen technischen und wirtschaftlichen Gesichtspunkten ein Kompromiss angestrebt werden muss. Die Verbundbauweise, also dem zweckvollen Kombinieren verschiedene Materialien nach ihren spezifischen Eigenschaften findet mittlerweile immer mehr Verwendung und bietet gegenüber herkömmlicher Differentialbauweise einige Vorteile. Muss das Bauteil mehreren Anforderungen genügen, beispielsweise hohe Zugkräfte in einem Teilbereich und hohe Verschleißfestigkeit in einem anderen Bereich, so können sich hierfür Hybridkombinationen bewähren. Spezielle technologische und analytische Problemen, wie etwa bei der Fügetechnik, müssen zuvor abgewägt werden. Vor allem kann die thermische Unverträglichkeit der Komponenten zu Problem führen – so zum Beispiel werden durch unterschiedliche Wärmedehnung Eigenspannungen induziert. Zur Materialauswahl werden gewichtsbezogene Bewertungskriterien eingeführt: Die Kenngrößen sind hierbei keinesfalls permanent gleichbleibend. So ist bei einem kleinem Strukturkennwert (Verhältnis der Last zur Länge) die Steifigkeit wichtig, bei großem hingegen, die Festigkeit. Das Bauteilgewicht kann als Basis oder Zielgröße betrachtet werden. Es kann eine Steifigkeit (Basis) vorgegeben und ein kleinstes Gewicht (Ziel) gefordert sein oder größte Steifigkeit (Ziel) bei konstantem Gewicht (Basis) angestrebt werden. Auch können Kosten und Festigkeiten gegenübergestellt werden.



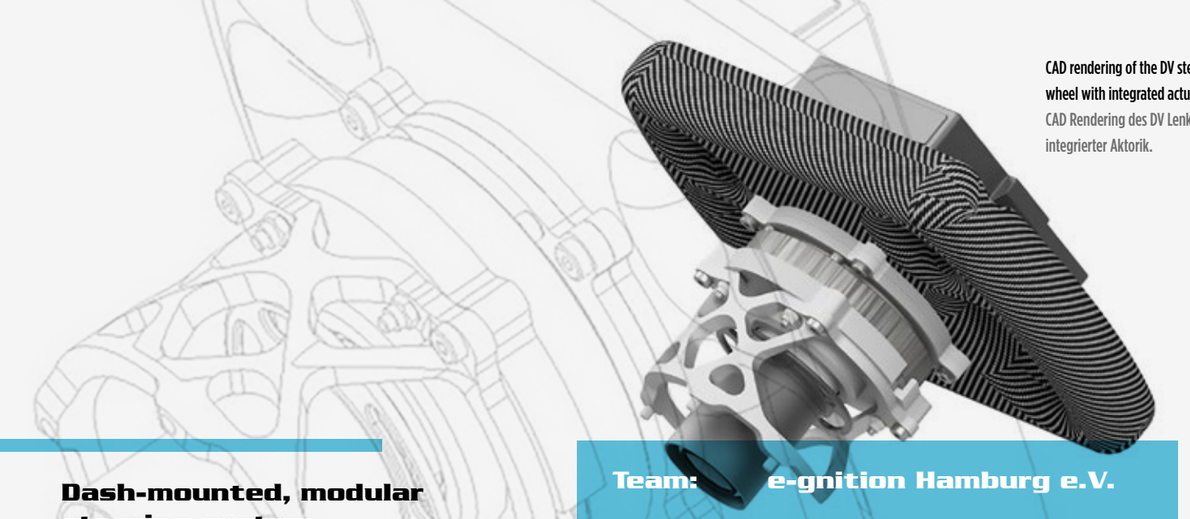
shear stress distribution in the joint. / Schubspannungsverlauf in der Verbindungsstelle.

Weight reduction through targeted material selection in the drive train of Ecurie Aix

The team uses a wheel hub drive with a high-speed electric motor in combination with a reduction gearbox, as the system has a higher power density than conventional direct drives. A multi-stage planetary gearbox meets the requirements of high transmission ratio, coaxial input and output shafts and generally compact design. Here, the ring gear of the first stages (3-shaft operation) transmits the torque to the sun of the second stage within the gearset. While high strength, hardness and toughness are the main material requirements for the teeth, the wheel body, which connects the two stages, is only subjected to a torsional load. In conjunction with subsequent grinding, case-hardened or low-pressure carburized steels can be used for this purpose. In this case, rheinitrided steels were used for the ring gear, which, due to low hardness distortion, do not have to be reground in order to achieve high gauge qualities if internal grinding is not possible. The wheel body accounts for most of the part weight and was therefore replaced by a composite structural component in the new design. Due to its high specific strength, an HT (high-tenacity) carbon fiber was selected, which is optimally utilized through targeted directional optimization with regard to the existing principal stresses in the component and draping simulations. Numerical simulations were used to analyze the shear stress curve in the joint of the materials and improve it by varying the partial stiffnesses and overlap lengths. A tooth contact analysis ensured that the tooth grip was not disadvantageous in terms of component safety due to modified conical expansion of the ring gear. 47% weight savings is the result of the hybrid design compared with the previous integral design using two joined steel components.

Gewichtsreduzierung durch gezielte Materialauswahl im Antriebsstrang von Ecurie Aix

Das Team nutzt einen Radnabenabtrieb mit hochdrehendem Elektromotor in Kombination mit einem Untersetzungsgetriebe, da das System eine höhere Leistungsdichte aufweist als herkömmliche Direktantriebe. Ein mehrstufiges Planetengetriebe erfüllt hierbei die Anforderungen einer hohen Übersetzung, koaxialen Ein- und Ausgangswellen und generell kompakter Bauweise. Das Hohlrad der ersten Stufen (3-Wellenbetrieb) überträgt hier innerhalb des Getriebes das Drehmoment auf die Sonne der zweiten Stufe. Während für die Zähne hohe Festigkeit, Härte und Zähigkeit als Anforderung an das Material gestellt werden, ist der Radkörper, der beide Stufen verbindet, lediglich einer Torsionsbelastung ausgesetzt. In Verbindung mit anschließendem Schleifen können hierzu einsatzgehärtete oder niederdruckaufgekohlte Stähle verwendet werden. In diesem Fall wurde für das Hohlrad auf rheinnitrierte Stähle zurückgegriffen, die durch geringen Härteverzug nicht nachgeschliffen werden müssen, um hohe Lehrenqualitäten zu erreichen. Innenschleifen war durch die Bauteilgröße nicht möglich gewesen. Der Radkörper macht den größten Teil des Teilegewichts aus und wurde daher bei der Neukonstruktion durch ein Strukturbauteil aus Verbundwerkstoff ersetzt. Durch die hohe spezifische Festigkeit wurde eine HT (high-tenacity) Carbonfaser ausgewählt, welche durch gezielte Richtungsoptimierung hinsichtlich der vorliegenden Hauptspannungen im Bauteil und Drapiersimulationen optimal ausgenutzt wird. Mittels numerischer Simulationen wurde der Scherspannungsverlauf in der Fügestelle der Materialien analysiert und durch Variieren der Teilesteifigkeiten und Überlappungslängen verbessert. Durch eine Zahnkontaktanalyse wurde sichergestellt, dass der Zahngriff durch veränderte konische Aufweitung des Hohlrades nicht nachteilig hinsichtlich der Bauteilsicherheit ausfällt. 47% Gewichtsersparnis sind das Ergebnis der Verbundbauweise gegenüber der vorherigen Integralbauweise von zwei gefügten Stahlbauteilen.



CAD rendering of the DV steering wheel with integrated actuators. / CAD Rendering des DV Lenkrad mit integrierter Aktorik.

Dash-mounted, modular steering system
Modulares Lenkssystem

Team: e-gnition Hamburg e.V.

CLASS: DV
YEAR: 2020

Keyfacts:
-> modular steering system
-> fast installation time

4

Challenges in the design of a hybrid Formula Student car

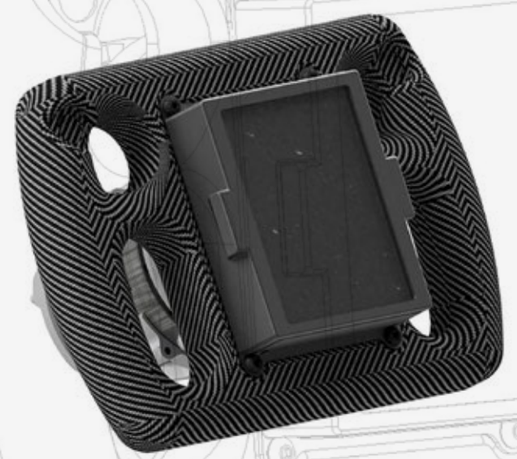
The announcement to merge the previously existing Driverless, Electric and Internal Combustion classes to FSG21, later postponed to FSG22 due to the pandemic, posed a fundamental question to the teams at the beginning of their development and design phase: How do we best respond to this change to ensure a smooth transition and high vehicle performance to be competitive right in the first year?
Whereas the majority of teams had previously converted existing older vehicles in order to participate in the autonomous competitions, the task now is to plan for the necessary hardware as early as possible in the concept phase. This creates a number of new opportunities, but also challenges, particularly in the packaging of the components. Many monocoques did not offer enough space to place the car PC or actuators inside, which is why external housings often had to be fitted. Now, appropriate changes can be made to find a better overall concept in terms of balance or center of gravity height. The placement of the sensors and their influence on the aerodynamics must also be considered so that the best possible downforce can still be generated in the disciplines with drivers. The interface to the driver is just as crucial. A good compromise must be found for the steering and braking systems so that the driver is not impaired, but autonomous driving is also possible. The rapid development of the teams in software development is now pushing some older cars close to their performance limits, which is why a vehicle at the current stage of development in the other assemblies would benefit here. In the case of the modified mechanical components, the focus was previously on reliability, simple and fast production and maintainability, as the test time on the track was to be maximized in order to apply the software as well as possible. For FSG22, this target definition will probably change quite a bit, since the integration will have a negative impact on performance with drivers anyway. The cars will be heavier, have a higher center of gravity and changed aerodynamics and the teams will try to compensate the loss of lap time in other places.

Herausforderungen bei der Konstruktion eines hybriden Formula Student Fahrzeugs

Die Ankündigung, die zuvor bestehenden Klassen Driverless, Elektrik und Verbrenner zur FSG21 beziehungsweise FSG22, zusammenzulegen stellte die Teams zu Beginn ihrer Entwicklungs- und Konstruktionsphase vor eine grundlegende Frage: Wie reagieren wir bestmöglich auf diese Veränderung, um einen reibungslosen Übergang und hohe Fahrzeug Performance sicherzustellen, um direkt im ersten Jahr wettbewerbsfähig zu sein?
Wurden zuvor von einem Großteil der Teams bestehende Altfahrzeuge umgebaut, um an den autonomen Wettbewerben teilzunehmen, gilt es jetzt die nötige Hardware bereits bestmöglich in der Konzeptphase einzuplanen. Insbesondere beim Packaging der Komponenten ergeben sich hierdurch einige neue Möglichkeiten, aber auch Herausforderungen. Viele Monocoques boten nicht genügend Platz, um Car-PC oder Aktorik innerhalb zu platzieren, weswegen oftmals externe Gehäuse angebracht werden mussten. Nun können entsprechende Änderungen vorgenommen werden, um hinsichtlich Balance oder Schwerpunktshöhe ein besseres Gesamtkonzept zu finden. Auch müssen die Platzierung der Sensoren und deren Einfluss auf die Aerodynamik betrachtet werden, damit in den Disziplinen mit Fahrer trotzdem bestmöglich Abtrieb generiert werden. Die Schnittstelle zum Fahrer ist ebenso entscheidend. Ein guter Kompromiss muss bei den Systemen Lenkung und Bremse gefunden werden, damit der Fahrer nicht beeinträchtigt wird, aber ebenso auch ein autonomer Fahrbetrieb möglich ist. Die rasante Entwicklung der Teams in der Softwareentwicklung bringt einige ältere Autos mittlerweile nah an ihre Leistungsgrenze, weswegen hier von einem Fahrzeug auf dem aktuellen Entwicklungsstand in den anderen Baugruppen profitiert wird. Bei den nachgerüsteten mechanischen Bauteilen stand zuvor noch Zuverlässigkeit, einfache und schnelle Fertigung und Wartbarkeit im Vordergrund, da die Testzeit auf der Strecke maximiert werden sollte, um die Software möglichst gut zu applizieren. Bedingt durch die strategischen Änderungen zur FSG22 wird sich an dieser Zielwertdefiniton vermutlich einiges ändern, da sich die Integration ohnehin negativ auf die Performance mit Fahrer auswirken wird. Die Fahrzeuge werden schwerer, haben einen höheren Schwerpunkt und veränderte Aerodynamik und die Teams werden versuchen den Rundenzeitverlust an anderen Stellen zu kompensieren.

Concept of a modular steering system for both, EV & DV class

While the removal of complete steering systems, which are housed inside the chassis, usually takes a very long time and on top of that loosens bolted connections and changes systems, which are checked within the scrutinieering, all vehicles have quick disconnect couplings on the steering wheel. The e-gnition team has therefore developed an actuation system that is housed inside the steering wheel. Two steering wheels, one for manual and one for autonomous driving, allow unrestricted operation in the EV class in terms of vehicle weight and steering resistance. The steering wheel for use in DV competition has a brushless DC motor, which can provide up to 15Nm of torque in conjunction with a reduction gearbox. A direct drive would not have been able to meet the tight restrictions of the installation space. The torque is supported by three shear bolts, which are inserted into corresponding holes in the dashboard when the steering wheel is mounted. The steering wheel is made of carbon in a shell construction with aluminum molds and also has an integrated display on which the driver can call up important information. The weight of the entire assembly is approximately 1.5 kg.



Konzept eines modularen Lenksystems für beide EV- und DV-Klassen

Während der Ausbau von vollständigen Lenkradsystemen, die innerhalb des Chassis untergebracht sind, meist sehr lange dauert und obendrein Schraubverbindungen löst und Systeme verändert, welche innerhalb des Scrutinieering überprüft werden, verfügen alle Fahrzeuge über Schnelltrennkupplungen am Lenkrad. Das e-gnition Team hat daher eine Aktuierung entwickelt, welche innerhalb des Lenkrads untergebracht ist. Zwei Lenkräder, einmal für den manuellen und einmal autononem Fahrbetrieb, ermöglichen somit uneingeschränkten Betrieb in der EV Klasse hinsichtlich Fahrzeuggewicht und Lenkwiderstand. Das Lenkrad für den Einsatz im DV Wettbewerb verfügt über einen bürstenlose Gleichstrommotor, welcher in Verbindung mit einem Untersetzungsgetriebe bis zu 15Nm Drehmoment stellen kann. Ein Direktantrieb hätte auch hier die engen Restriktionen vom Bauraum nicht einhalten können. Abgestützt wird das Drehmoment über drei Scherbolzen, welche beim Aufstecken des Lenkrades in einsprechende Bohrungen im Dashboard eingeführt werden. Das Lenkrad ist in Schalenbauweise in Aluminiumformen aus Carbon gefertigt und verfügt außerdem über ein integriertes Display auf welchem der Fahrer wichtige Informationen abrufen kann. Das Gewicht der gesamten Baugruppe beläuft sich auf ungefähr 1,5 kg.

Highly integrated e-packaging with innovative inverter housing

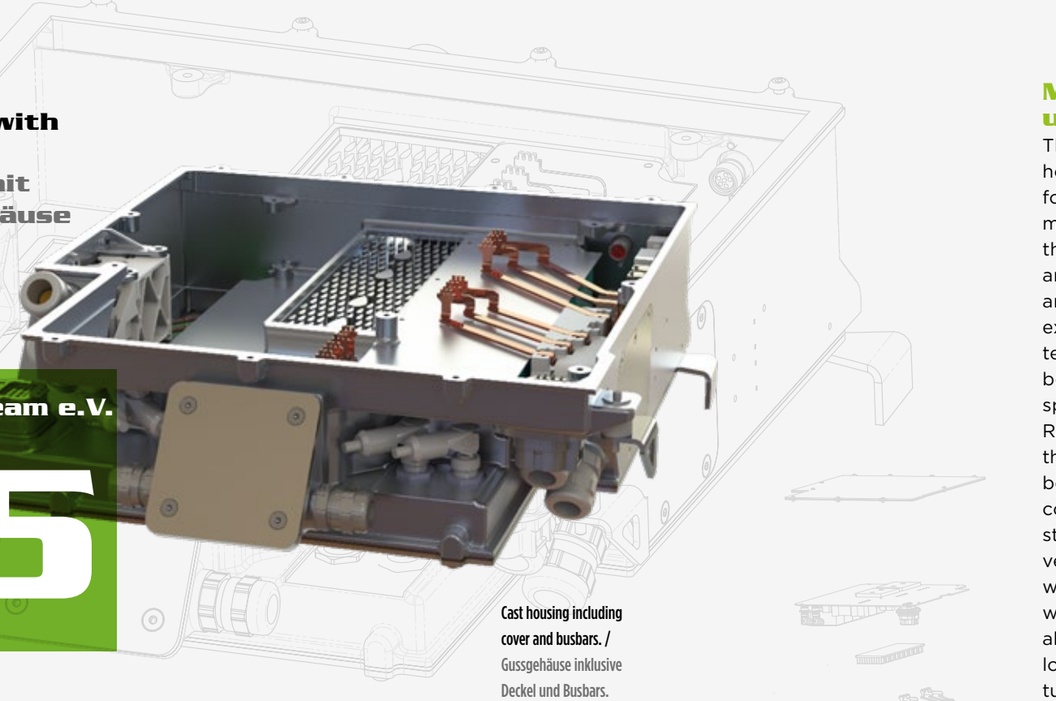
Hochintegriertes E-Packaging mit innovativem Wechselrichtergehäuse

Team: **Racetech Racing Team e.V.**

CLASS: EV
YEAR: 2021

Keyfacts:
-> multi-material usage
-> optimized packaging

5



Cast housing including cover and busbars. / Gussgehäuse inklusive Deckel und Busbars.

4WD – Powertrain integration

30 of the 43 participating teams in the FSG21 EV class rely on all-wheel drive with wheel hub motors in their powertrains. In recent years, this concept has gained acceptance due to its high power density, advantages in chassis design and aerodynamics, and vehicle weight, and has prevailed over inboard drives. High integration of the wheel hub and rim with the transmission allow the drive to be housed completely within the tire.

For the remaining main components, battery and inverter, either one dual inverter each is fitted in the front end under the driver's legs and one above the battery in the rear end, or both systems are housed entirely in the rear end. While the separated inverter offers a better center of gravity, it has some disadvantages over a quad inverter for wiring, weight and aerodynamics. Systems based on SiC MOSFETs instead of conventional IGBTs represent the current state of the art and allow very fast switching times and high switching frequencies in order to minimize system losses and drive the motors with a better sinusoidal curve. The modules also consume less installation space.

However, the high electrical complexity of inverters and the associated long development time, combined with limited human resources, often forces teams to rely on a purchased system, which usually deviates slightly from the target parameters of the cars, as it tends to be oversized, and, in terms of lightweight construction, cooling and integration, only meets the requirements of a race car to a limited extent.

4WD – Antriebsstrang-integration

30 der 43 teilnehmenden Teams in der EV Klasse der FSG21 setzen in ihrem Antriebsstrang auf einen Allradantrieb mit Radnabenmotoren. In den vergangenen Jahren hat sich dieses Konzept auf Grund der hohen Leistungsdichte, Vorteile bei der Chassis-Konstruktion und Aerodynamik und Fahrzeuggewicht gegen innenliegende Antriebe durchgesetzt. Hohe Integration von Radnabe und Felge mit dem Getriebe ermöglichen es, den Antrieb vollständig innerhalb des Reifens unterzubringen.

Für die verbleibenden Hauptkomponenten, Batterie und Umrichter werden wahlweise je ein Dual-Inverter im Vorderwagen unter den Beinen des Fahrers und einer über der Batterie im Hinterwagen vorgesehen oder beide Systeme vollständig im Hinterwagen untergebracht. Während der getrennte Umrichter einen besseren Schwerpunkt bietet, hat er Zwecks Verkabelung, Gewicht und Aerodynamik einige Nachteile gegenüber einem Quad-Inverter. Systeme auf Basis von SiC MOSFETs anstelle herkömmlicher IGBT stellen den aktuellen Stand der Technik dar und erlauben sehr schnelle Schaltzeiten und hohe Schaltfrequenzen, um zum einen Systemverluste zu minimieren und die Motoren mit einer besseren Sinus-Kurve anzusteuern. Die Module brauchen außerdem einen geringeren Bauraum.

Die hohe elektrische Komplexität von Umrichtern und damit verbundene lange Entwicklungszeit in Verbindung mit begrenzten personellen Ressourcen zwingt Teams jedoch oftmals dazu auf ein Kaufsystem zu setzen, welches meist leicht von den Zielparametern der Autos abweicht. Zudem ist dieses System tendenziell überdimensioniert und genügt bei den Themen Leichtbau, Kühlung und Integration nur bedingt den Ansprüchen an ein Rennauto.

Multi-material & technology usage for the RT14

The Freiberg team impressively demonstrates how such a purchased system can be optimized for use in Formula Student through targeted modifications and reverse engineering, as well as the use of different manufacturing technologies and materials. Only the electrical components and circuit boards were taken over, the rest was exchanged and the two dual inverters were integrated into a single housing. The weight could be reduced by 60% to 6kg and the installation space by 35%.

Racetech manufactured the inverter housing for the RT14 from AlSiMg0.6 with wall thicknesses between 2 and 3mm. This is complemented by covers made of magnesium. An analysis of the standard heat sink using CFD simulations revealed considerable potential to save cooling and weight and was therefore replaced by a cooler with a “pinfin design”. These droplet profiles still allow very good heat transfer with minimal flow losses. Separations in the previous cooling structure could also be eliminated. Since there are high demands on surface quality, the heat sink was designed as a separate milled part, welded into the housing and subsequently face-milled again with reference to the joints in the housing.

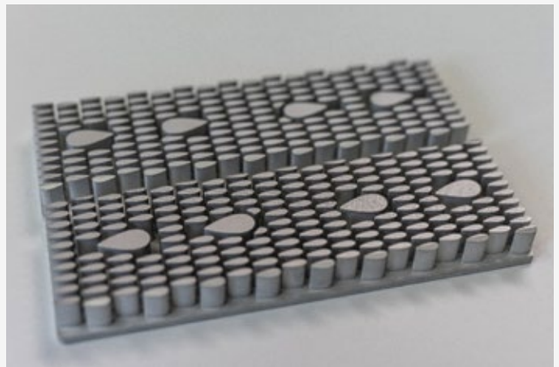
Casting and machining are supplemented by additive manufacturing in the form of plastic printing (SLS) and aluminum printing (SLM). For example, some components for guiding and attaching the self-developed busbars were designed, which have further saved volume through improved use of installation space. Compared to conventional cables, the copper and aluminum busbars can not only be made flatter, but also allow tighter runs and folds in the housing, since they are not limited by any possible bending radi of the cables. The geometrical flexibility made possible by the additive manufacturing process has played a significant role in the high level of functional integration that has been achieved within the converter, while at the same time being fully compliant with regulations. Not only were the lightweight design and installation space objectives achieved at the assembly level, but the goal of an aerodynamically optimized chassis geometry was also realized for the overall vehicle in order to improve lap times.

Multi-Material- & Technologieeinsatz für den RT14

Das Freiberger Team zeigt eindrucksvoll wie ein solches Kaufsystem für den Einsatz in der Formula Student durch gezielte Änderungen und Reverse Engineering, sowie den Einsatz verschiedener Fertigungstechnologien und Materialien optimiert werden kann. Lediglich die elektrischen Komponenten und Platinen wurden übernommen, der Rest wurde ausgetauscht und die zwei Dual-Inverter in ein gemeinsames Gehäuse integriert. Das Gewicht konnte um 60% auf 6kg und der Bauraum um 35% verringert werden.

Racetech hat für den RT14 das Invertergehäuse aus AlSiMg0,6 mit Wandstärken zwischen 2 und 3mm gefertigt. Ergänzt wird dieses durch Deckel aus Magnesium. Eine Analyse des Standard-Kühlkörpers mittels CFD-Simulationen offenbarte erhebliches Potenzial, Kühlung und Gewicht einzusparen und wurde daher von einem Kühler mit „Pinfin-Design“ ersetzt. Diese Tropfenprofile ermöglich bei geringsten Strömungsverlusten trotzdem einen sehr guten Wärmeübergang. Ablösungen in der vorherigen Kühlstruktur konnten zusätzlich eliminiert werden. Da hohe Anforderungen an die Oberflächengüte bestehen, wurde der Kühlkörper als separates Frästeil ausgeführt, in das Gehäuse eingeschweißt und nachträglich erneut plangefräst.

Ergänzt werden Guss- und zerspanende Fertigung von additiver Fertigung in Form von Kunststoffdruck (SLS) und Alumniumdruck (SLM). So wurden einige Bauteile zur Führung und Anbringung der selbstentwickelten Stromschienen designt, welche durch verbesserte Bauraumausnutzung weiter Volumen eingespart haben. Im Vergleich zu herkömmlichen Kabeln, können die Kupfer- und Alu-Schienen nicht nur flacher ausgeführt werden, sondern ermöglichen auch engere Verläufe und Knicke im Gehäuse, da man nicht von etwaigen Biegeradius der Kabel limitiert ist. Die Geometriefreiheiten, die durch den additiven Fertigungsprozess ermöglicht wurden, haben erheblichen Anteil an der hohen Funktionsintegration, die innerhalb des Umrichters umgesetzt werden konnte und sind gleichzeitig vollends regelkonform. Nicht nur auf Baugruppenebene konnten die Zielsetzungen an Leichtbau und Bauraum erreicht, sondern auch für das Gesamtfahrzeug das Ziel einer aerodynamisch optimierten Chassis-Geometrie realisiert werden, um die Rundenzeit zu verbessern.



Pinfin-Cooling-Structure. / Pinfin-Kühlstruktur.

Formula Bharat

A look beyond the horizon: Formula Student in India
Ein Blick über den Tellerrand: Formula Student in Indien

Written by Cathy D'Souza and Theresa Stach

Cathy D'Souza
Event Manager in Formula Bharat

Pit lane Formula Bharat. / Boxengasse Formula Bharat.

Cathy D'Souza brings a lot of experience in the field of Formula Student. As the current event manager of Formula Bharat, she is organizing the Formula Student competition in India. She gives us an impressive glimpse into her Formula Student life path, an interesting insight into the Indian competition and, as well, useful advice for participating FS students.

Cathy D'Souza bringt reichlich Erfahrung im Bereich der Formula Student mit. Als aktuelle Eventmanagerin der Formula Bharat leitet sie den Formula Student Wettbewerb in Indien. Sie gibt uns einen spannenden Einblick in ihren FS Lebensweg, blickt mit uns hinter die Kulissen des indischen Wettbewerbs und teilt nützliche Tipps für teilnehmende FS-Studierende.

How did you get in contact with FS and what is your long-term motivation?

I joined the University of Toronto Racing Team in 2007 as a Business Team member because I was fascinated by the race car project. I eventually took up roles on the Engine Team and in my final year, led the team as Team Manager. During my time on the team, I attended the Formula SAE Michigan and Formula Student Germany competitions.
After my last competition as a student at FSG 2010, myself along with a few of my team mates from UofT Racing decided to launch a Formula Student event in Canada. We always thought that having an event on home soil would be a great opportunity for fellow Canadian teams and would also provide exposure to the Formula Student series amongst our peers. We also wanted to bring aspects of the FSG event at Formula North – indoor pits and the warm hospitality. I personally felt that I learnt so much on the team and it was with that passion that I championed the Formula North project. With the help of family and friends, we launched Formula North in May 2012. The banner was completely not-for-profit and we only hired our first part-time paid event manager after the 2016 event. The event ran independently until 2018, after which it officially moved under the SAE International banner.
Around the end of 2014, I made a 'temporary' move to India. Short version: I married in a year and was approached by FS alumnus in India (including Claude Rouelle, Pat Clarke, Peter Jones and Steve Fox) in 2016 to launch an FS event here that would meet international levels. In 2017, we ran the first Formula Bharat event and it has been consecutively running every January at the Kari Motor Speedway since, bar January 2021 due to the pandemic.

Wie bist du mit der FS in Kontakt gekommen und was ist deine langfristige Motivation?

Ich bin 2007 dem University of Toronto Racing Team als Mitglied des Business Teams beigetreten, weil mich das Projekt faszinierte. Schließlich übernahm ich eine Rolle in der Abteilung, die für den Motor zuständig ist. In meinem letzten Jahr leitete ich das Team als Teammanagerin. Während meiner Zeit im Team nahm ich an den Wettbewerben Formula SAE Michigan und Formula Student Germany teil.

Nach meinem letzten Wettbewerb als Studentin bei der FSG 2010 beschloss ich zusammen mit ein paar meiner Teamkollegen von UofT Racing, ein Formula Student Event in Kanada zu starten. Wir dachten immer, dass ein Event auf heimischem Boden eine großartige Gelegenheit für andere kanadische Teams wäre und auch die Formula Student Serie unter unseren Kollegen bekannt machen würde. Wir wollten auch Aspekte des FSG-Events in die Formula North einbringen – beispielsweise die Indoor-Boxen und die herzliche Gastfreundschaft. Ich persönlich hatte das Gefühl, dass ich im Team so viel lernen durfte. Mit der gleichen Leidenschaft habe ich mich anschließend für das Formula North-Projekt eingesetzt. Mit der Hilfe von Familie und Freunden starteten wir die Formula North im Mai 2012. Sie war komplett gemeinnützig und wir stellten erst nach der Veranstaltung 2016 unseren ersten teilzeitbeschäftigten Eventmanager ein. Die Veranstaltung lief bis 2018 unabhängig von anderen Wettbewerben, danach wechselte sie offiziell unter die Schirmherrschaft der SAE International.
Gegen Ende des Jahres 2014 zog ich „vorübergehend" nach Indien.
Kurzfassung: Ich heiratete innerhalb eines Jahres und wurde 2016 von FS-Alumni in Indien (darunter Claude Rouelle, Pat Clarke, Peter Jones und Steve Fox) angesprochen, mit der Idee hier ein FS-Event auf die Beine zu stellen, das internationalem Niveau entspricht. Im Jahr 2017 haben wir das erste Formula Bharat-Event durchgeführt, das seitdem jeden Januar auf dem Kari Motor Speedway stattfindet – abgesehen vom Januar 2021, aufgrund der Pandemie.

Volunteers Formula Bharat 2020.

Can you give us a short insight into Formula Bharat?

Formula Bharat was launched by FS Indian Alumni to develop a platform in India that would meet International FS competition standards. Formula Bharat's purpose is simple – providing a platform for engineering students to get hands-on practical experience, while building a prototype that would meet international engineering standards. With the assistance of various advisors from FS events all over the world, the event continues to improve its platform and its delivery to participants and sponsors. Formula Bharat hopes to become THE platform in India that will foster innovation in the mobility engineering domain in the country (and all over South Asia), for many years to come.

What are the main differences between FSAE and Formula Bharat?

In the most literal sense, Formula Bharat uses the Formula Student rule book, produced by Formula Student Germany.

Is there something unique at Formula Bharat?

Since FSG's entry into the Formula Student domain in 2006, we have seen many Formula Student competitions around the world launch with FS Alumni backing. Such is also the case for Formula Bharat. But what makes Formula Bharat more unique is the reason behind its launch. FS Indian Alumni at the time felt that there was no platform in India at the time that could push them to match international levels. Many teams that were delivering better results each year also felt that their growth had stagnated. Also within the international community, teams from India back in 2016 and earlier, were not looked at with the same lens as those from western nations – their international peers would assume that Indian teams were on a lower innovation and performance level, and that Indian teams would be unable to match their level of competitiveness. I feel that this perception and the need to change it, drives the FS Alumni at Formula Bharat even more to continue their work here. It is this reason that makes Formula Bharat unique.

Where do you see Formula Bharat in 10 years?

Formula Bharat just introduced the Electric Vehicle category in 2018. Although we are thinking about the Driverless Category, we still have ways to go with EV. In the short term, we hope to bridge the gap within EV teams on cohesive collaborations between the mechanical and electrical departments. Only by creating an A+ teams, will we hope to see increased 'finishers' at the Endurance event.
In 10 years, Formula Bharat hopes to become the South Asian event that meets the competitiveness level of its international peers.

How does the sponsorship work for the Indian teams and Formula Bharat?

In present day, same as elsewhere in the world: word-of-mouth, personal introductions, 2 minute pitches, and if teams are lucky, then college funding is possible.
However, compared to 6-7 years ago, today, corporate India has become digital and so have their CSR initiatives. Hence approaching a large corporation is much easier than it was before.
As for Formula Bharat, many new sponsors have arrived with a focus on the EV category. With the Indian Government's goal of an all-electric mobility industry by 2030, funding initiatives have been largely dedicated to this segment.

Team Defianz Racing,
Formula Bharat 2020.

Kannst du uns einen kurzen Einblick in die Formula Bharat geben?

Die Formula Bharat wurde von FS Indian Alumni ins Leben gerufen, um in Indien ein Eventformat zu entwickeln, das den internationalen FS-Wettbewerbsstandards entspricht. Der Zweck der Formula Bharat ist einfach: eine Plattform für Studierende der Ingenieurswissenschaften zu schaffen, um praktische Erfahrungen zu sammeln und gleichzeitig einen Prototypen zu bauen, der den internationalen Ingenieur Standards entspricht. Mit der Unterstützung verschiedener Berater von FS-Veranstaltungen auf der ganzen Welt wächst die Veranstaltung kontinuierlich und erweitert ihre Möglichkeiten sowie ihr Angebot für Teilnehmer und Sponsoren. Formula Bharat hofft, DIE Plattform in Indien zu werden, die die Innovation im Bereich der Mobilitätstechnik im Land (und in ganz Südasien) für viele Jahre fördern wird.

Was sind die Hauptunterschiede zwischen FSAE und Formula Bharat?

Die Formula Bharat nutzt das Regelwerk der Formula Student, welches von der Formula Student Germany erstellt wurde.

Gibt es aus deiner Sicht etwas Einzigartiges bei der Formula Bharat?

Seit dem Einstieg der FSG in die Formula Student im Jahr 2006 haben wir gesehen, wie viele Formula Student Wettbewerbe auf der ganzen Welt mit Unterstützung von FS Alumni gestartet sind. Das ist auch bei der Formula Bharat der Fall. Aber was die Formula Bharat noch einzigartiger macht, ist der Grund für ihren Start. Die indischen FS Alumni hatten damals das Gefühl, dass es in Indien keine Plattform gab, die sie auf ein internationales Niveau bringen konnten.

Viele Teams, die sich Jahr für Jahr weiterentwickelten und kontinuierlich bessere Ergebnisse lieferten, hatten zudem das Gefühl, dass ihr Wachstum stagnierte. Auch innerhalb der internationalen Gemeinschaft wurden Teams aus Indien bis 2016 nicht mit den gleichen Augen gesehen wie die aus westlichen Nationen. Ihre internationalen Kollegen gingen davon aus, dass indische Teams auf einem niedrigeren Innovations- und Leistungsniveau waren und somit nicht in der Lage, ihr Wettbewerbsniveau zu erreichen. Ich habe das Gefühl, dass diese Wahrnehmung und die Notwendigkeit, dies zu ändern, die FS Alumni bei Formula Bharat noch mehr angetrieben hat bzw. weiterhin antreibt, ihre Arbeit hier fortzusetzen. Diese Motivation macht die Formula Student Bharat einzigartig.

Wo siehst du die Formula Bharat in 10 Jahren?

Formula Bharat hat 2018 die Elektroklasse (EV) eingeführt. Obwohl wir über autonomes Fahren bereits nachdenken, haben wir mit EV noch einen langen Weg vor uns. Kurzfristig hoffen wir, die Lücke innerhalb der EV-Teams zu schließen, indem wir die Zusammenarbeit zwischen den mechanischen und elektrischen Abteilungen verbessern. Nur durch die Etablierung von A+-Teams werden wir hoffentlich mehr „Finisher" beim Endurance-Event sehen.

In 10 Jahren hofft die Formula Bharat, die südasiatische Veranstaltung zu werden, die das Wettbewerbsniveau ihrer internationalen Kollegen erreicht.

Wie funktioniert das Sponsoring für die indischen Teams und die Formula Bharat?

Heutzutage genauso wie anderswo auf der Welt: Mund-zu-Mund-Propaganda, persönliches Vorstellen, 2-Minuten-Pitches, und wenn die Teams Glück haben, dann ist die Unterstützung durch die Universität möglich.

Aber im Vergleich zu den vergangenen 6-7 Jahren sind die indischen Unternehmen heute digital geworden und damit auch ihre CSR-Initiativen. Daher ist es viel einfacher, an ein großes Unternehmen heranzukommen als früher.
Was die Formula Bharat betrifft, so sind viele neue Sponsoren zu Tage getreten, die sich auf die EV-Kategorie konzentrieren. Mit dem Ziel der indischen Regierung, bis zum Jahr 2030 eine rein elektrische Mobilitätsindustrie zu schaffen, sind die Finanzierungsinitiativen weitgehend auf dieses Segment ausgerichtet.

What was your best FS-moment?

Hands-down, post Awards at Formula Bharat 2020.
Engineering students have always known education to be a very competitive domain. It is typical to be secretive about everything. Hence this culture was very predominant in the Indian Formula Student landscape for many years. In 2017, we vowed to change that and introduce the concept of 'Comradery in the paddock, competition on the track'. The Formula Bharat organizing team believes that in order for Indian teams to rise to a competitive level, they must rise together and they must foster the concept of being open to learn from each other and share resources, when possible. Post Awards Ceremony at FB2020 was such an amazing sight for the eyes. Teams were wishing each other in their efforts and many consoled those who didn't perform so well. Teams took group photos together and shared their team apparel. It was a sight of the true Formula Student spirit. It gave hope for great things to come and I truly was so proud that moment to be a part of the Formula Bharat journey.

What is your advice for young students participating FS?

Formula Student is such an amazing platform for engineering students to build their all-rounded skills. Getting involved in the platform forces you to network, adapt and assess your potential. As an individual, you not just learn more about the trade of building a race car, but you also learn so much about yourself. My advice to new students in FS would be to keep learning – no job is ever too small, so it's important to keep your pride and ego aside. Building a race car can be daunting but you will get to be the 'expert' on the team soon enough. Be realistic with your reasons as to why you want to be on an FS team. If you show up the first time, show up every time. Don't expect to be called or asked for, instead, ask where you can help, every single time. It's truly the best way to learn and grow.

My top go-to list of characteristics to any new FS participant would be: Communicate, Persevere, be Reliable and be Realistic.

Was war einer deiner schönsten FS Momente?

Zweifellos: Die Momente nach dem Abschluss der Formula Bharat 2020.

Ingenieurstudierende haben schon immer gewusst, dass die Ausbildung eine sehr wettbewerbsintensive Domäne ist. Es ist oft die Regel, dass man um alles ein Geheimnis macht. Daher war diese Kultur viele Jahre lang in der indischen Formula Student-Landschaft sehr weit verbreitet. 2017 haben wir uns geschworen, das zu ändern und das Konzept „Kameradschaft im Fahrerlager, Wettbewerb auf der Strecke" einzuführen. Das Organisationsteam der Formula Bharat glaubt, dass indische Teams nur dann auf ein konkurrenzfähiges Niveau aufsteigen können, wenn sie zusammenarbeiten und das Konzept fördern, offen dafür zu sein, voneinander zu lernen und Ressourcen zu teilen, wenn möglich. Die Preisverleihung nach der FB2020 war ein einmaliger Anblick für uns. Die Teams beglückwünschten sich gegenseitig zu ihren Erfolgen und viele trösteten diejenigen, die nicht so gut abgeschnitten hatten. Die Teams machten gemeinsame Gruppenfotos und teilten ihre Teamkleidung. Es war ein Anblick von echtem Formula Student-Geist. Es gab Hoffnung für große Dinge, die noch kommen werden, und ich war in diesem Moment wirklich so stolz, ein Teil der Formula Bharat-Reise zu sein.

Was ist Dein Rat für junge Studierende, die an der FS teilnehmen?

Die Formula Student ist eine großartige Plattform für Studierende der Ingenieurswissenschaften, um ihre vielseitigen Fähigkeiten auszubauen. Die Teilnahme an der Plattform zwingt einen dazu, sich zu vernetzen, sich anzupassen und sein Potenzial einzuschätzen. Als Individuum lernt man nicht nur mehr über das Handwerk, einen Rennwagen zu bauen, sondern auch so viel über sich selbst. Mein Rat an neue Studierende in der FS wäre, weiter zu lernen – keine Aufgabe ist jemals zu klein, also ist es wichtig, seinen Stolz und sein Ego beiseite zu lassen. Einen Rennwagen zu bauen, kann angsteinflösend sein, aber man wird noch schnell genug zu einem „Experten" im Team heranwachsen. Seid realistisch mit euren Gründen, warum ihr in einem FS-Team sein wollt. Wenn ihr beim ersten Mal auftaucht, taucht jedes Mal auf. Erwartet nicht, dass man euch ruft oder fragt, sondern fragt selbständig jedes Mal, wo ihr helfen könnt.

Das ist wirklich der beste Weg, um zu lernen und zu wachsen. Meine Top-Liste von Eigenschaften für jeden neuen FS-Teilnehmer wäre: Kommuniziert, bleibt hartnäckig, seid verlässlich und realistisch.

FIND FURTHER PARTS...

We asked Cathy additionaly:

Can you name some of your biggest obstacles you had to face during your FS-time?

What are the key fact you learned while building FS competitions?

What kind of impact had the pandemic on Formula Bharat and how did the competition in January look like under these circumstances?

ERFAHRE NOCH MEHR...

Wir haben Cathy außerdem gefragt:

Was waren die größten Hindernisse, denen du während deiner FS-Zeit begegnet bist?

Was sind die wichtigsten Dinge, die du beim Aufbau von FS-Wettbewerben gelernt hast?

Welchen Einfluss hatte die Pandemie auf die Formula Bharat und wie sah der Wettbewerb im Januar unter diesen Umständen aus?

https://formulabharat.com

Participating Formula Student Combustion TEAMS 2021

Teams

https://fsg.one/cv21

Car	City/University	Country	Pit	Page
211	Wrocław TU	Poland	M-03	109
212	Kempten UAS	Germany	M-02	106
218	Sevilla U	Spain	M-15	107
229	Stuttgart U	Germany	M-18	108
239	Heilbronn UAS	Germany	M-14	105
243	Pisa U	Italy	M-13	107
248	Bochum U	Germany	M-17	103
249	Erlangen U	Germany	M-08	104
250	Lübeck TH	Germany	M-21	106
258	Paderborn U	Germany	M-16	106
269	Hamburg UAS	Germany	M-20	105
281	Ecully ECL	France	M-04	103

Car	City/University	Country	Pit	Page
285	Padova U	Italy	M-12	107
288	Bologna U	Italy	M-10	103
294	Esslingen UAS	Germany	M-05	104
313	Berlin TU	Germany	M-11	102
314	Vigo U	Spain	M-07	109
321	Stralsund UAS	Germany	M-22	108
372	Hamburg HSU	Germany	M-19	104
395	Valéncia UPV	Spain	M-06	108
399	Karlsruhe UAS	Germany	M-09	105

STATUS/STAND: 21.07.2021

Participating Formula Student Electric TEAMS 2021

Teams

https://fsg.one/ev21

Car	City/University	Country	Pit	Page
13	München UAS	Germany	14-B	118
15	Madrid TU	Spain	37-A	117
16	New Delhi IIT	India	44-A	118
18	Diepholz UAS	Germany	32-A	112
20	Hannover U	Germany	44-B	114
21	Karlsruhe KIT	Germany	41-B	115
23	Amberg OTH	Germany	14-A	110
25	Athens TU	Greece	16-A	110
26	Stuttgart U	Germany	23-B	121
29	Bayreuth U	Germany	17-B	111
31	München TU	Germany	38-B	118
34	Ingolstadt UAS	Germany	29-A	115
35	Wolfenbüttel UAS Ostfalia	Germany	31-A	122
41	Wien TU	Austria	20-A	122
43	Konstanz UAS	Germany	12-A	116
50	Lisboa IST	Portugal	29-B	117
51	Sevilla U	Spain	35-A	121
53	Kiel UAS	Germany	32-B	116
54	Barcelona UPC	Spain	35-B	111
59	Dresden TU	Germany	10-A	113

Car	City/University	Country	Pit	Page
60	Nürnberg GSO UAS	Germany	40-A	119
62	Regensburg OTH	Germany	26-A	120
63	Trondheim NTNU	Norway	20-B	122
71	Ilmenau TU	Germany	19-A	115
76	Freiberg TU	Germany	43-A	113
77	Stuttgart DHBW	Germany	07-A	121
85	Delft TU	Netherlands	04-A	112
96	Zwickau UAS	Germany	41-A	123
97	Schweinfurt UAS	Germany	38-A	120
99	Aachen RWTH	Germany	07-B	110
101	Mannheim DHBW	Germany	17-A	117
127	Lausanne EPFL	Switzerland	22-A	116
130	Saarbrücken U Saarland	Germany	47-A	120
153	Graz TU	Austria	34-A	114
161	Göttingen HAWK	Germany	23-A	113
167	Prague CTU	Czech Republic	04-B	119
185	Padova U	Italy	26-B	119
188	Augsburg UAS	Germany	10-B	111
742	Darmstadt TU	Germany	19-B	112
778	Hamburg TU	Germany	46-B	114

STATUS/STAND: 21.07.2021

Participating Formula Student Driverless TEAMS 2021

Teams

https://fsg.one/dv21

Car	City/University		Country	Pit	Page
413	München UAS	ELECTRIC	Germany	16-B	128
414	Budapest TU	ELECTRIC	Hungary	47-B	125
421	Karlsruhe KIT	ELECTRIC	Germany	43-B	127
426	Stuttgart U	ELECTRIC	Germany	25-B	129
431	München TU	ELECTRIC	Germany	40-B	127
433	Zürich ETH	ELECTRIC	Switzerland	46-A	129
444	Deggendorf IT	ELECTRIC	Germany	06-A	126
450	Lisboa IST	ELECTRIC	Portugal	31-B	127
454	Barcelona UPC	ELECTRIC	Spain	37-B	125
463	Trondheim NTNU	ELECTRIC	Norway	22-B	129
466	Augsburg UAS	ELECTRIC	Germany	12-B	124
467	Prague CTU	ELECTRIC	Czech Republic	06-B	128
469	Hamburg UAS	ELECTRIC	Germany	34-B	126
477	Stuttgart DHBW	ELECTRIC	Germany	09-A	128
499	Aachen RWTH	ELECTRIC	Germany	09-B	124
519	Roma U Sapienza	COMBUSTION	Italy	28-A	124
543	Pisa U	COMBUSTION	Italy	28-B	123
549	Erlangen U	COMBUSTION	Germany	25-A	123
842	Darmstadt TU	ELECTRIC	Germany	19-B	125
878	Hamburg TU	ELECTRIC	Germany	46-B	126

STATUS/STAND: 21.07.2021

Formula Student Team profiles

14 nations

629 students

21 teams Combustion

40 teams Electric

20 teams Driverless

3 Combustions / **17** Electric

BERLIN

Technische Universität Berlin

Car 313 **Pit M-11** **WRL 164** Germany

The FT20c will challenge its competition with the new overall „Size 250" concept, that thrives on a new powertrain, focuses on aerodynamic efficiency, and entails changes in all areas of the race car. FaSTTUBe combines its strengths and, thanks to the clever design of the steel lattice frame and a multi-link rear axle, enables optimum packaging in the rear of the vehicle to provide more design freedom and surface area for the underbody as the most efficient component of the aerodynamic package.

FRAME CONSTRUCTION Tubular Steel Frame
MATERIAL Docol R8
OVERALL L / W / H 2899mm / 1573mm / 1195mm
WHEELBASE / TRACK (Fr / Rr) 1575mm / 1200mm / 1200mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 112kg / 121kg
SUSPENSION Double unequal length A-Arm (front) and Multilink (rear). Pushrod on front and rear
TYRES (Fr / Rr) 16.0x7.5-10 Hoosier LC0 / 16.0x7.5-10 Hoosier LC0
WHEELS (Fr / Rr) OZ Formula Student Magnesium CL 10
ENGINE KTM 450 SX-F (2018)
BORE / STROKE / CYLINDERS / DISPLACEMENT 95mm / 63,4mm / 1 cylinder / 450cc
COMPRESSION RATIO 12,8
FUEL SYSTEM Self build aluminium tank, external fuel pump, two injectors, pressure regulator
FUEL E85
MAX POWER/TORQUE DESIGN 9000 rpm/ 8000rpm
DRIVE TYPE Chain drive, original gearbox
DIFFERENTIAL Drexler limited slip differential
COOLING symmetric twin radiator setup
BRAKE SYSTEM 4-Disk floating syst, hub mounted, 143mm(FR), 113mm(RA), ISR Calipers, Cockpit adjustable
ELECTRONICS Self developed Body Control Unit, Bosch MS4, electr. throttle, clutch, shifting system

BOCHUM

Ruhr University Bochum

Car 248 **Pit M-17** **WRL 468** Germany

One Team – One Mission – One Car: The RUB20– RUB Motorsports newest single-seater FS racing car. We want our car to be as light, fast and reliable as possible. With this vision, we developed our incredible new race car. A completely new chassis, a whole new aerodynamic package, and the change to a new engine packaging are the results of the past 24 months of dedicated work. Special thanks to our sponsors and our university for their commitment and great support!

FRAME CONSTRUCTION Hybrid-Monocoque with tubular steel rear-spaceframe
MATERIAL Carbonfiber +Rohacell core material and Steel tubing
OVERALL L / W / H 3088mm / 1508mm / 1160mm
WHEELBASE / TRACK (Fr / Rr) 1540mm / 1235mm / 1200mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 111kg / 134kg
SUSPENSION Double unequal lenght wishbone, pullrod actuated horizontally orientated spring and damper
TYRES (Fr / Rr) Hoosier 18.0 x 6.0 - 10 R25B
WHEELS (Fr / Rr) Alumnium 3-piece Keizer Rim (center-lock, 10
ENGINE KTM SX-F 450 2019
BORE / STROKE / CYLINDERS / DISPLACEMENT 95mm / 63,4mm / 1 cylinder / 449cc
COMPRESSION RATIO 12,6:1
FUEL SYSTEM Bosch MS3 Sport, Sequential Injection and single coil ignition system
FUEL 98 octane unleaded gasoline
MAX POWER/TORQUE DESIGN 9000 rpm/ 7500rpm
DRIVE TYPE 4-Speed conventional dog-clutch gearbox
DIFFERENTIAL Drexler limited-slip differential, Preload 0-70Nm
COOLING Side mounted water and oil-radiator, single fan
BRAKE SYSTEM 4/2-Piston ISR calipers, 196mm/182mm self developed rotors, adjustable brake-balance
ELECTRONICS Fully sealed self developed harness, electronic throttle body, electro-pneumatic shifting

BOLOGNA

University of Bologna

Car 288 **Pit M-10** **WRL 66** Italy

Our vehicle, UBM Tenace GN, is the 8th iteration of the UniBo Motorsport Combustion dynasty. The core of our team are people. Students with different background sharing their knowledge for a common purpose, working together, stimulating each other to give it all. The effort of the entire team is to create a fast but solid prototype, synthesis of the different experiences made in the design phase. These are converted into the main project guidelines, the search for ligthness and validation.

FRAME CONSTRUCTION Front monocoque, rear steel spaceframe
MATERIAL T800, M46J, Zylon composites, Aluminum and Nomex honeycomb. 25CrMo4
OVERALL L / W / H 2896mm / 1440mm / 1150mm
WHEELBASE / TRACK (Fr / Rr) 1580mm / 1200mm / 1160mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 134kg / 148kg
SUSPENSION Double whisbones, push rod actuation, helicoidal springs, blade adjustable anti roll bar
TYRES (Fr / Rr) Hoosier 18x7.5-10 R25B / Hoosier 18x7.5-10 R25B
WHEELS (Fr / Rr) OZ 10
ENGINE Suzuki GSX-R 600 K6-K7
BORE / STROKE / CYLINDERS / DISPLACEMENT 67mm / 42,5mm / 4 cylinders / 599cc
COMPRESSION RATIO 14,5
FUEL SYSTEM Student des/built, fuel injection, sequential, quick release hose
FUEL E85
MAX POWER/TORQUE DESIGN 10000 rpm/ 8000rpm
DRIVE TYPE Regina 520 Steel drive chain
DIFFERENTIAL Drexler Formula SAE Specific Clutch Pack Limited Slip Differential
COOLING Two side pod single core double pass radiators, with electric fans and electric pump
BRAKE SYSTEM 4 AISI 420 self-designed floating disc system with Brembo calipers
ELECTRONICS Wiring harness sealed to IP67, Electropneumatic shifting system, Self-designed Telemetry

ECULLY

École Centrale de Lyon

Car 281 **Pit M-04** **WRL 220** France

EPSA is a 40-student strong French FS team of the Ecole Centrale de Lyon. We have participated in the FS competition since 2014 in the CV category and are currently in our electrical transition. Our goal this year is to present our last CV prototype, Invictus. It was designed to be reliable, powerful and it gathers all the progress we made the previous years. Our project is special because we work with worker schools to produce the car and every member is never in the team more than 2 years!

FRAME CONSTRUCTION Tubular spaceframe steel chassis
MATERIAL SAE 4130 steel tubes from outside diameter 30, 25, 20, 15 mm
OVERALL L / W / H 2980mm / 1470mm / 1050mm
WHEELBASE / TRACK (Fr / Rr) 1575mm / 1254mm / 1200mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 143kg / 144kg
SUSPENSION Double unequal length and non parallel A-Arm. Pull/Push rod actuated spring and damper
TYRES (Fr / Rr) 205/470 R13, Continental C19 / 205/470 R13, Continental C19
WHEELS (Fr / Rr) 7.0x13, 1 pc Mg OZ Rim / 7.0x13, 1 pc Mg OZ Rim
ENGINE Modified Honda CBR600RR (PC40)
BORE / STROKE / CYLINDERS / DISPLACEMENT 67mm / 42,5mm / 4 cylinders / 599cc
COMPRESSION RATIO 12,2:1
FUEL SYSTEM Self build aluminium tank, external fuel pump and regulator, 4 injectors on a common rail
FUEL 98 octane unleaded gasoline
MAX POWER/TORQUE DESIGN 10200 rpm/ 8500rpm
DRIVE TYPE 520 chain, 6 gears sequential gearbox
DIFFERENTIAL Drexler Adjustable Limited Slip differential
COOLING Self-build water intercooler, ECU controlled fan
BRAKE SYSTEM 4 floating disk system, self developed rotors, ajustable brake balance, Beringer gallopers
ELECTRONICS Custom wiring, DTA S80 ECU, modulable screen, electro-actuated shifting, sensors recording

ERLANGEN

Friedrich-Alexander-Universität Erlangen-Nürnberg

Car 249 **Pit M-08** **WRL 224** Germany

For the first time in our 14-year history, we were able to use a rudimentary lap time simulation to help us define the top priorities of our design. Combined with the feedback of our drivers and previous generations of team members, we decided on the following three crucial ingredients to create a fast racing car:1)Aerodynamic Efficiency,2) Lightweight Design and 3)Drivers Ergonomics.

FRAME CONSTRUCTION CFRP full monocoque
MATERIAL CFRP
OVERALL L / W / H 2860mm / 1900mm / 1198mm
WHEELBASE / TRACK (Fr / Rr)
1560mm / 1240mm / 1150mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 111kg / 114kg
SUSPENSION Double-wishbone with roll-heave-system and anti-roll bar using KW dampers and carbon tubes
TYRES (Fr / Rr) Hoosier R25B, 16 x 7.5 - 10
WHEELS (Fr / Rr) 7.5x10 self-designed CFRP rims
ENGINE Modified KTM 450 SX-F
BORE / STROKE / CYLINDERS / DISPLACEMENT
95mm / 72mm / 1 cylinder / 510cc
COMPRESSION RATIO 14,2:1
FUEL SYSTEM Bosch EV-14 xT, Low pressure Bosch-intake runner system
FUEL E85
MAX POWER/TORQUE DESIGN 9000 rpm/ 7000rpm
DRIVE TYPE Chain drive (520 pitch), 5-speed sequent
DIFFERENTIAL Drexler limited slip differential, bias: 60% drive, 42% decel, preload 40Nm
COOLING side mounted core cross-flow radiator, 530 cfm fan mounted to cfrp radiator duct
BRAKE SYSTEM 4 self developoed brake disks, adjustable brake balance
ELECTRONICS electronic clutch, electronic gearshift, ETC, launch control, shift-by-wire

ESSLINGEN

University of Applied Sciences Esslingen

Car 294 **Pit M-05** **WRL 25** Germany

01.09.2019: How to proceed after a successful 2019 season? Play safe or risk all: Since the former was not an option for us, it was obvious that we wanted to improve every module of our 2019. However, we all know 2020 hit differently. Again, the team had two choices: proceed with the finalization of the car as soon as possible or use the extra time for additional innovations. It was clear what to do. From March 2020 - October 2020, we focused on highlights to implement into our Stallardo '21.

FRAME CONSTRUCTION Modular chassis consisiting of a one piece monocoque and a tubular rear frame
MATERIAL CFRP Monocoque with alumnium honeycomb, steel rear frame
OVERALL L / W / H 3009mm / 1452mm / 1185mm
WHEELBASE / TRACK (Fr / Rr)
1600mm / 1218mm / 1218mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 128kg / 140kg
SUSPENSION pushrod actuated SLA, self designed roll damper, rear wheel steering
TYRES (Fr / Rr) 20x7-13 FSAE Goodyear
WHEELS (Fr / Rr) 20x7-13 FSAE Goodyear
ENGINE KTM LC8c
BORE / STROKE / CYLINDERS / DISPLACEMENT
88mm / 58mm / 2 cylinders / 706cc
COMPRESSION RATIO 12:1
FUEL SYSTEM port injection
FUEL E85
MAX POWER/TORQUE DESIGN 8800 rpm/ 5500rpm
DRIVE TYPE chain, sequential gearbox
DIFFERENTIAL Drexler
COOLING side mounted self developed radiator with fans
BRAKE SYSTEM floating rotors, 220mm OD, 142mm ID, adjustable brake balance
ELECTRONICS 7 input Multifunctional Steering Wheel, STM32 based ECU's, selfdeveloped RTOS - StallardOS

HAMBURG

Helmut Schmidt University of Federal Armed Forces Hamburg

Car 372 **Pit M-19** **WRL 534** Germany

On this year's car we focused on achieving high reliability, drivability and sustainability. To reach these goals we overhauled our engineering approach and vastly improved the ergonomics. We aim to set a solid foundation to build on for the following years to come. Especially the integration of the chassis and suspension in interaction with the driver has seen a great improvement. We expect to gain a lot of experience through a car that can run all day in Hockenheim.

FRAME CONSTRUCTION Tubular space frame
MATERIAL E235+C
OVERALL L / W / H 2765mm / 1470mm / 1090mm
WHEELBASE / TRACK (Fr / Rr)
1550mm / 1250mm / 1200mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 125kg / 153kg
SUSPENSION Double unequal length A-Arm. Push rod actuated horizontally oriented spring and damper.
TYRES (Fr / Rr) 20.5x7.0-13, Hoosier R25B / 20.5x7.0-13, Hoosier R25B
WHEELS (Fr / Rr) 7x13, 22mm offset, 1pc Al Rim / 7x13, 22mm offset, 1pc Al Rim
ENGINE 2014 Yamaha MT-07
BORE / STROKE / CYLINDERS / DISPLACEMENT
80mm / 68,6mm / 2 cylinders / 690cc
COMPRESSION RATIO 11,5:1
FUEL SYSTEM Student design/built, fuel injection, sequential
FUEL 98 RON
MAX POWER/TORQUE DESIGN 9000 rpm/ 6500rpm
DRIVE TYPE 520 chain
DIFFERENTIAL clutch pack limited slip, 35Nm preload
COOLING Side mounted radiator and 140mm electric fan
BRAKE SYSTEM 4-Disk system, self developed rotors with 220mm diameter, adjustable brake balance
ELECTRONICS Dashboard with shift light and gear indicator, electromagnetic shifting system

HAMBURG

University of Applied Sciences Hamburg

Car 269 **Pit M-20** **WRL 307** Germany

For the first time, Hawks Racing participates at FSG with two cars. Our H16 („Valeria") is the 16th car we have built, featuring the third iteration of our unique V2 engine with transversal gearbox layout. This season, we concentrated our efforts on refining the powertrain design, focusing on reliability of both hardware and software components.Accompanied by our first DV and EV car, we plan for Valeria to conclude the era of our combustion vehicles with a great performance at Hockenheim.

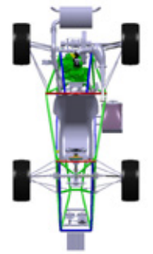
FRAME CONSTRUCTION Full body CFRP/ aluminium sandwich monocoque w/ bonded / bolted additional parts
MATERIAL 200 gsm twill 2/2 E323, 150 gsm UD E340 prepregs, EN AW 5056 honeycomb, IG-F110 foam
OVERALL L / W / H 2994mm / 1460mm / 1185mm
WHEELBASE / TRACK (Fr / Rr)
1550mm / 1200mm / 1200mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 132kg / 149kg
SUSPENSION short arm long arm (SLA) with push rods,roll and heave decoupled
TYRES (Fr / Rr) 205x96 R13, Continental C-20
WHEELS (Fr / Rr) 7x13-22mm offset, CFRP-aluminium-rim
ENGINE Suzuki SV650 '99-'02 derived self-made V2
BORE / STROKE / CYLINDERS / DISPLACEMENT
81mm / 62,6mm / 2 cylinders / 645cc
COMPRESSION RATIO 11.5:1
FUEL SYSTEM self-built, port fuel injection, one injector per runner, full sequential
FUEL RON100
MAX POWER/TORQUE DESIGN 7500 rpm/ 7000rpm
DRIVE TYPE self- designed bevel gear drive
DIFFERENTIAL limited slip differential (Drexler)
COOLING twin side radiators, electric water pump and electric fans
BRAKE SYSTEM 4-Disk-system, self designed, rotors with 250mm diameter, adjustable bias bar
ELECTRONICS self developed BMS, Powerhub w/ electronic and hardware fuses, distributed data collection

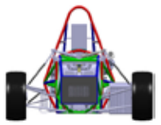
HEILBRONN

Heilbronn University

Car 239 **Pit M-14** **WRL 376** Germany

We at HHN Racing e.V. dedicated the year 2021 to revise on our cooling system, steering and wheel hub for one goal: RELIABILITY. Our changes on the car should lead to less technical problems which occourd 2019. We are also proud to say that HNR21's front and rear wing got upgrated and should perform better than ever.





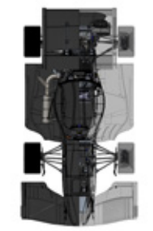
FRAME CONSTRUCTION Welded steel spaceframe with water jet cutted aluminium endplate
MATERIAL E355 steel tubing, 7075 Aluminium endplate, Aluminium honeycomb crashstructure
OVERALL L / W / H 2920mm / 1405mm / 1188mm
WHEELBASE / TRACK (Fr / Rr)
1525mm / 1200mm / 1200mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 126kg / 140kg
SUSPENSION Double unequal length A-Arm. Push rod actuated dampers, adjustable in compression.
TYRES (Fr / Rr) 205/470 R13 Continental
WHEELS (Fr / Rr) OZ Formula Student 13
ENGINE Modified Husqvarna SMR 510
BORE / STROKE / CYLINDERS / DISPLACEMENT
97mm / 67,8mm / 1 cylinder / 501cc
COMPRESSION RATIO 13,3
FUEL SYSTEM Bosch fuel injection EV14 L-Valve in student designed housing in manifold
FUEL 98 octane unleaded gasoline
MAX POWER/TORQUE DESIGN 9000 rpm/ 8000rpm
DRIVE TYPE Chaindrive
DIFFERENTIAL adjustable limited slip differential
COOLING left side mounted, single core, 240mm x 200mm, single electric fan rear mounted
BRAKE SYSTEM 4-Disk system, self-developed rotors with front 218mm and rear 208mm diameter, adj. brake
ELECTRONICS Bosch MS6 ECU; electropneumatic shifting & clutch; Telemetry; Instruments with RGB-LEDs

KARLSRUHE

University of Applied Sciences Karlsruhe

Car 399 **Pit M-09** **WRL 21** Germany

High Speed Karlsruhe is part a of Formula Student since 2007. With the F-115, our 15th car, we set a new standard and reworked almost the whole car. It is equiped with an all new monocoque following the new aerodynamics concept with the wide undertray and a chassis integrated diffusor. The new kinematics were developed to supply the best grip and support the aero devices to work reliably. With our in house machining center, we are able to manufacture the majority of our racecar by ourself.



FRAME CONSTRUCTION Full CFRP monocoque
MATERIAL Carbon fibre with aluminium honeycomb core
OVERALL L / W / H 2855mm / 1524mm / 1177mm
WHEELBASE / TRACK (Fr / Rr)
1530mm / 1220mm / 1220mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 114kg / 122kg
SUSPENSION Unequal length double-wishbone, pushrod actuated dampers, U-type anti-roll-bars
TYRES (Fr / Rr) 16.0 x 7.5 - 10.0 Hoosier R25B / 16.0 x 7.5 - 10.0 Hoosier R25B
WHEELS (Fr / Rr) 7.0 x 10.0, 4.0 mm rim offset, 2 pc CFRP rim with AL7075 rimstar (Front and Rear)
ENGINE Modified Suzuki RMX 450, 2011
BORE / STROKE / CYLINDERS / DISPLACEMENT
100mm / 62,1mm / 1 cylinder / 488cc
COMPRESSION RATIO 15.2:1
FUEL SYSTEM Self designed system with fuel injection and spark ignition
FUEL Ethanol
MAX POWER/TORQUE DESIGN 9000 rpm/ 7500rpm
DRIVE TYPE Chain drive
DIFFERENTIAL Clutch pack limited slip, 10Nm preload, adjustable ratios
COOLING Two Radiators behind Drive Axle
BRAKE SYSTEM 4-Disk system, self designed 4 piston calipers (Fr). 2 piston calipers (Rr)
ELECTRONICS 10 self-developed control and sensor units, electropneumatic shifting

KEMPTEN

UAS Kempten

Car 212 **Pit M-02** **WRL 316** Germany

The end of an era - the TOMSOI XII will be the final combustion race car in the history of Infinity Racing. In our last vehicle we combine the best of 14 awesome years of racing. We want to participate in as much events as possible to celebrate the farewell appropriately.

FRAME CONSTRUCTION Composite monocoque at the front; steel spaceframe at the rear
MATERIAL Prepreg carbon, aluminum honeycomb
OVERALL L / W / H 3000mm / 1400mm / 1220mm
WHEELBASE / TRACK (Fr / Rr) 1530mm / 1220mm / 1156mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 139kg / 145kg
SUSPENSION Double unequal length A-Arm. Pullrod actuated vertically oriented spring and damper
TYRES (Fr / Rr) 205/470 R13 Continental / 205/470 R13 Continental
WHEELS (Fr / Rr) 7.47x13, OZ magnesium rim / 205/470 R13 Continental
ENGINE 2005 Yamaha R6 RJ 09 4 cylinder DOHC
BORE / STROKE / CYLINDERS / DISPLACEMENT 65,5mm / 44,5mm / 4 cylinders / 599cc
COMPRESSION RATIO 12.4:1
FUEL SYSTEM Student built, fuel injection, sequential
FUEL 98 octane unleaded gasoline
MAX POWER/TORQUE DESIGN 13000 rpm/ 7700rpm
DRIVE TYPE chain drive chain typ: Enuma 520MRD6
DIFFERENTIAL Drexler clutch pack limited slip FS 2010, 10 Nm preload, 1200 Nm maximum torque
COOLING Side pod mounted radiator with thermostatic controlled electric fan
BRAKE SYSTEM 4-Disk system, adjustable brake balance
ELECTRONICS Self-developed power management device, Live-Telementy System and Data Logging

LÜBECK

Technische Hochschule Lübeck

Car 250 **Pit M-21** **WRL 508** Germany

Founded only in 2018, we, the Seagulls Lübeck, are one of the youngest Formula Student teams worldwide. After a first, successful season in 18/19, we now look back on two more spectacular years marked by interruptions and obstacles. But we have made the most of the time: Not only to prepare intensively for the quizzes, but also to invest a lot of time, heart and soul into an all-around improved race car. Now we proudly present the second race car in the short Seagulls history: the SG-02.

FRAME CONSTRUCTION Steel Tube Frame
MATERIAL 1.0045, 1.0308, 1.0580 steel round tubing 25mm to 30mm diameter
OVERALL L / W / H 2750mm / 1320mm / 1191mm
WHEELBASE / TRACK (Fr / Rr) 1581mm / 1105mm / 1105mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 171kg / 152kg
SUSPENSION Double unequal length A-Arm. Push rod actuated horizontally oriented spring and damper.
TYRES (Fr / Rr) 205x55 R13, Continental
WHEELS (Fr / Rr) 7x13, 30mm offset, 1pc Magnesium Rim
ENGINE 2005/2006 Kawasaki ZX-636 C
BORE / STROKE / CYLINDERS / DISPLACEMENT 68mm / 43,8mm / 4 cylinders / 636cc
COMPRESSION RATIO 12,9:1
FUEL SYSTEM Kawasaki ,fuel injection, sequential
FUEL 98 octane
MAX POWER/TORQUE DESIGN 9000 rpm/ 8000rpm
DRIVE TYPE 520 X-Ring Chain
DIFFERENTIAL Clutch pack limited slip, 30-35Nm preload, XXXX BIAS RATIO
COOLING Single side dual radiators with thermostatic controlled electric fans
BRAKE SYSTEM 4-Disk system, self-developed discs with 230mm diameter, adjustable brake balance
ELECTRONICS Graphic display in dashpanel, electromechanical gear shift, self-designed throttle control

PADERBORN

University of Paderborn

Car 258 **Pit M-16** **WRL 125** Germany

One last dance!Building and manufactoring probably the last combustion race car in our team history we wanted to find closure by annoying the big teams as much as possible. Let's see how far we can take it.

FRAME CONSTRUCTION front monocoque, rear spaceframe
MATERIAL CFRP, 15CDV6 (1.7734.5)
OVERALL L / W / H 2992mm / 1397mm / 1146mm
WHEELBASE / TRACK (Fr / Rr) 1600mm / 1052mm / 1032mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 133kg / 150kg
SUSPENSION double enqual wishbone, decoupled pullrod suspension (FR), decoupled pushrod suspension RR
TYRES (Fr / Rr) 10
WHEELS (Fr / Rr) cast magnesium
ENGINE Suzuki GSX-R 600 K8
BORE / STROKE / CYLINDERS / DISPLACEMENT 67mm / 42,5mm / 4 cylinders / 599cc
COMPRESSION RATIO 13
FUEL SYSTEM BOSCH EV12 injectors with student-made fuel rail
FUEL super 98
MAX POWER/TORQUE DESIGN 10500 rpm/ 7500rpm
DRIVE TYPE chain drive 22,5mm
DIFFERENTIAL Drexler Formula Student limited slip differential
COOLING 2 rear mounted 34mm core radiators, with fans and scoops
BRAKE SYSTEM 4-disk system, self develpoed rotors Ø187, adjustable brake balance, Brembo calipers and p
ELECTRONICS wiring harness sealed to IP67, Multifunctional Steering Wheel, Electropneumatic Shifting S

PADOVA

University of Padova

Car 285 **Pit M-12** **WRL 17** Italy

Race UP Team started participating in Formula SAE ruled competi-ti_x005F_x0002_ons since 2003. This year the team is coming back to Formula Student Germany with its 15th car, the first to implement a hybrid frame. All the components are designed to give the best performance on track and to reach the best integration. The goals of the year are to reduce the COG in order to improve vehicle dynamics and to extract the maximum performance out of the new car, with an intense testing.

FRAME CONSTRUCTION Hybrid structure: CFRP monocoque and tubolar spaceframe
MATERIAL CFRP and Steel AISI 4130 (25CrMo4)
OVERALL L / W / H 2894mm / 1482mm / 1180mm
WHEELBASE / TRACK (Fr / Rr) 1535mm / 1220mm / 1190mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 128kg / 134kg
SUSPENSION Double unequal length A-Arm. Pull-rod actuated. Longitudinally oriented spring and damper
TYRES (Fr / Rr) 185x40 R13 Pirelli / 185x40 R13 Pirelli
WHEELS (Fr / Rr) 7X13, 30,5mm offset, OZ Racing Mg Rim (both Fr and Rr)
ENGINE Honda CBR 600 RR 2007-2008
BORE / STROKE / CYLINDERS / DISPLACEMENT 67mm / 42,5mm / 4 cylinders / 599cc
COMPRESSION RATIO 14.7:1
FUEL SYSTEM Single injector per cylinder, low pressure
FUEL E85
MAX POWER/TORQUE DESIGN 11000 rpm/ 9000rpm
DRIVE TYPE Gearbox (student developed), 520 chain
DIFFERENTIAL Drexler LSD
COOLING Both sides 22 core 240x300 mm radiators, 460 cfm fans mounted to radiators' back
BRAKE SYSTEM 4 self developed rotors (250mm front, 220 rear), ISR Calipers, adjustable brake bias
ELECTRONICS Self-developed dashboard, electropneumatic clutch and shifting system

PISA

University of Pisa

Car 243 **Pit M-13** **WRL 57** Italy

E-Team Squadra Corse, the team born in 2007 in Pisa and composed by 80 members, presents its first hybrid chassis car. The major innovations of this year are a front monocoque chassis, a new vehicle dynamics with low profile tire and a new steering variable pitch rack. Moreover, the car is equipped with a customized telemetry system with integrated PTT and an electronic clutch. After you take some pictures with the Leaning Tower of Pisa, come to our workshop to talk to us!

FRAME CONSTRUCTION composite monocoque for the front part and steel space frame for the rear
MATERIAL carb. fiber + aluminium honeycomb core and BS4T45 steel for the spaceframe and fronthoop
OVERALL L / W / H 2904mm / 1467mm / 1184mm
WHEELBASE / TRACK (Fr / Rr) 1528mm / 1250mm / 1135mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 143kg / 150kg
SUSPENSION Double unequal length A-Arm, push (Fr), pull (Rr) rod actuated by spring-dampers. ARB
TYRES (Fr / Rr) 180/530, Pirelli / 180/530, Pirelli
WHEELS (Fr / Rr) 7"x13", 30mm offset, 1 pc Mg Rim / 7"x13", 30mm offset, 1 pc Mg Rim
ENGINE Honda CBR600RR (PC37)
BORE / STROKE / CYLINDERS / DISPLACEMENT 67mm / 42,5mm / 4 cylinders / 599cc
COMPRESSION RATIO 12,5:1
FUEL SYSTEM Student des/built, external pump by bosch, custom Al rail, injectors by bosch
FUEL 98 octane unleaded gasoline
MAX POWER/TORQUE DESIGN 11000 rpm/ 9000rpm
DRIVE TYPE 520 chain, 15.875mm pitch
DIFFERENTIAL LSD, 35Nm preload, ramp angle setup 40deg (ON power)/ 50deg (OFF power)
COOLING Twin side pod mounted radiators with electric fans
BRAKE SYSTEM Self developed, inox, floating 230mm (front), floating 210mm (Rr), driver adj. balance bar
ELECTRONICS Self developed PDU, gear shift, telemetry, clutch control, multifunctional LCD dashboard

SEVILLA

University of Seville

Car 218 **Pit M-15** **WRL 239** Spain

ARUS has been competing in Formula Student for eight years now, being the first team from Andalusia, Spain. From just an idea of a couple of crazy students, to an established team within both the University and the City of Seville. Many years of emotions, massive efforts, and a constant will to learn and make everyone else learn too, have made ARUS not only a contender for trophies, but also and more important, a team noticed and remembered by everyone who happens to share a moment with us.

FRAME CONSTRUCTION Steel Space frame
MATERIAL Steel E355
OVERALL L / W / H 2385mm / 680mm / 1045mm
WHEELBASE / TRACK (Fr / Rr) 1535mm / 1250mm / 1175mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 145kg / 145kg
SUSPENSION Double unequal length A-Arm. Pull/Push rod actuated spring and damper, anti-roll bar.
TYRES (Fr / Rr) 18x7,5-10. R25B. Hoosier/18x7,5-10. R25B. Hoosier
WHEELS (Fr / Rr) 3pc Al Rim, custom Al center
ENGINE Honda CBR 600 RR
BORE / STROKE / CYLINDERS / DISPLACEMENT 67,0mm / 42,5mm / 4 cylinders / 599cc
COMPRESSION RATIO 12
FUEL SYSTEM Fuel injectors DENSO 6 AT.
FUEL 98 octane unleaded gasoline
MAX POWER/TORQUE DESIGN 10750 rpm/ 8700rpm
DRIVE TYPE Chain/Sprocket
DIFFERENTIAL Drexler
COOLING Side mounted 386 x 273 core Aluminum radiator 55° inclined, 0,59 cfm electronic fan mounted to rear
BRAKE SYSTEM Self-designed floating disks with AP Racing CP4227-2S0 and Tilton 78-Series
ELECTRONICS wiring harness sealed to IP67, Multifunctional Steering Wheel, Electronic Shifting S

STRALSUND

University of Applied Sciences Stralsund

Car 321 **Pit M-22** **WRL 200** Germany

Baltic Racing exists since 1999. We are the first german team that participated in Formula Student. With every season, the team is growing with its tasks and its size. For our members, Baltic Racing is more than just a hobby and a project. Our workshop is a place to have fun and be together with like-minded and motorsport addicted friends. This year we can proudly participate in our 20th consecutive season, with our 20th (and last) combustion racecar. #thelastofitskind

FRAME CONSTRUCTION steel tubular space frame
MATERIAL 25CrMo4
OVERALL L / W / H 2831mm / 1570mm / 1075mm
WHEELBASE / TRACK (Fr / Rr) 1560mm / 1250mm / 1200mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 125kg / 140kg
SUSPENSION unequal length double A-arms / pull-rod actuated / horizontally orientated spring and damp
TYRES (Fr / Rr) Continental C19 - 205/470R13 / 205/470R13
WHEELS (Fr / Rr) 7,0 x 13,0 single piece cast magnesium with center lock
ENGINE Triumph Street Triple 675
BORE / STROKE / CYLINDERS / DISPLACEMENT 74,0mm / 52,3mm / 3 cylinders / 675cc
COMPRESSION RATIO 12,65:1
FUEL SYSTEM original fuel injection and ignition system @ EcuMaster ECU, fully sequential
FUEL RON98
MAX POWER/TORQUE DESIGN 9000 rpm/ 8500rpm
DRIVE TYPE 520 ERV 7
DIFFERENTIAL torque biasing Torsen B (by Quaife), self designed housing, Al 7075 hard-anodized
COOLING twin radiator, mounted on each side, parallel conn. flow, self made cooling fans, ~3700 m³/h @ max.
BRAKE SYSTEM 4-Disk system, self developed rotors with 200mm diameter, adjustable brake balance
ELECTRONICS multifunctional steering wheel, electrical shifting system with flat shift and blipper

STUTTGART

University of Stuttgart

Car 229 **Pit M-18** **WRL 59** Germany

We - the Rennteam Uni Stuttgart - are very proud to be part of Formula Student Germany for the 15th time. After our breakdown in Endurance 2019 and the cancellation in 2020, we are highly motivated to achieve overall victory this year. To prevail against the strong competition, we have focused our attention on the manufacturing quality of our components, new lightweight construction concepts and a well-rounded and extensively tested vehicle setup. Complete - Finish - Win!

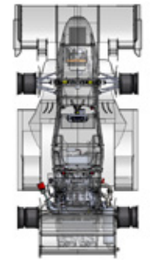
FRAME CONSTRUCTION Singlepiece monocoque with tubular rearframe
MATERIAL CFRP Sandwich Monocoque, steel rearframe
OVERALL L / W / H 3030mm / 1435mm / 1195mm
WHEELBASE / TRACK (Fr / Rr) 1630mm / 1212mm / 1192mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 139kg / 114kg
SUSPENSION Double unequal length A-Arms, pushroad actuated KW damper, adj. U-ARB
TYRES (Fr / Rr) 16.0 x 7.5 - 10 LC0 Hoosier
WHEELS (Fr / Rr) 16.0 x 7.5 - 10 LC0 Hoosier
ENGINE Modified Yamaha YZF-R6
BORE / STROKE / CYLINDERS / DISPLACEMENT 65,5mm / 44,5mm / 4 cylinders / 599cc
COMPRESSION RATIO 14.87:1
FUEL SYSTEM Student build fuel injection system using MiTeC, fully sequential
FUEL E85
MAX POWER/TORQUE DESIGN 9000 rpm/ 7500rpm
DRIVE TYPE Self developed sequential 4speed gearbox
DIFFERENTIAL Drexler limited slip
COOLING Side mounted core dual radiator, fan mounted to back of each radiator
BRAKE SYSTEM 4-disk system, adjustable brake balance, self-designed rotors
ELECTRONICS Digital multifunctional steering wheel, self-developed display system

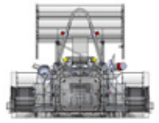
VALÉNCIA

Universitat Politécnica de Valéncia

Car 395 **Pit M-06** **WRL 3** Spain

We, the FSUPV Team in our 8th year, have a strong philosophy based on setting self-challenging season goals that demand an efficient Team and resources management to make the most out of the car. This need for continuous improvement has taken us to be 1st in Europe and 3rd in the Formula Student World Ranking List. Far from giving up and despite the difficulties posed by the pandemic, our main goal for the season is to be Top 1 in every competition.





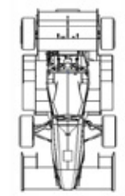
FRAME CONSTRUCTION Aluminium sandwich panel bodyframe with integrated front hoop
MATERIAL 20 mm thick Aluminium honeycomb core and prepreg carbon fiber skin
OVERALL L / W / H 3004mm / 1496mm / 1190mm
WHEELBASE / TRACK (Fr / Rr) 1585mm / 1200mm / 1170mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 117kg / 149kg
SUSPENSION Double unequal length A-Arm. Push rod actuated horizontally oriented spring and damper
TYRES (Fr / Rr) 190.5x53 R10, Hoosier R25B
WHEELS (Fr / Rr) 8x10", 2 CF rim parts + Al wheel centre / 9x10", 2 CF rim parts + Al wheel centre
ENGINE Modified 2005 Honda CBR 600 RR
BORE / STROKE / CYLINDERS / DISPLACEMENT 68mm / 42,5mm / 4 cylinders / 617cc
COMPRESSION RATIO 14.1:1
FUEL SYSTEM Student designed/built ,fuel injection, sequentially staged
FUEL E85
MAX POWER/TORQUE DESIGN 11400 rpm/ 7900rpm
DRIVE TYPE Chain 520 x-ring
DIFFERENTIAL Adjustable Limited Slip Differential - 75W140 - Drive 40º Decel 50º 30-35 Nm
COOLING Rear mounted 40mm core single radiator , 1400 cfm fan mounted to rear radiator
BRAKE SYSTEM 4-Disk system, self developed rotors with 200 mm OD, adjustable bias
ELECTRONICS Self-developed DAQ system based on CAN commnication protocol with 3 main modules and DAS

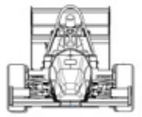
VIGO

University of Vigo

Car 314 **Pit M-07** **WRL 400** Spain

UVigo Motorsport is the first Formula Student team in the Spanish region of Galicia, which faces the sixth season since our creation. After getting our best endurance result in the FS with the UM19 for the first time, we want to keep improving our prototype in order to gain a foothold in the competition and be able to compete against with the best teams in the Formula Student.





FRAME CONSTRUCTION hybrid chassis consisting of monocoque and subframe
MATERIAL Carbon fiber monocoque and steel subframe
OVERALL L / W / H 2857mm / 1402mm / 1132mm
WHEELBASE / TRACK (Fr / Rr) 1540mm / 1210mm / 1150mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 130kg / 130kg
SUSPENSION Double unequal length A-Arm. Pull rod actuated horizontally oriented spring and adjustable
TYRES (Fr / Rr) 200x72 R13, AVON
WHEELS (Fr / Rr) Mg CAST 7x13, 4-Stud (4x100), ET = 30 mm
ENGINE 2012 Kawasaki ER6-N 650, parallel-twin
BORE / STROKE / CYLINDERS / DISPLACEMENT 83mm / 60mm / 2 cylinders / 649cc
COMPRESSION RATIO 11.3:1
FUEL SYSTEM Indirect fuel injection OEM system, sequential injection
FUEL 98 octane gasoline
MAX POWER/TORQUE DESIGN 8500 rpm/ 7500rpm
DRIVE TYPE Reinforced chain
DIFFERENTIAL Adjustable Drexler LSD V2
COOLING Single rear radiator with ECU controlled electric fans (temp sensors)
BRAKE SYSTEM 4 floating disk, self developed rotors made in aluminium, adjustable brake balance
ELECTRONICS Modular wiring harness, electropneumatic Shifting System, AIM EVO5 Data Logger

WROCŁAW

Wrocław University of Technology

Car 211 **Pit M-03** **WRL 29** Poland

PWR Racing Team was formed in 2009 and since then has built 11 combustion cars. We have started as a place for students interested in automotive and now we are the biggest science club at our university, with 80 people on board. We design and build a vehicle but moreover we share the same positive energy and passion. We've come a long way since the first car. We've improved our skills and gained experience and it led us to win again!

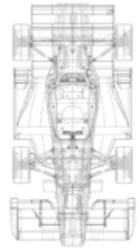
FRAME CONSTRUCTION Monocoque and tubular engine cage
MATERIAL Gurit SE84LV prepreg, aluminum honeycomb and Rohacell foam monocoque and DOCOL R8 steel spaceframe
OVERALL L / W / H 2911mm / 1488mm / 1188mm
WHEELBASE / TRACK (Fr / Rr) 1525mm / 1200mm / 1180mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 129kg / 139kg
SUSPENSION Double A-Arm, pushrod actuated, T-bar stabilizer (Fr), U-bar stabilizer (Rr)
TYRES (Fr / Rr) 16.0/7.5-10, R25B, Hoosier
WHEELS (Fr / Rr) 8.2x10, 50mm off set, 2pc CFRP Rim
ENGINE Modified Honda PC40 (CBR 600RR)
BORE / STROKE / CYLINDERS / DISPLACEMENT 67mm / 42mm / 4 cylinders / 599cc
COMPRESSION RATIO 12.2:1
FUEL SYSTEM Denso 1060, multi point injection, 2 fuel rails
FUEL 98 octane unleaded gasoline
MAX POWER/TORQUE DESIGN 9500 rpm/ 9200rpm
DRIVE TYPE 520 non-oring chain, 4 gear gearbox
DIFFERENTIAL Drexler LSD variable preload 0-75Nm
COOLING two side radiators, four fans on each radiator mounted on core
BRAKE SYSTEM 4-disk floating system with self developed 4-piston calipers on the front, 2-piston rear
ELECTRONICS Ultralightweight military grade wiring harness; team-developed measuring modules

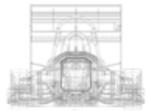
AACHEN

RWTH Aachen University

Car 99 **Pit 07-B** **WRL 25** Germany

Ecurie Aix is one of the oldest Formula Student Teams in Germany, founded in the year 1999. The team name is derived from the French words „ecurie" meaning racing team and „aix" standing for Aachen. The eace09 - Nuri is our ninth EV-car and is an evolution of its predecessor. The focus of the vehicle development was on lightweight design, as well as reliability and maintainability, in order to enable a long test phase for performance enhancement.





FRAME CONSTRUCTION CFRP Sandwich Monocoque
MATERIAL Carbon Fibre Prepreg (Woven & UD), Aluminium Honeycomb & Foam Core, CFRP and Aluminium Inserts
OVERALL L / W / H 3024mm / 1541mm / 1184mm
WHEELBASE / TRACK (Fr / Rr)
1530mm / 1275mm / 1275mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 110kg / 115kg
SUSPENSION double unequal length A-Arm. Longitudinal mounted dampers & springs with pushrod actuation
TYRES (Fr / Rr) 205/470 R13 Continental C19
WHEELS (Fr / Rr) 7Jx13, 30mm offset, CFRP/Al Rim
NUMBER OF MOTORS / LOCATION / MAX POWER
4 / wheel hub mounted / 36 kW
MOTOR TYPE AMK / DD5-14-10-POW
MAX MOTOR RPM 20000
MOTOR CONTROLLER KW26-S5-FSE-4Q
MAX SYSTEM VOLTAGE 600V
ELECTRODE MATERIALS LiCo02
COMBINED ACCUMULATOR CAPACITY
TRANSMISSION RATIO (PRIMARY / SECONDARY)
14.5:1 /
DRIVE TYPE coupled, two-staged planetary gearbox
DIFFERENTIAL
COOLING
BRAKE SYSTEM grinded X46Cr13 disks attached via 5 floaters to hub, self developed 5-axis brake calipers
ELECTRONICS self developed BMS & VCU, highly-integrated telemetry system & radio

AMBERG

Ostbayerische Technische Hochschule Amberg-Weiden (OTH)

Car 23 **Pit 14-A** **WRL 57** Germany

The Running Snail Racing Team was established in August 2004 at the OTH Amberg-Weiden in eastern Bavaria. After building eight combustion cars, the „RS20" is our eighth generation electric powered racecar. With further weight reduction, optimized motors and a new aerodynamics package, we hope to be able to surpass last year's results.

FRAME CONSTRUCTION CFRP / aluminium honeycomb Monocoque
MATERIAL CFRP prepreg (Twill, UD), aluminium honeycomb
OVERALL L / W / H 2864mm / 1674mm / 1183mm
WHEELBASE / TRACK (Fr / Rr)
1530mm / 1230mm / 1210mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 112kg / 136kg
SUSPENSION Double unequal length A-Arm. Direct acting spring and damper
TYRES (Fr / Rr) 7.0x16 R10, Hoosier
WHEELS (Fr / Rr) 7.0x10, OZ Racing Magnesium Rim
NUMBER OF MOTORS / LOCATION / MAX POWER
4 / FR, FL, RR, RL / 35.3kW per Motor
MOTOR TYPE Fischer Elektromotoren TI085-052-070
MAX MOTOR RPM 20000
MOTOR CONTROLLER LENZE Schmidhauser MOBILE DCU
MAX SYSTEM VOLTAGE 600V
ELECTRODE MATERIALS LiPo, LiCoO2 (Catode), Graphit
COMBINED ACCUMULATOR CAPACITY 7.98kWh
TRANSMISSION RATIO (PRIMARY / SECONDARY)
1:12.67 / n/a
DRIVE TYPE planetary Gear
DIFFERENTIAL n/a
COOLING twin front mounted radiators
BRAKE SYSTEM 4-Disk system, semi-floating, hub mounted, 175mm diameter, ISR 22-048 piston Al caliper
ELECTRONICS Torque vectoring, traction control

ATHENS

National Technical University of Athens

Car 25 **Pit 16-A** Greece

Prom Racing of NTU Athens arrives for the second time in FSG. Today, the team is way bigger than it was at its first year, consisted of 65 members. P20 marks our first year in the EV Class and we have worked extremely hard over the past year to design and manufacture a reliable and fast vehicle. In the midst of enormous challenges of the past 2 years, our team has remained focused and haven't stopped giving their best shot. And you know our motto, don`t you? "Eat.Sleep.PROM.Repeat".

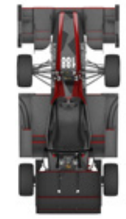
FRAME CONSTRUCTION Full Carbon Monocoque, CFRP/ Aluminum sandwich panel structure
MATERIAL MTM-28 prepreg & Aluminum core sandwich
OVERALL L / W / H 3042mm / 1490mm / 1192mm
WHEELBASE / TRACK (Fr / Rr)
1620mm / 1238mm / 1200mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 123kg / 139kg
SUSPENSION Double unequal length A-Arm F&R, Direct actuated F/Push rod actuated R, U-bar ARB R
TYRES (Fr / Rr) 16x7.5-10
WHEELS (Fr / Rr) Central Lock Magnesium OZ 10
NUMBER OF MOTORS / LOCATION / MAX POWER
1 / Center Rear / 120kW
MOTOR TYPE CR: Emrax 228 HV CC
MAX MOTOR RPM CR: 6500
MOTOR CONTROLLER Bamocar Inverter PG-D3 700V
MAX SYSTEM VOLTAGE 588V
ELECTRODE MATERIALS LiCoO2
COMBINED ACCUMULATOR CAPACITY 8,23kWh
TRANSMISSION RATIO (PRIMARY / SECONDARY)
1:3,9 / n/a
DRIVE TYPE Driving-Driven Sprocket, Chain
DIFFERENTIAL FSAE Drexler LSD Differential
COOLING Rear mounted diffusser supplied radiator, CFRP Shroud, 195mm DCDC fan
BRAKE SYSTEM 4-Disk system, self developed rotors, ISR Brake Calipers, Driver adjustable brake balance
ELECTRONICS CAN Bus based selfdesigned Live-Telemetry System, Dashboard interface, Optimized harness

AUGSBURG

University of Applied Sciences Augsburg

Car 188 **Pit 10-B** **WRL 99** Germany

Evolution instead of revolution quickly turned in revolution for the yet unnamed electric vehicle UASA2108 of StarkStrom Augsburg. The mechanical parts of StarkStrom's 8th car were strongly revised and optimized, especially in the area of all CFRP parts. The electrical area of the vehicle also underwent decisive improvements with focus on our redesigned accumulator. The team is extremely proud that despite the challenges caused by Covid-19 our car is ready to perform at Formula Student Events.



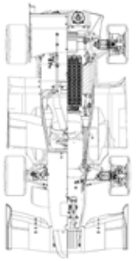
FRAME CONSTRUCTION One piece Composite monocoque with rollbar structures
MATERIAL Carbon Fiber with honeycomb/ S355 steeltubing rollbars 25mm diam. /ENAW-6061
OVERALL L / W / H 2950mm / 1430mm / 1195mm
WHEELBASE / TRACK (Fr / Rr)
1535mm / 1250mm / 1200mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 90kg / 110kg
SUSPENSION Double Whishbones with Pushrod and Heave-Roll System
TYRES (Fr / Rr) 205/470 R13 C19, unknown, Continental/ 205/470 R13 C19, unknown, Continental
WHEELS (Fr / Rr) 7x13, 22mm offset, Magnesium/7x13, 22mm offset, Magnesium
NUMBER OF MOTORS / LOCATION / MAX POWER
4 / wheel hub motor / 32kW
MOTOR TYPE AMK - DD5-14-10-POW
MAX MOTOR RPM 20000 1/min
MOTOR CONTROLLER AMK Motor Controller
MAX SYSTEM VOLTAGE 600V
ELECTRODE MATERIALS LiNiCoAlO2
COMBINED ACCUMULATOR CAPACITY 7,98kWh
TRANSMISSION RATIO (PRIMARY / SECONDARY)
1:13,65 / n/a
DRIVE TYPE planetary gear
DIFFERENTIAL n/a
COOLING rear mounted radiator 145x135x32mm and electric fan type 4114 NH6
BRAKE SYSTEM 4-Disk system; self developed rotors, floating; calipers: titan, self designed, 3D-printed
ELECTRONICS tire-temperature sensor, DCU designed with improved user interface, DRS by servomotors

BARCELONA

PT University of Catalonia - Engineering School of Barcelona

Car 54 **Pit 35-B** **WRL 29** Spain

BCN eMotorsport is the new era of ETSEIB Motorsport, one of the oldest Formula Student Teams founded in 2007. After building four combustion cars, the team decided to change to the EV category. Since 2011, nine electric cars have been created by the team. This year, we bring up to the table the CAT13e, an evolution of the previous car, which was the first with 4WD. We are excited to come back to FSG, ready to race against the bests teams.



FRAME CONSTRUCTION Single-piece CFRP Monocoque + fully laminated FH + steel rollover protection.
MATERIAL Toray T800 & M40JB fibers, 5052 Aluminium Core, 6063 T6 FH, S355 Steel MH
OVERALL L / W / H 2963mm / 1442mm / 1131mm
WHEELBASE / TRACK (Fr / Rr)
1530mm / 1200mm / 1150mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 78kg / 126kg
SUSPENSION Double unequal A-Arm, direct acting from upper Arm
TYRES (Fr / Rr) Hoosier 18 x 7.5 - 10 R25B
WHEELS (Fr / Rr) 7x10, 35mm offset, Laminated CF Rim
NUMBER OF MOTORS / LOCATION / MAX POWER
4 / 4WD / 35,4
MOTOR TYPE Fischer Elektromotoren TI085
MAX MOTOR RPM 20000
MOTOR CONTROLLER Lenze DCU 60/60
MAX SYSTEM VOLTAGE 596V
ELECTRODE MATERIALS LiCoO2
COMBINED ACCUMULATOR CAPACITY 7.14kWh
TRANSMISSION RATIO (PRIMARY / SECONDARY)
1:11,71 / n/a
DRIVE TYPE self-custom in-wheel planetary gearbox
DIFFERENTIAL n/a
COOLING Two radiators placed on a rear diffuser with thermostatic controlled fans
BRAKE SYSTEM 4-disk system, self-developed steel rotos-with 182.5mm diameter, adjustable brake balance
ELECTRONICS wiring harness sealed to IP67, Wifi-based Telemetry System and datalogging of 4 CAN Bus ch

BAYREUTH

University of Bayreuth

Car 29 **Pit 17-B** **WRL 45** Germany

Founded in 2004, the Elefant Racing Team from the university of Bayreuth is one of the oldest Formula Student Teams in Germany. In 2011 we changed from combustion to electric driven vehicles and 2019 to all-wheel-driven ones. We are proud to present our brand new car - the FR20 Ragnarök. The FR20 features a fully redesigned aerodynamics package, a highly improved torque vectoring and traction control systems. We are looking forward to exciting days at FSG 2021.

FRAME CONSTRUCTION Full CFRP monocoque with aluminum Front and Steel Main Hoop
MATERIAL CFRP prepreg, Al-honeycomb, balsa and abachi wood , EP adhesive film prepreg
OVERALL L / W / H 2875mm / 1400mm / 1168mm
WHEELBASE / TRACK (Fr / Rr)
1530mm / 1200mm / 1200mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 130kg / 148kg
SUSPENSION Double unequal length A-Arm. Direct acting spring/damper front, pushrod actuated rear.
TYRES (Fr / Rr) 16.0x7.5 R10, Hoosier LC0/ 16.0x7.5 R10, Hoosier LC0
WHEELS (Fr / Rr) 7x10, 35mm offset, 1 pc Carbon Rim/ 7x10, 35mm offset, 1 pc Carbon Rim
NUMBER OF MOTORS / LOCATION / MAX POWER
4 / each wheel one / 35kW per Motor
MOTOR TYPE Elefant Racing/ MaToMo-v1.1
MAX MOTOR RPM 18,000 per Motor
MOTOR CONTROLLER Lenze DCU 60/60
MAX SYSTEM VOLTAGE 588V
ELECTRODE MATERIALS LiCoO2
COMBINED ACCUMULATOR CAPACITY 6.84 kWh
TRANSMISSION RATIO (PRIMARY / SECONDARY)
1:11,49 / --
DRIVE TYPE Planetary Gear with stepped planets
DIFFERENTIAL software
COOLING Twin side pod mounted radiators with thermostatic controlled electric fans
BRAKE SYSTEM 4-Disk system, self developed 42CrMo4 rotors, adjustable brake balance
ELECTRONICS Self developed, reduandant VCU, Live-Telemetry via LTE, self developed BMS

DARMSTADT

Technische Universität Darmstadt

Car 742 **Pit 19-B** **WRL 68** Germany

The TU Darmstadt Racing Team was founded in 2005 and is attending FSG since its beginning. 2011 the Team switched to electric cars, and 2017 decided also to go driverless. 40 students are currently working on the electric and the driverless project. Since last year we build a car designed for the participation in electric and driverless class. This year we use new motors and inverters. Therefore, we developed a completely new wheelpackage.

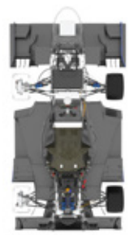
FRAME CONSTRUCTION Monocoque
MATERIAL CFRP-Prepreg, Aluminium honeycomb
OVERALL L / W / H 2994mm / 1454mm / 1201mm
WHEELBASE / TRACK (Fr / Rr) 1534mm / 1378mm / 1331mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 131kg / 142kg
SUSPENSION Double, unequal-length A-Arms, Push rod actuated horizontally oriented spring and damper
TYRES (Fr / Rr) 205/470 R13, Continental / 205/470 R13, Continental
WHEELS (Fr / Rr) 7x13, 17.95 mm offset, 1 pc CFRP Rim/7x13, 17.95 mm offset, 1 pc CFRP Rim
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / 1 at each Wheel / 35,4kW each
MOTOR TYPE Fischer TI085-052-070
MAX MOTOR RPM 20000
MOTOR CONTROLLER Lenze Schmidhauser DCU 60/60
MAX SYSTEM VOLTAGE 443V
ELECTRODE MATERIALS Polymer Li-Ion Battery
COMBINED ACCUMULATOR CAPACITY 5,81 kWh
TRANSMISSION RATIO (PRIMARY / SECONDARY) 13,73 / -
DRIVE TYPE Directly driven planetary gearbox
DIFFERENTIAL no differential
COOLING water-cooled, radiators on diffusor
BRAKE SYSTEM 4-Disk System, self developed rotors with 220mm diameter front and rear
ELECTRONICS Torque vectoring, Bidirectional TCP streaming via WLAN, Multifunctional Steering Wheel

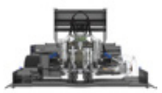
DELFT

Delft University of Technology

Car 85 **Pit 04-A** **WRL 18** Netherlands

The DUT21, the newest addition to the Formula Student Team Delft family! This year's extensive focus has been on the aerodynamics package of the DUT21. Significantly improving downforce numbers over its predecessor. The DUT21 is also the first in a long streak to decrease its chassis size which gives it that overall slim look!Something that can't be seen from the outside is the introduction of our custom-designed motor controllers which will be featured for the first time in the DUT21!





FRAME CONSTRUCTION Composite Monocoque
MATERIAL CFRP with Aluminium Honeycomb core
OVERALL L / W / H 2940mm / 1590mm / 1170mm
WHEELBASE / TRACK (Fr / Rr) 1530mm / 1250mm / 1250mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 116kg / 122kg
SUSPENSION Double unequal length A-arm. Push rod actuated horizontally oriented spring damper + ARB
TYRES (Fr / Rr) 225x368 R10, Vredestein / 225x368 R10 Vredestein
WHEELS (Fr / Rr) 214mm CFRP self-made two-piece rim / 214mm CFRP self-made two-piece rim
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / Integrated in the wheels / 35kW, 35kW, 35kW, 35kW
MOTOR TYPE Fischer TI085, PMSM
MAX MOTOR RPM 20000
MOTOR CONTROLLER Self-Developed
MAX SYSTEM VOLTAGE 600V
ELECTRODE MATERIALS LiCoO2
COMBINED ACCUMULATOR CAPACITY 7.0kWh
TRANSMISSION RATIO (PRIMARY / SECONDARY) 1:10.82 / n/a
DRIVE TYPE Single Stage Planetary with 3 planets
DIFFERENTIAL Electronic Torque vectoring with active tyre load optimisation
COOLING Optimised single loop system with 2 Rear mounted radiators and 60 W fans.
BRAKE SYSTEM 4-disk system with self-developed calipers integrated in upright. Adjustable brake balance
ELECTRONICS Selfdesigned Motorcontrollers, Selfdesigned cloud-based data acquisition

DIEPHOLZ

University of Applied Sciences Diepholz/Oldenburg/Vechta

Car 18 **Pit 32-A** **WRL 86** Germany

We are Deefholt Dynamics, the racing team of the PHWT from Diepholz. As part of our studies we participate at Formula Student since 2006. The special thing about us: our car is built every year by a first year team within only six months. This season 40 students joined the project with one goal: Building a competitive car as fast as no one else can do. So within our long-term concept we optimize our car step by step, year by year. This season with the first monocoque in the histoy of our team

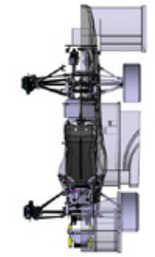
FRAME CONSTRUCTION Carbon Monocoque
MATERIAL Carbon aluminium honeycomb sandwich
OVERALL L / W / H 3149mm / 1450mm / 1180mm
WHEELBASE / TRACK (Fr / Rr) 1560mm / 1230mm / 1180mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 160kg / 160kg
SUSPENSION Double-wishbone suspension with pushrod system
TYRES (Fr / Rr) 205/470R13 Continental
WHEELS (Fr / Rr) OZ Formula Student Magnesium 4H wheel
NUMBER OF MOTORS / LOCATION / MAX POWER 2 / Rear / 52
MOTOR TYPE EMRAX 188
MAX MOTOR RPM 8000
MOTOR CONTROLLER emDrive H300 (BLDC motor contro
MAX SYSTEM VOLTAGE 400V
ELECTRODE MATERIALS Li-Ion
COMBINED ACCUMULATOR CAPACITY 6,428kWh
TRANSMISSION RATIO (PRIMARY / SECONDARY) 1:4 / -
DRIVE TYPE Motor - Clutch - Planetary gear - driv
DIFFERENTIAL electrical
COOLING two rear mounted radiator each for one Motor/ Contoller
BRAKE SYSTEM 4-Disk system 42CrMo4 steel, o.d.: 220mm, i.d.:166mm
ELECTRONICS Multifunctional Steering Wheel

DRESDEN

Technische Universität Dresden

Car 59 **Pit 10-A** **WRL 17** Germany

Elbflorace e.V. is a student team from Dresden. In the last two years we have been working on our 13th vehicle. Already in the concept phase the team decided for an internal turnaround. For years the team has increasing their vehicle performance. For the current vehicle the reliability, as well as the integration of the DV components moved into the focus. Elbflorace will participate in the 2021 events with their first hybrid vehicle in the club's history. Be excited!



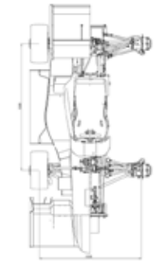
FRAME CONSTRUCTION Full Size CFRP Monocoque
MATERIAL CFRP with aramid honeycomb core and alumnium honeycomb core
OVERALL L / W / H 2954mm / 1415mm / 1179mm
WHEELBASE / TRACK (Fr / Rr) 1535mm / 1200mm / 1150mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 119kg / 135kg
SUSPENSION Double unequal lenght triangular A-Arm Suspension, pitch/roll decoupled spring/damper
TYRES (Fr / Rr) 205x470 R13 Continental C20
WHEELS (Fr / Rr)
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / Wheel Hubs FL FR RR RL / 35,3 kW
MOTOR TYPE Fischer Motors
MAX MOTOR RPM 20000
MOTOR CONTROLLER Selfdeveloped
MAX SYSTEM VOLTAGE 588V
ELECTRODE MATERIALS LiCoO2
COMBINED ACCUMULATOR CAPACITY 6,5 kWh
TRANSMISSION RATIO (PRIMARY / SECONDARY) -3 / 4,65
DRIVE TYPE
DIFFERENTIAL Eletrical Torque Vectoring
COOLING Air co
BRAKE SYSTEM 4-Disk system
ELECTRONICS wiring harness sealed to IP67, Multifunctional Steering Wheel, Electropneumatic Shifting S

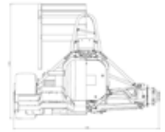
FREIBERG

TU Bergakademie Freiberg

Car 76 **Pit 43-A** **WRL 4** Germany

Racetech Racing Team was founded in 2005. This year we built our 14th car and ninth electric vehicle. After an era of rear-wheel drive cars, the RT14's key design changes are the switch to all-wheel drive and an increased focus on aerodynamics. This resulted in big changes throughout the car's layout and components, which we are proud to show off at this year's events. The RT14 will take on the competition in the Netherlands, Austria and Germany. We are looking forward to meeting you!





FRAME CONSTRUCTION Hybrid: F/R: aluminium monocoque, M: CFRP monocoque
MATERIAL F/R: 2017/6082 Al-sheets + Al-Honeycomb; M:CFRP, Al-Honeycomb/Airex rigid foam; Mg/Al Inlays
OVERALL L / W / H 3000mm / 1472mm / 1170mm
WHEELBASE / TRACK (Fr / Rr) 1530mm / 1220mm / 1220mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 130kg / 136kg
SUSPENSION Double unequal length A-arms, Pushrod actuated Heave/Roll decoupled dampers
TYRES (Fr / Rr) 205/470 R13, C20 Continental
WHEELS (Fr / Rr) 7x13, Hybrid rim: CFRP shell, Al center
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / FR, FL, RR, RL / 37,1kW
MOTOR TYPE self-developed Racetech M1-VZG
MAX MOTOR RPM 19200
MOTOR CONTROLLER Lenze-Schmidhauser Mobile DCU
MAX SYSTEM VOLTAGE 596V
ELECTRODE MATERIALS LiCoO2, pouch cells
COMBINED ACCUMULATOR CAPACITY 6,935kWh
TRANSMISSION RATIO (PRIMARY / SECONDARY) 14,24 / -
DRIVE TYPE 1,5 stage planetary gearbox
DIFFERENTIAL wheels driven independently, torque vectoring
COOLING 2 independent circuits for motors and inverters, Sidewing mounted radiators
BRAKE SYSTEM 4-Disk system, self developed DSLM Aluminium calipers, adj. brake balance
ELECTRONICS self developed vehicle dynamics control module, Live Telemetry system

GÖTTINGEN

Hochschule für angewandte Wissenschaft und Kunst Hildesheim/ Holzminden/Göttingen

Car 161 **Pit 23-A** **WRL 69** Germany

Blue Flash was originally known for implementing a low voltage tractive system within the formula student. Since then we have switched to a high voltage system, but still focus on building an especially safe and reliable vehicle. Also, all our cars weigh below 200kg as we continue to develop lightweight and simple solutions. A specialty of this year's eHA-WK20B is that we used the extra year of development time to upgrade our drivetrain by combining a gearbox with a differential.

FRAME CONSTRUCTION Tubular space frame
MATERIAL S235 +C , S355 +N ; 27x1.5, 26x1.2, 30x2
OVERALL L / W / H 2800mm / 1350mm / 1200mm
WHEELBASE / TRACK (Fr / Rr) 1550mm / 1350mm / 1350mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 112kg / 137kg
SUSPENSION Double A-Arm, unequal length, Push rod, Spring and Damper horizontally
TYRES (Fr / Rr) 205/470 R13 Conti C16
WHEELS (Fr / Rr) Mg CAST 7x13 Wheel, 30mm offset
NUMBER OF MOTORS / LOCATION / MAX POWER 1 / Rear Center / 68kW
MOTOR TYPE Emrax 208 High Volatge liquid cooled
MAX MOTOR RPM 6000 (7000 with field weakening)
MOTOR CONTROLLER DTI HV500 LC
MAX SYSTEM VOLTAGE 457V
ELECTRODE MATERIALS LiCoO2 - graphite
COMBINED ACCUMULATOR CAPACITY 7,67kWh
TRANSMISSION RATIO (PRIMARY / SECONDARY) 1:5,3 / n/a
DRIVE TYPE spur gears
DIFFERENTIAL Limited slip differential (Drexler)
COOLING Two separate cooling circuits for inverter and motor
BRAKE SYSTEM 4-Disk system, self dev. rotors with 207/207mm (f/r) diameter, adj. brake balance
ELECTRONICS self design main control unit, self designed battery management system

GRAZ

Graz University of Technology

Car 153 **Pit 34-A** Austria

We are the TU Graz Racing Team from Austria and are participating forthe 16th consecutive time at FSG. This year will be for us the first time with an electric car, called Gina. To achieve this goal, we worked very hard to develop a new electric TANKIA and are now looking forward to compete with the best in the world of Formula Electric.

FRAME CONSTRUCTION one piece CFRP monocoque
MATERIAL carbon fi bre prepregs, Nomex and aluminium honeycombs, structual foam
OVERALL L / W / H 2885mm / 1430mm / 1174mm
WHEELBASE / TRACK (Fr / Rr) 1550mm / 1180mm / 1180mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 101kg / 131kg
SUSPENSION double unequal length A-arms, pushrod actuated horizontally oriented spring and damper
TYRES (Fr / Rr) 16.0 x 7.5 - R10, Hoosier LCO / 16.0 x 7.5 - R10, Hoosier LC0
WHEELS (Fr / Rr) 7.5 x 10.0, 2 piece, 3 spoke design, CFRP superlightweight
NUMBER OF MOTORS / LOCATION / MAX POWER 2 / RR/RL / 35kW
MOTOR TYPE Fischer Losing It
MAX MOTOR RPM 20000
MOTOR CONTROLLER Selfmade
MAX SYSTEM VOLTAGE 598V
ELECTRODE MATERIALS LIPO
COMBINED ACCUMULATOR CAPACITY 7,48
TRANSMISSION RATIO (PRIMARY / SECONDARY) 12,35 /
DRIVE TYPE Planetary Gearbox
DIFFERENTIAL
COOLING Lunaqua Selfmade Raditor Speciale
BRAKE SYSTEM 4 disk system, self designed rear and front brakes, electric adj. brake balance
ELECTRONICS multifunctional steering wheel, electric clutch actuation, self designed live telemetry

HAMBURG

Hamburg University of Technology

Car 778 **Pit 46-B** **WRL 47** Germany

The egn20 is the most innovative and forward-thinking car e-gnition has ever build. In the coming years FSG is looking to integrate driverless technology into every car participating in the event. We decided to start this integration one year early. The egn20 is able to run EV and with a quick change of the steering wheel and front wing it is capable to drive DV as well. The steering actuation is fully integrated into the steering wheel and easily exchangeable with a quick release.

FRAME CONSTRUCTION Monocoque structure with prep-reg and aluminium honeycomb core
MATERIAL Unidirectional fibers M21T800S + different kinds of aluminium honeycomb structure
OVERALL L / W / H 2935mm / 1422mm / 1175mm
WHEELBASE / TRACK (Fr / Rr) 1530mm / 1200mm / 1150mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 112kg / 142kg
SUSPENSION double unequal length a-arms, pushrod actuated bellcranks, heave-roll-decoupled system
TYRES (Fr / Rr) 470 x 205 R13 Continental
WHEELS (Fr / Rr) 7x13" 30mm offset, CFRP rim
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / Every wheel / 35 kW, 35kW, 35kW, 35kW
MOTOR TYPE All: Fischer TI085-052-070-04B7S-07S04BE2
MAX MOTOR RPM All: 20000rpm
MOTOR CONTROLLER Lenze Schmidhauser Mobile Drives
MAX SYSTEM VOLTAGE 588V
ELECTRODE MATERIALS LiCoO2
COMBINED ACCUMULATOR CAPACITY 6,216kWh
TRANSMISSION RATIO (PRIMARY / SECONDARY) 1:12,78 / n/a
DRIVE TYPE two staged planetary gear
DIFFERENTIAL n/a
COOLING Water cooling. Two fans and heat exchangers, four motors, two inverters and a DV computer
BRAKE SYSTEM self developed rotors 222mm diameter, lasersintered self manufactured brake callipers
ELECTRONICS ECU, AMS, ACU, fuse board and sensor boards self designed.

HANNOVER

Leibniz Universität Hannover

Car 20 **Pit 44-B** **WRL 75** Germany

HorsePower Hannover e.V. was founded in 2007 and first competed as a combustion team in 2009. The first electric car was build in 2011, the electricHorse11. This season, we build our 10th electric vehicle, the eH20, with an AWD concept with four individual wheel hub drives, CFRP aluminium sandwich monocoque, full aerodynamic package and a HV accumulator stored in the side pods.

FRAME CONSTRUCTION single-piece CFRP monocoque
MATERIAL CFRP prepreg with aluminium honeycomb
OVERALL L / W / H 2920mm / 1425mm / 1145mm
WHEELBASE / TRACK (Fr / Rr) 1555mm / 1220mm / 1180mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 146kg / 146kg
SUSPENSION Double A-Arm with direct actuation at the front and pushrod actuation at the rear.
TYRES (Fr / Rr) Continental C19 470/205 R13
WHEELS (Fr / Rr) OZ Magnesium Rim
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / AWD near-wheel-drive / 36 kW each
MOTOR TYPE AMK / DT5-14-10-POW 14000-B5
MAX MOTOR RPM 20000
MOTOR CONTROLLER AMK KW26-S5-FSE
MAX SYSTEM VOLTAGE 588V
ELECTRODE MATERIALS LiPo
COMBINED ACCUMULATOR CAPACITY 6kWh
TRANSMISSION RATIO (PRIMARY / SECONDARY) 13,185 / n/a
DRIVE TYPE AWD wheel hub drive
DIFFERENTIAL programmable
COOLING Watercooled circuit for motors and inverter, cooled by two radiators laterally at the rear
BRAKE SYSTEM 4-Disk system, adjustable brake balance
ELECTRONICS traction control, torque vectoring, dash-board integrated in cockpit

ILMENAU

Ilmenau University of Technology

Car 71 **Pit 19-A** **WRL 153** Germany

Team Starcraft is the Formula Student Team of the TU Ilmenau and combines a wide variety of courses. In racing, progress and efficiency play a major role. Therefore, we have been building purely electric race cars since 2011. The main design goal for this year's car was to re-engineer the packaging of our electric components for better maintenance of important parts. A revised monocoque and aerodynamic parts improve both, the stiffness of the overall car as well as the air flow around it.

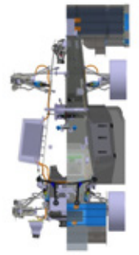
FRAME CONSTRUCTION Monocoque
MATERIAL Prepreg CFRP layup with aluminium honey-comb core
OVERALL L / W / H 2915mm / 1450mm / 1119mm
WHEELBASE / TRACK (Fr / Rr) 1530mm / 1200mm / 1200mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 123kg / 120kg
SUSPENSION Double equal length A-Arm. Pushrod actua-ted horizontally oriented spring/damper
TYRES (Fr / Rr) Continental 205x34 R13
WHEELS (Fr / Rr) OZ FSAE Mg 7x13
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / FR, FL, RR, RL / 35kW, 35kW, 35kW, 35kW
MOTOR TYPE AMK-DD5-14-10-POW
MAX MOTOR RPM 20
MOTOR CONTROLLER Self-developed SiC-based inverter
MAX SYSTEM VOLTAGE 600V
ELECTRODE MATERIALS LiCoO2
COMBINED ACCUMULATOR CAPACITY 8,3 kWh
TRANSMISSION RATIO (PRIMARY / SECONDARY) 15,49:1 / N/A
DRIVE TYPE N/A
DIFFERENTIAL N/A
COOLING water cooling of motors and inverter, air cooling of accumulator container
BRAKE SYSTEM 4-Disk system; Front 218,8mm/Rear 197,3mm; adjustable brake balance
ELECTRONICS Multifunctional Steering Wheel

INGOLSTADT

Technische Hochschule Ingolstadt

Car 34 **Pit 29-A** **WRL 98** Germany

Since 2010 our SRe's, as we name our cars, have been constructed in Ingolstadt, by a team of 50 dedicated students from over 10 different courses of study. This year's goal was to create a reliable, competitive and easy-to-drive car. We are proud to present you the lightest car in our team's history: the SRe20! After very promising initial vehicle tests, we are looking forward to a successful FSG21. By the way a fun fact about our team: we proudly wear the city's emblem - the blue panther!



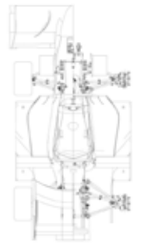
FRAME CONSTRUCTION single piece CFRP Monocoque
MATERIAL Rohacell core sandwich panel
OVERALL L / W / H 2902mm / 1470mm / 1197mm
WHEELBASE / TRACK (Fr / Rr) 1550mm / 1200mm / 1164mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 130kg / 166kg
SUSPENSION Double unequal length A-Arm, Push rod actuated at upper A-Arm, Direct acting coilover
TYRES (Fr / Rr) 205/470 R13, Continental C20 / 205/470 R13, Continental C20
WHEELS (Fr / Rr) 7x13, 30mm off set, 1 Pc Mg Rim (OZ) / 7x13, 30mm off set, 1 Pc Mg Rim (OZ)
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / outboard wheelhub motors / 35 kW
MOTOR TYPE AMK DD5-14-10-POW-18600-B5
MAX MOTOR RPM 20000 rpm
MOTOR CONTROLLER AMK KW26-S5-FSE-4Q
MAX SYSTEM VOLTAGE 600V
ELECTRODE MATERIALS NCA
COMBINED ACCUMULATOR CAPACITY 7,8 kWh
TRANSMISSION RATIO (PRIMARY / SECONDARY) 14,6 / n/a
DRIVE TYPE 1.5-stage planetary gearbox
DIFFERENTIAL n/a
COOLING air cooled accumulator, water cooled inverters and motors
BRAKE SYSTEM self developed rotors with 228 mm dia-meter, 4 piston front, 2 piston rear
ELECTRONICS dashboard with temperature and SoC on bargraphs, Live telemetry system via LoRa

KARLSRUHE

Karlsruhe Institute of Technology

Car 21 **Pit 41-B** **WRL 16** Germany

„One Team - two Cars" KA-RaceIng is designing, manufacturing and competing with an FSE and FSD car in 2021. After a successful season in 2019, we decided that it is more fun to change everything possible on the car instead of validating and refining the known concept. In addition we decided that we like challenges, so we packaged our chassis as tight as possible.



FRAME CONSTRUCTION CFRP Monocoque
MATERIAL UHM UD, HM Twill, HS UD, Aluminium and nomex honeycombs
OVERALL L / W / H 2863mm / 1546mm / 1180mm
WHEELBASE / TRACK (Fr / Rr) 1530mm / 1220mm / 1220mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 124kg / 137kg
SUSPENSION double uneq. length A-Arm, Pushrod acutatetd horizontally orientated spr. damp. System
TYRES (Fr / Rr) 16x 7,5 - 10 Hoosier R25B
WHEELS (Fr / Rr) Student Made CFRP rim 10×6.5
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / Wheelhub / 20kW
MOTOR TYPE PMSM
MAX MOTOR RPM 20000
MOTOR CONTROLLER ETI SIC01-600V-65A, self designed
MAX SYSTEM VOLTAGE 600V
ELECTRODE MATERIALS LiPo
COMBINED ACCUMULATOR CAPACITY 7,6kWH
TRANSMISSION RATIO (PRIMARY / SECONDARY) 12,009 / -
DRIVE TYPE two stage planetary wheelhub gearbox
DIFFERENTIAL direct drive
COOLING closed system, water cooling, two seperated circuits (motors, PE), radiators positioned on the side
BRAKE SYSTEM 4- Disk system, 8-piston self developed brake calliper at the front
ELECTRONICS Live-Telemetry, Traction Control, Active Yaw Control, Torque Vectoring, Interface Unit

KIEL

University of Applied Sciences Kiel

Car 53 **Pit 32-B** **WRL 83** Germany

For the third time in a row Raceyard is back at FSG! Due to the pandemic we designed and manufactured our new car, the T-Kiel A CE within two years. Following the cancelled events last year we built a new team and focused on the improvement of its predecessor. This way we aimed our targets on weight reduction, increasing reliability and enabling the compatibility to driverless components for the next season. In pursuit of efficiency optimization we introduced a recuperation system.

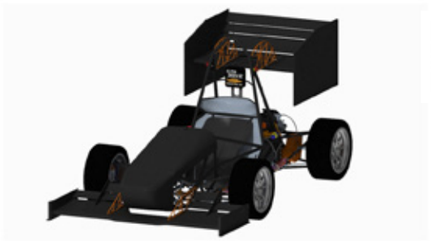
FRAME CONSTRUCTION CFRP sandwich monocoque with tubular steel roll bars
MATERIAL Prepreg Carbon Fiber layup with aluminium honeycomb sandwich panels
OVERALL L / W / H 3170mm / 1410mm / 1195mm
WHEELBASE / TRACK (Fr / Rr) 1565mm / 1200mm / 1200mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 123kg / 130kg
SUSPENSION Double unequal length wishbone; Push rod; seperated heave and roll spring and damper
TYRES (Fr / Rr) 205/470 R13, Continental C19 / 205/470 R13, Continental C19
WHEELS (Fr / Rr) 7x13, 30 mm offset, 1 pc Mg Rim (OZ) / 7x13, 30 mm offset, 1 pc Mg Rim (OZ)
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / each Wheelhub / 4x 35,4kW
MOTOR TYPE TI085-052-070-04B7S-07S04BE2
MAX MOTOR RPM 20000
MOTOR CONTROLLER Lenze-Schmidhauser Mobile DCU
MAX SYSTEM VOLTAGE 600V
ELECTRODE MATERIALS LiCoO2
COMBINED ACCUMULATOR CAPACITY 6,77kWh
TRANSMISSION RATIO (PRIMARY / SECONDARY) 12,5:1 / n/a
DRIVE TYPE 1,5-stage planetary gearbox
DIFFERENTIAL n/a
COOLING water cooled motors and motor controller, air cooled accumulator
BRAKE SYSTEM 4 wheel recuperation; topology optimized brake system desinged for SLM manufacturing
ELECTRONICS Torque Vectoring; multifunctional steering wheel; DC-DC converter

KONSTANZ

University of Applied Sciences Konstanz

Car 43 **Pit 12-A** Germany

This year we are proud to present to you our team's first ever electric Formula Student car: the Iltis2021E. It is the result of almost three years of work, since the design of the accumulator and drivetrain already started parallel to the 2019 season. The car has a 600V accumulator, which supplies a Lenze DCU inverter. The inverter drives the two Emrax 208 electric motors mounted in the rear of the vehicle.



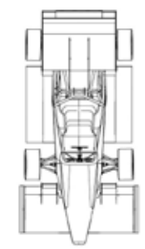
FRAME CONSTRUCTION Tubular steel frame
MATERIAL 25CrMo4
OVERALL L / W / H 2840mm / 1460mm / 1180mm
WHEELBASE / TRACK (Fr / Rr) 1530mm / 1210mm / 1170mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 126kg / 163kg
SUSPENSION Double unequal length A-Arm, Pull rod actuated horizontally oriented spring and damper
TYRES (Fr / Rr) 205/470 R13, Continental 34M
WHEELS (Fr / Rr) wheels 7x13, 30mm offset, Mg rim, OZ S.p.A
NUMBER OF MOTORS / LOCATION / MAX POWER 2 / Rear right, rear left / 68kW each
MOTOR TYPE EMRAX 208
MAX MOTOR RPM 6000
MOTOR CONTROLLER Lenze DCU 6060
MAX SYSTEM VOLTAGE 600V
ELECTRODE MATERIALS LiPo-graphite
COMBINED ACCUMULATOR CAPACITY 7,5 kWh
TRANSMISSION RATIO (PRIMARY / SECONDARY) 1:4,41 / n/a
DRIVE TYPE custom build single stage transmission
DIFFERENTIAL n/a
COOLING Rear mounted, custom build radiator
BRAKE SYSTEM self devel. floating rotors with 225mm OD, adj. brake bias, 4- and 2-piston ISR calipers
ELECTRONICS Steering Wheel with integrated Display, self-designed PDM

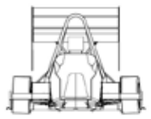
LAUSANNE

École Polytechnique Fédérale de Lausanne

Car 127 **Pit 22-A** **WRL 151** Switzerland

Thanks to our new and motivated team, we had the opportunity to really focus on research and development this year, to make a big step forward and try to catch up with the teams that have been in the business years before us. We also greatly progressed on the manufacturing side; developing our first parts in carbon fiber. We were able to test, try out, experiment and learn all year long, and this resulted in our newest and best race car: Mercury.





FRAME CONSTRUCTION Front and rear tubular space frame
MATERIAL Steel E235, Steel Docol R8 (from SSAV), round tubing 25.4mm to 31.75mm dia
OVERALL L / W / H 3065mm / 1540mm / 1185mm
WHEELBASE / TRACK (Fr / Rr) 1570mm / 1240mm / 1200mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 138kg / 137kg
SUSPENSION Double unequal length A-arm. Pull rod actuated vertically oriented spring and damper.
TYRES (Fr / Rr) 160x75 R10, Hoosier
WHEELS (Fr / Rr) 7x10, 22mm offset, 1pc magnesium rim
NUMBER OF MOTORS / LOCATION / MAX POWER 2 / rear right, rear left / 52kW
MOTOR TYPE Emrax 188, Three phase PMSM
MAX MOTOR RPM 8000
MOTOR CONTROLLER Bamocar D3 400/400
MAX SYSTEM VOLTAGE 403V
ELECTRODE MATERIALS LiPo
COMBINED ACCUMULATOR CAPACITY 1,037
TRANSMISSION RATIO (PRIMARY / SECONDARY) 1:4.5 / n/a
DRIVE TYPE Planetary (single gear)
DIFFERENTIAL electronic differential
COOLING Twin side pod mounted radiators without fans
BRAKE SYSTEM 4 disk system, 175 outer diam, 25mm calipers,4 pistons front, 2 rear
ELECTRONICS Simple differential, traction control, data logging via sbrio 9627, 2 waterpumps

LISBOA

Universidade de Lisboa - Instituto Superior Técnico

Car 50 **Pit 29-B** **WRL 54** Portugal

FST Lisboa was established in 2001 and is the Formula Student team from Uni Lisbon. After developing 3 CV cars, this year the team presents its 7th EV - FST10e. It is based on our previous car with improved reliability in our transmissions, cooling circuit and electronics, a major weight reduction and a newly developed aerodynamic package and torque vectoring algorithm. For two years, more than 80 members are eager to present their work and compete in the top tier competitions of the world.

FRAME CONSTRUCTION Composite single-piece monocoque built with 2 negative carbon fiber moulds
MATERIAL Carbon fiber sandwich structure with Honeycomb, Rohacell and 3D core as the core
OVERALL L / W / H 2991mm / 1444mm / 1189mm
WHEELBASE / TRACK (Fr / Rr) 1540mm / 1200mm / 1200mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 136kg / 150kg
SUSPENSION Double unequal A-Arms, Push rod actuated spring/damper and torsional ARB
TYRES (Fr / Rr) Continental C19
WHEELS (Fr / Rr) OZ 7x13 CL Magnesium Wheel
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / Outboard wheel motors / 35 kW,35 kW,35 kW,35 kW
MOTOR TYPE AMK/ DD5-14-10-POW
MAX MOTOR RPM 20
MOTOR CONTROLLER AMK-KW26-S5-FSE-4Q
MAX SYSTEM VOLTAGE 588V
ELECTRODE MATERIALS LiCoO2
COMBINED ACCUMULATOR CAPACITY 7.6kWh
TRANSMISSION RATIO (PRIMARY / SECONDARY) 15.21:1 / N/A
DRIVE TYPE Epicyclic stepped gear train, 3 planets
DIFFERENTIAL N/A
COOLING Twin rear mount radiator with 35W fans for motor and inverter water cooling. Air cooled Accumulator
BRAKE SYSTEM 4 - Floating disk Sysem, self developed rotors with 220mm OD, adjustable brake balance
ELECTRONICS Drivetrain sensor aquisistion, pilot interface in dash, 2xCAN comm, WiFi Telemetry

MADRID

Technical University of Madrid (UPM)

Car 15 **Pit 37-A** **WRL 90** Spain

Founded in 2003, UPM Racing is the first Spanish FS team, made up of 60 engineering students of the Universidad Politécnica de Madrid. In 2018, we moved on from combustion and changed our philosophy, switching to our first carbon fibre monocoque, 4 in-wheel-drive electric system to create the most revolutionary car of our history. This season we have optimized that concept to extract its maximum potential, now embodied in the UPM04e, which will fly with us to FSG boosting us to do our best!

FRAME CONSTRUCTION Composite sandwich monocoque chassis / Attached MH and encapsulated FH
MATERIAL CFRP and aramid epoxy prepreg + hexagonal aluminium and aramid honeycomb
OVERALL L / W / H 3001mm / 1430mm / 1212mm
WHEELBASE / TRACK (Fr / Rr) 1550mm / 1200mm / 1200mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 132kg / 168kg
SUSPENSION Double unequal wishbone, actuated by push rod on the upper a-arm, with bellcrank
TYRES (Fr / Rr) Hoosier, 6.0/18.0; rim:10 (inches) / Hoosier, 6.0/18.0; rim:10 (inches)
WHEELS (Fr / Rr) 6.0x10, -5 mm offset, Aluminium alloy / 6.0x10, -5 mm offset, Aluminium alloy
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / Front&Rear, Right&Left, / 27.3kW per motor
MOTOR TYPE AMK DD5-14-10-POW-18600-B5
MAX MOTOR RPM 20
MOTOR CONTROLLER AMK KW26-S5-FSE-4Q
MAX SYSTEM VOLTAGE 580V
ELECTRODE MATERIALS LiCoO2
COMBINED ACCUMULATOR CAPACITY 8.11kWh
TRANSMISSION RATIO (PRIMARY / SECONDARY) 13,176 / n/a
DRIVE TYPE Compound planetary gear with locked ring
DIFFERENTIAL n/a
COOLING 3 independent water-cooling systems for inverters and motors. Air forced convection battery cooling
BRAKE SYSTEM 4-disk, adjustable brake balance system with self-developed 188mm rotors
ELECTRONICS Self-Designed BMS, Telemetry & Data Acquisition System and Power Distribution with LV BMS

MANNHEIM

Duale Hochschule Baden-Württemberg - Mannheim

Car 101 **Pit 17-A** **WRL 134** Germany

We proudly present EVA, our CM-21x vehicle. She is our fourth EV and first autonomous driving vehicle. Accentuated by a revolutionary aerodynamic package, the enhanced performance of EVA represents the major innovations in vehicle dynamics to date. Not only are the mechanics pathing their way to modernization, but also electronics, where our one-way telemetry via LTE is able to provide a detailed insight into EVA in real-time, of course only to all authorized team members.

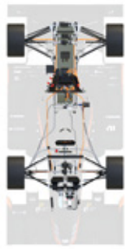
FRAME CONSTRUCTION Tubular steel space frame, 28,57 mm diameter tubes
MATERIAL Docol Tube R8
OVERALL L / W / H 2947mm / 1465mm / 1188mm
WHEELBASE / TRACK (Fr / Rr) 1550mm / 1200mm / 1250mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 150kg / 150kg
SUSPENSION double A-Arms, Pullrod actuated horizontally oriented spring and damper
TYRES (Fr / Rr) 205/470 R 13 - Continental
WHEELS (Fr / Rr) 205/470 R 13 - Continental
NUMBER OF MOTORS / LOCATION / MAX POWER 2 / two motors in cars rear / 68 kW
MOTOR TYPE Axial flux synchronous motors
MAX MOTOR RPM 6000 (7000 active field weakning)
MOTOR CONTROLLER BAMOCAR-PG-D3-700-160
MAX SYSTEM VOLTAGE 453V
ELECTRODE MATERIALS LiCoO2
COMBINED ACCUMULATOR CAPACITY 6.4 kWh
TRANSMISSION RATIO (PRIMARY / SECONDARY) 1:5 / -
DRIVE TYPE Direct drive with single-gear planetary
DIFFERENTIAL -
COOLING Rear mounted radiator with two temperature controlled electric fans
BRAKE SYSTEM 4-Disk system; AP-Racing Master cylinders; self developed rotors with 240/230 mm (F/R)
ELECTRONICS Data logging: Transmits CAN data per LTE & mqtt to server, saving to db & shows on website

MÜNCHEN

Technical University of Munich

Car 31 **Pit 38-B** **WRL 1** Germany

The TUfast Racing Team from the TU Munich consists of 90 Team members who designed and build two racecars last season (electric + driverless). One Team – Two Cars – TUfast. Searching for potential in innovative concepts, we developed a completely new racecar. The eb020 is our electric race car from 2020 and focuses on the main goals lightweight design, aerodynamic performance and vehicle control. The result is the lightest car in TUfast history.



FRAME CONSTRUCTION CFRP Monocoque
MATERIAL Aluminum honeycomb sandwich panel
OVERALL L / W / H 3003mm / 1450mm / 1165mm
WHEELBASE / TRACK (Fr / Rr) 1650mm / 1225mm / 1225mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 108kg / 108kg
SUSPENSION Double unequal length A-Arm, Push rod actuated at lower A-Arm, Roll/heave SDS
TYRES (Fr / Rr) 16x7.5 - 10 Hoosier LC0
WHEELS (Fr / Rr) 8x10, 1 pc CFRP Rim
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / in-wheel drive / 35kW
MOTOR TYPE permanent excitated watercooled synchronous
MAX MOTOR RPM 20
MOTOR CONTROLLER self-developed SiC-inverter
MAX SYSTEM VOLTAGE 600V
ELECTRODE MATERIALS LiCoO2
COMBINED ACCUMULATOR CAPACITY 6,2kWh
TRANSMISSION RATIO (PRIMARY / SECONDARY) 13 / -
DRIVE TYPE 4x in-wheel drive
DIFFERENTIAL Individually driven wheels
COOLING air scoop over driver's head
BRAKE SYSTEM 4-Disk system, self-developed floating disks, 193 outer diameter; aluminum milled calipers
ELECTRONICS self-developed LV-system; bidirectional UDP streaming via WLAN/RF, LTE Live-Telemetry

MÜNCHEN

University of Applied Sciences München

Car 13 **Pit 14-B** **WRL 15** Germany

PassionWorks - not only the name of our cars but also our guiding principle! Founded in 2005 our team celebrates not only the 15th FS-season, but also our 10th electric car. Coming a long way from our first vehicle, this years's electric car, PWeX.20, is not only fitted with 4-wheel-drive, CFRP mono and full aero package but its first self-developed SiC-inverter for a more efficient powertrain. After two long years of development and constructing we are exited to finally compete on a race track!

FRAME CONSTRUCTION Full Composite Monocoque
MATERIAL CFRP, Aramid, PMI Foam, Epoxy Resin
OVERALL L / W / H 2869mm / 1450mm / 1180mm
WHEELBASE / TRACK (Fr / Rr) 1530mm / 1200mm / 1200mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 124kg / 125kg
SUSPENSION Double unequal length A-Arms, Pull-rod actuated horizontally mounted three spring system
TYRES (Fr / Rr) 16,0x7,5-10 Hoosier R25B / x7,5-10 Hoosier R25B
WHEELS (Fr / Rr) 7,5x10 CFRP rims
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / Wheehubdrive / 35kW
MOTOR TYPE permanent excitated watercooled synchronous
MAX MOTOR RPM 20000
MOTOR CONTROLLER self developed SiC
MAX SYSTEM VOLTAGE 554V
ELECTRODE MATERIALS LiNiCoAlO2
COMBINED ACCUMULATOR CAPACITY 7,128
TRANSMISSION RATIO (PRIMARY / SECONDARY) 12,3 / n/a
DRIVE TYPE planetery gearbox with step planets
DIFFERENTIAL torque vectoring
COOLING Rear mounted radiators with thermostatically controlled electric fans, water cooled motor housings
BRAKE SYSTEM 4 calipers, floating, x20cr13, hub mounted, effective diameter 170/165mm (front/rear)
ELECTRONICS Recuperation, Traction Control, Torque Vectoring, Live Time Telemetry via 2,4GHz WLAN

NEW DELHI

Indian Institute of Technology Delhi

Car 16 **Pit 44-A** **WRL 121** India

AXLR8R Formula Racing is a team of over 30 students from the Indian Institute of Technology Delhi, working towards setting up a milestone in Formula Student competitions. Since its inception in 2006, we have built 5 combustion and 3 electric cars. With improved vehicle dynamics and advanced integrated cooling in the powertrain, we are ready to take a leap with our XLR-20.

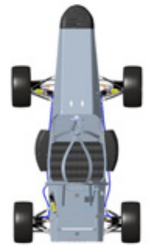
FRAME CONSTRUCTION Tubular Steel Spaceframe Chassis
MATERIAL AISI 1015 Mild Steel
OVERALL L / W / H 2640mm / 1455mm / 1130mm
WHEELBASE / TRACK (Fr / Rr) 1600mm / 1250mm / 1200mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 139kg / 163kg
SUSPENSION Double unequal length A-arm, Push actuation (both front and rear)
TYRES (Fr / Rr) 205/470 R13, FSAE Dry, Continental
WHEELS (Fr / Rr) 7x13
NUMBER OF MOTORS / LOCATION / MAX POWER 2 / Rear left, Rear right / 30 kW, 30 kW
MOTOR TYPE Permanent Magnet Synchronous Motor
MAX MOTOR RPM 7000
MOTOR CONTROLLER Rinehart PM100DZ
MAX SYSTEM VOLTAGE 397V
ELECTRODE MATERIALS LiCoO2-Graphite
COMBINED ACCUMULATOR CAPACITY 7,8kWh
TRANSMISSION RATIO (PRIMARY / SECONDARY) 1:6.25 / n/a
DRIVE TYPE Stepped Planetary Gearbox
DIFFERENTIAL Torque vectoring implemented, No mechanical differential used
COOLING Water Cooled Motors and Inverters, Forced convection cooling of Accumulator using 8 electric fans
BRAKE SYSTEM Compact Pedal Box, Self designed rotors with 4 piston calipers in front and 2 in rear
ELECTRONICS Live Telemetry via LTE, Self-Designed BMS, LCD Driver Display

NÜRNBERG

Georg-Simon-Ohm-Hochschule Nürnberg

Car 60 **Pit 40-A** **WRL 53** Germany

Never has anything different come into question: since the release of our first car NoRa1 in 2013, Strohm und Söhne e.V. is committed to sustainable motorsport in Formula Student. We proudly present NoRa7, the latest car in our era of electric vehicles and are excited to be part of Formula Student Germany 2021. After starting from scratch last season, we managed to build both – a new car and a new team – and are ready to race TH Nürnberg Georg Simon Ohm to the top ranks.



FRAME CONSTRUCTION Aluminium sandwich monocoque with tubular steel roll bars
MATERIAL Plascore honeycomb - AW6082 skins (18 mm core, sides 0.8)
OVERALL L / W / H 2674mm / 1400mm / 1078mm
WHEELBASE / TRACK (Fr / Rr) 1530mm / 1190mm / 1150mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 126kg / 139kg
SUSPENSION Double A-Arm. Push rod actuated, KW dampers. Adjustable damping, ride & roll rate
TYRES (Fr / Rr) 205x470 R13 34M Continental
WHEELS (Fr / Rr) 7Jx13 in., 30 mm offset, Magnesium Center Lock
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / Fr, Fl, Rr, Rl / 35kW
MOTOR TYPE AMK DD5-14-10-P0W-18600-B5
MAX MOTOR RPM FL,FR: 20.000; RR,RL: 20.000
MOTOR CONTROLLER AMK - KW26-S5-FSE-4Q 2
MAX SYSTEM VOLTAGE 600V
ELECTRODE MATERIALS Li-Ion
COMBINED ACCUMULATOR CAPACITY 7,2576
TRANSMISSION RATIO (PRIMARY / SECONDARY) 1:13.83 / N/A
DRIVE TYPE Planetary Gearbox
DIFFERENTIAL N/A
COOLING two 800cc radiators mounted on each side of the car, no fan used, carbon cooling duct
BRAKE SYSTEM 4-Disk system, self developed rotors with 202mm/176mm diameter (front/rear)
ELECTRONICS Self developed CAN sensor node system, dashboard screen with touchscreen

PADOVA

University of Padova

Car 185 **Pit 26-B** **WRL 76** Italy

This is our fourth electric car.The concept is an all-wheel drive car with 4 AMK motors, mounted on the wheel group.The layup of the carbon fiber monocoque has been completely redesigned.The battery pack is composed of 284 Prismatic Lithium Ion cells stored in a fire resistant composite fiber case. Push-rod suspension and self-developed planetary gearbox. New torque vectoring and launch control algorithms. Self-developed electronic circuitry with on-board telemetry and data logger.

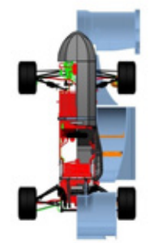
FRAME CONSTRUCTION One-piece CFRP monocoque
MATERIAL GG204P, IMS 65, T1000, Zylon, Aluminium Honeycomb 4.5pcf, Aluminium Honeycomb 6.1 pcf
OVERALL L / W / H 2900mm / 1425mm / 1132mm
WHEELBASE / TRACK (Fr / Rr) 1535mm / 1535mm / 1200mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 132kg / 143kg
SUSPENSION Double wishbone, push-rod, rocker with spring+damper and adjustable sway bar
TYRES (Fr / Rr) Hoosier 18.0 x 7.5-10 R25B
WHEELS (Fr / Rr) 7x10, OZ Central Lock Magnesium rim
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / FR,FL,RR,RL / 35kW
MOTOR TYPE AMK / DD5-14-10-POW-18600-B5
MAX MOTOR RPM 20000
MOTOR CONTROLLER AMK KW26-S5-FSE-4Q
MAX SYSTEM VOLTAGE 532V
ELECTRODE MATERIALS LiCoO2
COMBINED ACCUMULATOR CAPACITY 6.7kWh
TRANSMISSION RATIO (PRIMARY / SECONDARY) 14.4:1 / 14.4:1
DRIVE TYPE Planetary Gearbox
DIFFERENTIAL Software-applied torque vectoring
COOLING Twin sidepod mounted water radiators,3D printed motor cooling jackets, aluminium inverter coldplates
BRAKE SYSTEM 4-Disk system, self developed floating rotors
ELECTRONICS wiring harness sealed to IP67, Multifunctional Steering Wheel, On-board Telemetry System

PRAGUE

Czech Technical University in Prague

Car 167 **Pit 04-B** **WRL 49** Czech Republic

We are the first and only electric formula team in Czech Republic. This is the 10th genereation of the eForce Fee Prague Formula named FSE.X. With its powerfull drivetrain and light weight, it can compete against any other FS electric team. Brand new powertrain combined with four in-wheel motors and two stage planetary gearbox, with each motor controlled independetly produces best on-trac performance and is alredy prepared for DV class modifications.



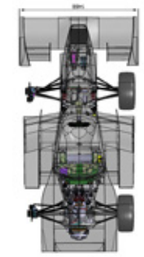
FRAME CONSTRUCTION Composite monocoque
MATERIAL CFRP, Steel hoop and support
OVERALL L / W / H 2795mm / 1516mm / 1185mm
WHEELBASE / TRACK (Fr / Rr) 1525mm / 1200mm / 1200mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 123kg / 125kg
SUSPENSION Double wishbone, direct acting
TYRES (Fr / Rr) Hoosier 16x7,5-10
WHEELS (Fr / Rr) 8 inch, Keizer
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / in each wheel hub / 4x35.37
MOTOR TYPE PMSM
MAX MOTOR RPM 20000
MOTOR CONTROLLER Lenze Schmidhauser DCU 60/60
MAX SYSTEM VOLTAGE 604V
ELECTRODE MATERIALS LiCoO2
COMBINED ACCUMULATOR CAPACITY 7.4kWh
TRANSMISSION RATIO (PRIMARY / SECONDARY) 13.3:1 / n/a
DRIVE TYPE Gearbox
DIFFERENTIAL electronical
COOLING Water cooling system with radiators
BRAKE SYSTEM 4-Disk system, self develpoped
ELECTRONICS Strain gauge sensor,vehicle dynamics control unit and customisable steering wheel display

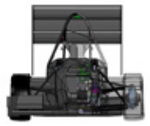
REGENSBURG

Ostbayerische Technische Hochschule Regensburg

Car 62 **Pit 26-A** **WRL 81** Germany

Dynamics e.V. was founded in 2007 and has built combustion vehicles until 2019. In 2019 we started to build electric cars. With our 2nd electric car we aim to be faster than with our combustion cars. Highlights of the RP21e are the further developed aerodynamic package, our new self developed planetary gearbox, the new rear chassis part, new rear axle, new accumulator cell type and better performing inverters.





FRAME CONSTRUCTION CFRP Monocoque
MATERIAL CFRP, Kevlar, Honeycomb, Rohacell
OVERALL L / W / H 2947mm / 1466mm / 1200mm
WHEELBASE / TRACK (Fr / Rr) 1527mm / 1200mm / 1160mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 126kg / 144kg
SUSPENSION double Wishbone, push-rod
TYRES (Fr / Rr) Continental 205x47 R13
WHEELS (Fr / Rr) OZ Cast, 1 pc, 7x13 inch, Mg centerlock wheel
NUMBER OF MOTORS / LOCATION / MAX POWER 2 / Rear Left, Rear Right / 52kW
MOTOR TYPE RR, RL: Emrax 188 LC
MAX MOTOR RPM RL, RR: 8000
MOTOR CONTROLLER Unitek Bamocar PG D3 700 160
MAX SYSTEM VOLTAGE 453V
ELECTRODE MATERIALS Polymer Li-ion
COMBINED ACCUMULATOR CAPACITY 6,39 kWh
TRANSMISSION RATIO (PRIMARY / SECONDARY) 1:5,172 / n/a
DRIVE TYPE Planetary Gear drive
DIFFERENTIAL Torque vectoring system
COOLING Rear mountet mini radiator and electric fan
BRAKE SYSTEM 4-Disk system
ELECTRONICS selfdesigned Multifunctional Steering Wheel, Live-Telemetry System, Control Unit, BMS

SAARBRÜCKEN

Saarland University

Car 130 **Pit 47-A** **WRL 168** Germany

Evolution Racing Team Saar e.V. is a small, yet highly dedicated Team with students from all three Universities in the Saarland. We are formed by motivated students from many different fields of study. Because of our small numbers, every single person working on this project has a noticeable impact on our success. Our name is our mission: Constant personal and technical evolution. We would like to thank each and every sponsor for the time, effort and trust they put into us.

FRAME CONSTRUCTION tubular steel space frame
MATERIAL S235
OVERALL L / W / H 2880mm / 1360mm / 1140mm
WHEELBASE / TRACK (Fr / Rr) 1540mm / 1125mm / 1085mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 121kg / 181kg
SUSPENSION Double unequal length A-Arm. Pushrod over rocker vertically oriented spring and damper.
TYRES (Fr / Rr) Hoosier R25B/WET R13
WHEELS (Fr / Rr) 7.0x13 Mg Rims by O.Z. 1pc
NUMBER OF MOTORS / LOCATION / MAX POWER 2 / Rear left and right / 58kW per motor
MOTOR TYPE PSM Vues AFW507
MAX MOTOR RPM 7500
MOTOR CONTROLLER Bamocar D3 400/700 by Unitek
MAX SYSTEM VOLTAGE 504V
ELECTRODE MATERIALS LiPo (LiCoO2)
COMBINED ACCUMULATOR CAPACITY 6,35kWh
TRANSMISSION RATIO (PRIMARY / SECONDARY) 2:1 / 3:1
DRIVE TYPE 2-stage spur gearbox
DIFFERENTIAL electric differential with torque vectoring
COOLING twin-side mounted radiators, optimized radiator size
BRAKE SYSTEM Front: 4-piston Rear: 2-piston. Full floating, vented 220 mm brake disks.
ELECTRONICS self-designed PCBs and Software for each purpose (MCU,BSPD,TSAL...)

SCHWEINFURT

University of Applied Sciences Würzburg-Schweinfurt

Car 97 **Pit 38-A** **WRL 88** Germany

Mainfranken Racing e.V. was founded in 2006 out of the idea of some motor sport enthusiastic students from the University of Applied Sciences Schweinfurt. The team consist of 30 motivated students building the 13th racecar. Our goal for our second electric vehicle is to finish every endurance we attend. The car was built over a decade of two years and received ongoing improvements in the second year. This season we are happy to participate at FSCz FSS and FSG.

FRAME CONSTRUCTION Tubular space frame
MATERIAL E235+C
OVERALL L / W / H 2940mm / 1475mm / 1180mm
WHEELBASE / TRACK (Fr / Rr) 1530mm / 1200mm / 1175mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 136kg / 136kg
SUSPENSION Double unequal lenght A-Arm, pull (front) / push (rear) rod actuated
TYRES (Fr / Rr) 16.0 x 7.5-10 R25B Hoosier / 16.0 x 7.5-10 R25B Hoosier
WHEELS (Fr / Rr) 7.0x10 22mm offset, 1 pc Carbon Rim
NUMBER OF MOTORS / LOCATION / MAX POWER 1 / Rear middle / 109 kW
MOTOR TYPE EMRAX 228 MV LC
MAX MOTOR RPM 5500
MOTOR CONTROLLER UNITEK BAMOCAR-D3
MAX SYSTEM VOLTAGE 587V
ELECTRODE MATERIALS Li-Ion (LiNiMnCoO2)
COMBINED ACCUMULATOR CAPACITY 7,75kWh
TRANSMISSION RATIO (PRIMARY / SECONDARY) 3,12 / 1
DRIVE TYPE Belt-drive
DIFFERENTIAL Drexler limited slip differential 50Nm
COOLING Twin rear mounted radiators with self developed electric fans and optimized cfk fan-channels
BRAKE SYSTEM 4-Disk system, floating self developed brake rotors, front: 4pistons, rear: 2pistons
ELECTRONICS Multifunctional steering wheel, datalogger, self designed accumulator management system

SEVILLA

University of Seville

Car 51 **Pit 35-A** **WRL 100** Spain

ARUS in 2018, decided to face the great challenge of also designing an electric vehicle. Every minor step was a huge success and required tremendous sacrifice but, despite all that progress, scrutineering proved to be too much for our car the first two seasons. The pandemic has given us extra time to keep working and now truly aim to compete in dynamic events, while also fighting for static event trophies.

FRAME CONSTRUCTION Steel space frame
MATERIAL STEEL S355
OVERALL L / W / H 2385mm / 680mm / 1045mm
WHEELBASE / TRACK (Fr / Rr) 1535mm / 1250mm / 1175mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 145kg / 145kg
SUSPENSION Double unequal length A-Arm. Pull/Push rod actuated spring and damper, anti-roll bar.
TYRES (Fr / Rr) 18x7,5-10. R25B. Hoosier/18x7,5-10. R25B. Hoosier
WHEELS (Fr / Rr) 3pc Al Rim, custom Al center
NUMBER OF MOTORS / LOCATION / MAX POWER 1 / Rear / 62kW
MOTOR TYPE EMRAX 228
MAX MOTOR RPM 5500
MOTOR CONTROLLER Bamocar-PG-D3
MAX SYSTEM VOLTAGE 450V
ELECTRODE MATERIALS Polymer Li-ion battery
COMBINED ACCUMULATOR CAPACITY 6.4kWh
TRANSMISSION RATIO (PRIMARY / SECONDARY) 1:3 / 1:3
DRIVE TYPE Chain drive, 520 pitch.No gearbox.
DIFFERENTIAL Drexler limited slip differential
COOLING Tow independent circuits. A 387 cm2 AL radiator and a 567 cm2 AL radiator
BRAKE SYSTEM Self-designed floating disks with AP Racing CP4227-2S0 and Tilton 78-Series
ELECTRONICS wiring harness sealed to IP67, Multifunctional Steering Wheel

STUTTGART

Baden-Württemberg Cooperative State University Stuttgart

Car 77 **Pit 07-A** **WRL 5** Germany

DHBW Engineering Stuttgart - a team of nearly 100 students of the Cooperative State University of Baden Wuerttemberg. Starting in Formula Student Combustion and switching to Formula Student Electric in 2011, we've been building high performance cars for 13 years. For building an even better race car this year, our main goal of the season is to implement our self developed powermodule „PrePulse". To accomplish this challenge we depend on a perfectly harmonized and organised team.

FRAME CONSTRUCTION unibody monocoque with integrated front hoop
MATERIAL HM/HT carbon fibers / aluminium honeycomb
OVERALL L / W / H 2844mm / 1527mm / 1186mm
WHEELBASE / TRACK (Fr / Rr) 1530mm / 1220mm / 1220mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 111kg / 130kg
SUSPENSION Double unequal length A-Arm, Heave and roll decoupled suspension
TYRES (Fr / Rr) 16.0x7,5-10 Hoosier LC0
WHEELS (Fr / Rr) 7.2x10, 2 pc CFRP Rim
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / all wheels / 36
MOTOR TYPE AMK DT5
MAX MOTOR RPM 20000
MOTOR CONTROLLER AMK
MAX SYSTEM VOLTAGE 600V
ELECTRODE MATERIALS LiCoO2
COMBINED ACCUMULATOR CAPACITY 6,98kWh
TRANSMISSION RATIO (PRIMARY / SECONDARY) 11,69 / none
DRIVE TYPE planetary gear
DIFFERENTIAL none
COOLING single circuit for power electronics and motors
BRAKE SYSTEM 4-Disk system, self developed rotors with 190mm outer diameter, adjustable brake balance,
ELECTRONICS self-designed system electronics, telemetry system

STUTTGART

University of Stuttgart

Car 26 **Pit 23-B** **WRL 7** Germany

GreenTeam was founded in 2009 and currently consists of around 65 students from several courses of study. Our new car, the E0711-11 EVO, is a comprehensive revolution conceived for the long term: A new wheel package with single-piece CFRP rims, a new independent suspension, a new single-piece monocoque with a narrower shaped body and big improvements to the aerodynamic package extract a new level of performance that will be powered by our overall self-developed electric powertrain.

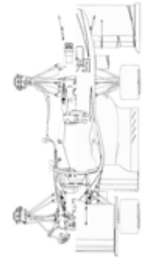
FRAME CONSTRUCTION Carbon fiber sandwich structure monocoque with aluminium honeycomb
MATERIAL CFRP pre-preg (Twill, UD), aluminium honeycomb
OVERALL L / W / H 2928mm / 1430mm / 1197mm
WHEELBASE / TRACK (Fr / Rr) 1540mm / 1200mm / 1200mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 61kg / 61kg
SUSPENSION independent suspension with anti roll bar on both axles with stepless change in stiffness
TYRES (Fr / Rr) Hoosier LC0 16.0 x 7.5-10
WHEELS (Fr / Rr) 8.0 x 10, single-piece CFRP
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / one at each wheel / 39
MOTOR TYPE self-developed GT4 PMSM in-runners
MAX MOTOR RPM 21000
MOTOR CONTROLLER Self-developed GTI1
MAX SYSTEM VOLTAGE 600V
ELECTRODE MATERIALS LiCoO2
COMBINED ACCUMULATOR CAPACITY 7,67kWh
TRANSMISSION RATIO (PRIMARY / SECONDARY) 1:12.37 / N/A
DRIVE TYPE self-developed planetary gearset
DIFFERENTIAL N/A
COOLING active air cooling and water cooling
BRAKE SYSTEM 4-disk system, self-developed brake calibers and brake disk
ELECTRONICS self-designed system electronics, wireless CAN, live telemetry

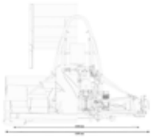
TRONDHEIM

Norwegian University of Science and Technology

Car 63 **Pit 20-B** **WRL 10** Norway

Revolve NTNU was founded in 2010. We developed two combustion cars, before switching to electric in 2014 and had our first 4WD electric car in 2016. Since 2018 we have been developing both an autonomous and an electric race car each year. Last year's vehicle was unfortunately never completed, so we are really looking forward to showing you everything we have been working on over the past two years. See you at FSG.





FRAME CONSTRUCTION CFRP two-piece monocoque
MATERIAL M46J(HM 6k) 2x2 twill DT120, UD 513 w/ HR40, Foam & ALUHC core, CRFP and Alu insert
OVERALL L / W / H 2886mm / 1440mm / 1158mm
WHEELBASE / TRACK (Fr / Rr) 1530mm / 1220mm / 1220mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 111kg / 116kg
SUSPENSION SLA, upper whisbone push rod actuated, T-bar ARB w/ progressive 3rd spring
TYRES (Fr / Rr) Hoosier 16.0 x 7.5-10
WHEELS (Fr / Rr) 10" x 7", CFRP shells, 56.2 mm offset
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / Hub mounted, all wheels / 35.3 kW per motor
MOTOR TYPE Permanent magnet synchronous motor
MAX MOTOR RPM 20000 per motor
MOTOR CONTROLLER Self-developed, SiCMOS technology
MAX SYSTEM VOLTAGE 600V
ELECTRODE MATERIALS LiCoO2
COMBINED ACCUMULATOR CAPACITY 6.8 kWh
TRANSMISSION RATION (PRIMARY / SECONDARY) 13.41:1 / N/A
DRIVE TYPE Hub mounted compound planetary gearbox
DIFFERENTIAL N/A
COOLING Water cooled motors and inverters, dual cycle. Rear mounted radiators with outlet ducts.
BRAKE SYSTEM 4-Disk system, 2 calipers at ech wheel in front, one at each wheel at the rear
ELECTRONICS All PCB's except IMD and telemetry and are self developed.

WIEN

Vienna University of Technology

Car 41 **Pit 20-A** **WRL 61** Austria

This year TU Wien Racing is attending the competition with the EDGE12, its seventh electric vehicle. Our goal for the season was to improve the self-developed powertrain and increase reliability by maximizing the amount of testing time conducted prior to Formula Student events. Each test run improves the car's performance and supplies the team with new data that forms the foundation for the development of the upcoming model. After a year of forced break, we cannot wait to compete on track again!

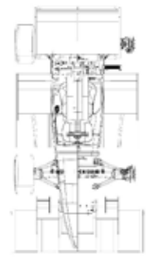
FRAME CONSTRUCTION Carbon Fibre Sandwich Monocoque with aluminium honeycomb core
MATERIAL Carbon Fibre Prepreg, up to 20mm honeycomb core
OVERALL L / W / H 2850mm / 1400mm / 1145mm
WHEELBASE / TRACK (Fr / Rr) 1525mm / 1200mm / 1160mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 100kg / 122kg
SUSPENSION Double unequal length A-Arm. Decoupled Roll/Heave System. Pullrod Front. Pushrod Rear.
TYRES (Fr / Rr) Hoosier 7,5/16,0-10 LC0 Front and Rear
WHEELS (Fr / Rr) 7.0x10, 25mm offset, one piece CFRP rim
NUMBER OF MOTORS / LOCATION / MAX POWER 2 / Rear / 40kW
MOTOR TYPE Self developed/TUWR-E3
MAX MOTOR RPM 17500
MOTOR CONTROLLER TUWRacing-I3 IGBT Inverter
MAX SYSTEM VOLTAGE 600V
ELECTRODE MATERIALS LiCoO2
COMBINED ACCUMULATOR CAPACITY 6
TRANSMISSION RATIO (PRIMARY / SECONDARY) 1:11.69 / -
DRIVE TYPE two stage planetary gear system
DIFFERENTIAL -
COOLING Rear mounted actived cooled cross flow radiators
BRAKE SYSTEM self developed rotors, adaptive brake balance via recuperation
ELECTRONICS self developed ECU and PDU, self developed Live-Telemetry System, Adaptiv Sensors Support

WOLFENBÜTTEL

University of Applied Sciences Ostfalia

Car 35 **Pit 31-A** **WRL 48** Germany

The Team wob-racing from the UAS Ostfalia was founded in 2003. After 7 combustion cars the team focused on the construction of electric vehicles. This means that the Team wob-racing has been Wolfsburg's second largest automotive manufacturer for 18 years. With 35 team members we have concentrated on learning from the weaknesses of the predecessor to build an even better performing and more reliable vehicle.



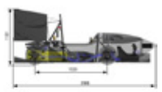
FRAME CONSTRUCTION Single Piece CFRP Monocoque
MATERIAL Aramid and EN AW 5056 Honeycomb sandwich panel
OVERALL L / W / H 2891mm / 1578mm / 1145mm
WHEELBASE / TRACK (Fr / Rr) 1530mm / 1250mm / 1230mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 117kg / 131kg
SUSPENSION Double unequal length A-arm, pushrod actuated horizontal Spring and Damper
TYRES (Fr / Rr) 152x20 R10, Hoosier (Fr&Rr)
WHEELS (Fr / Rr) 6.0x10, 0mm offset 3 piece AL-Carbon rim (Fr&Rr)
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / FL, FR, RL, RR / 4x 34 kW @ 16.000 rpm
MOTOR TYPE AMK DD5-14-10-POW
MAX MOTOR RPM 20.000 rpm
MOTOR CONTROLLER AMK KW26-S5-FSE-4Q
MAX SYSTEM VOLTAGE 600
ELECTRODE MATERIALS Lithium-Cobalt-Oxide & Graphit
COMBINED ACCUMULATOR CAPACITY 7.14 kW
TRANSMISSION RATIO (PRIMARY / SECONDARY) 14,56 / n/a
DRIVE TYPE 1.5 staged planetary gear mounted in ea
DIFFERENTIAL electronic differential using torque vectoring
COOLING Dual circuit, water cooled inverters and motors, radiator w/ fans mounted on undertray, and side
BRAKE SYSTEM 4x floating 190 mm rotors, separate systems Fr and Rr, adjustable balance
ELECTRONICS Multifunctional dashboard, online telemetry, selfdesigned BMS, diagnostics, dc/dc conv.

ZWICKAU

University of Applied Sciences Zwickau

Car 96 **Pit 41-A** **WRL 6** Germany

In the now 15th season the WHZ Racing Team presents its 11th all-electric Formula Race Car. Our team consists of 30 ambitious students from a variety of faculties of the University of Applied Sciences Zwickau.The latest race car is developed completely new with improvements on the overall package, performance and reliability.



FRAME CONSTRUCTION one piece monocoque, laminated Fronthoop
MATERIAL composite material (CFRP, aluminium honeycomb)
OVERALL L / W / H 2988mm / 1480mm / 1181mm
WHEELBASE / TRACK (Fr / Rr) 1530mm / 1200mm / 1200mm
WEIGHT WITH 68kg DRIVER (Fr / Rr) 129kg / 131kg
SUSPENSION Double unequal length A-Arm. Push rod actuated horizontally oriented spring and damper
TYRES (Fr / Rr) Hoosier LC0 16.0 x 7.5 -10 / Hoosier LC0 16.0 x 7.5 -10
WHEELS (Fr / Rr) 10" carbon fibre, self developed rims / 10" carbon fibre, self developed rims
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / Fr, Fl, Rr and Rr / 35,366
MOTOR TYPE FL, FR, RR, RL: PMSM, internal rotor
MAX MOTOR RPM 20000
MOTOR CONTROLLER LenzeSchmidhauser MOBILE DCU60/60
MAX SYSTEM VOLTAGE 600V
ELECTRODE MATERIALS Lithium-Polymer/LiCoO2
COMBINED ACCUMULATOR CAPACITY 7,032
TRANSMISSION RATIO (PRIMARY / SECONDARY) 1:13,02 / 1:1
DRIVE TYPE AWD, planetary gear
DIFFERENTIAL electronic
COOLING ater radiator with cooling duct integrated in side pod, Accumulator passiv cooled
BRAKE SYSTEM steel Rotors, di:145mm, do: 189mm; self developed calipers; ABS at recuperative braking
ELECTRONICS self designed ECUs, Multifunctional Steering Wheel

ERLANGEN

Friedrich-Alexander-Universität Erlangen-Nürnberg

Car 549 **Pit 25-A** Germany

We are proud to present the second Driverless racecar FAUmax byssa. For this year's DV car, we have crucially updated and optimized virtually all the components of our autonomous system. Among vast improvements to our algorithms and software pipeline, the other highlights of our autonomous system are the new pneumatic "Emergency Brake System" and our new sensor setup. We are excited to enter the last standalone Driverless competitions with FAUmax byssa.

DRIVERLESS COMBUSTION

FRAME CONSTRUCTION CFRP full monocoque in sandwich structure
MATERIAL Plascore aluminium honeycomb core 20mm; carbon fibre skins 1,8mm
OVERALL L / W / H 2520mm / 1450mm / 1190mm
WHEELBASE / TRACK (Fr / Rr) 1530mm / 1240mm / 1150mm
WEIGHT WITHOUT DRIVER (Fr / Rr) 72kg / 92kg
ENGINE Modified KTM SX-F 450
BORE / STROKE / CYLINDERS / DISPLACEMENT 95mm / 72mm / 1 cylinder / 510cc
BRAKE SYSTEM Self designed master cylinders and stainless steel rotors, wilwood calipers
PROCESSING UNITS NVIDIA Drive PX2 AutoChauffeur
PERFORMANCE OF PUs 16000 GFLOPS
POWER CONSUMPTION OF PUs 80 W
CAMERAS Basler dart daA1600-60uc
RADAR n/a
LIDAR Hesai Pandar 40P
OTHER SENSORS Vectornav VN300
HIGHLIGHTS OF THE DV SYSTEM Pneumatic brake system combining service and emergency brake. Combination of camera and LiDAR cone detection algorithms for better detection accuracy. Adapted FastSLAM implementation for cone fusion positioning and mapping. Robust triangulation based pathfinding for unknown tracks.

PISA

University of Pisa

Car 543 **Pit 28-B** Italy

E-Team Squadra Corse presents its first Driverless car, KerubLess, thanks to the University of Pisa and all the sponsors. Adding sensors such as LiDAR, stereo-camera and actuators, the driver is replaced by a distributed computing network. A customized alternator is used to fulfill the energy request of the new components. All of the team worked hard to create this innovative project and now it's ready to compete in the FSG competition. Come talk to us to discover the secrets of our car!

DRIVERLESS COMBUSTION

FRAME CONSTRUCTION tubular steel space frame
MATERIAL BS4 T45 round tubing from 19.05 mm to 31.75 mm
OVERALL L / W / H 3036mm / 1435mm / 1074mm
WHEELBASE / TRACK (Fr / Rr) 1530mm / 1265mm / 1135mm
WEIGHT WITHOUT DRIVER (Fr / Rr) 110kg / 120kg
ENGINE Honda CBR600RR (PC37)
BORE / STROKE / CYLINDERS / DISPLACEMENT 67mm / 42,5mm / 4 cylinders / 599cc
BRAKE SYSTEM Self developed, inox, floating 230mm (front), fixed 210mm (rear), driver adj. balance bar
PROCESSING UNITS 1x AAEON Up Xtreme i7 and 2x Nvidia Xavier AGX
PERFORMANCE OF PUs 22442 GFLOPS
POWER CONSUMPTION OF PUs 86 W
CAMERAS 1x Stereolabs ZED2 (with RGBD stream based on visible-light binocular vision)
RADAR n/a
LIDAR 1x Hesai Pandar 40P (40-channels ToF LiDAR)
OTHER SENSORS 1x Aceinna OpenIMU330RI (as IMU unit for vehicle state estimation)
HIGHLIGHTS OF THE DV SYSTEM RGBD camera with neural network for cone detection, lidar-based cone detecation using ESF, FastSLAM with particle filter, MPC with spatial formulation

ROMA

Sapienza University of Rome

Car 519 **Pit 28-A** Italy

Sapienza Corse Racing Team is the Combustion & Driverless Team of the University „La Sapienza". We compete in Formula Student events since 2008 when the first Gajarda was built. In 2016 the project of Gajarda AWD, with an all wheel drive system and full aero package, was presented, and built to race for the next season. On 2019 the car was converted to be a driverless car, giving the team successes during the racing season. As a team we like to get involved & overcome difficulties all together.

DRIVERLESS COMBUSTION

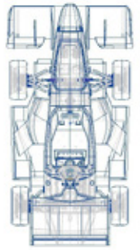
FRAME CONSTRUCTION CFRP Sandwich structure bottom case, CFRP Top closure and seat
MATERIAL ET445 Twill Carbon Fibre, ER450 UD HM Carbon Fibre, Al Honeycomb, EA451 Adhesive
OVERALL L / W / H 2960mm / 1410mm / 1164mm
WHEELBASE / TRACK (Fr / Rr) 1550mm / 1200mm / 1180mm
WEIGHT WITHOUT DRIVER (Fr / Rr) 60kg / 85kg
ENGINE Honda CBR600 F4i
BORE / STROKE / CYLINDERS / DISPLACEMENT 67mm / 42,5mm / 4 cylinders / 599cc
BRAKE SYSTEM 4-Disk system, self developed rotors with 220mm diameter, TiMotion - TA2P Linear Actuator
PROCESSING UNITS Intel Core i7 8550U
PERFORMANCE OF PUs 21,4 GFLOPS
POWER CONSUMPTION OF PUs 100 W
CAMERAS 2 pairs of stereocameras, range 16m, opening angle 108.16 degrees
RADAR n/a
LIDAR n/a
OTHER SENSORS Accelerometer, Differential GPS
HIGHLIGHTS OF THE DV SYSTEM Track acquisition by only cameras with customized image processing algorithm. Intel IPP low-lever libraries based image processing. IMU and GPS data sensing.

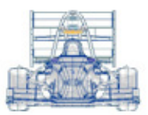
AACHEN

RWTH Aachen University

Car 499 **Pit 09-B** Germany

Ecurie Aix is one of the oldest Formula Student Teams in Germany, founded in the year 1999. The team name is derived from the French words „ecurie" meaning racing team and „aix" standing for Aachen. The eace07.d - Rita is our third autonomous racecar and we participate with it at FSG for the second time. Big improvements are a new LiDAR mounting concept, a new CarPC, big updates in our software and several weight reductions.





DRIVERLESS ELECTRIC

FRAME CONSTRUCTION CFRP Sandwich Monocoque
MATERIAL Carbon Fibre Prepreg (Woven & UD), Aluminium Honeycomb & Foam Core, CFRP Inserts
OVERALL L / W / H 2912mm / 1378mm / 1094mm
WHEELBASE / TRACK (Fr / Rr) 1530mm / 1250mm / 1200mm
WEIGHT WITHOUT DRIVER (Fr / Rr) 96kg / 121kg
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / wheel hub mounted / 32kW
COMBINED ACCUMULATOR CAPACITY 7.4 kWh
BRAKE SYSTEM grinded X46Cr13 disks attached via 4 floaters, ISR Calipers & AP-Racing Cylinders
PROCESSING UNITS Ryzen 5 5600X; GIGABYTE RTX 2060 Mini ITX
PERFORMANCE OF PUs 8400 GFLOPS
POWER CONSUMPTION OF PUs 200 W
CAMERAS 3 x Basler acA1440-73gc
RADAR n/a
LIDAR Hesai Pandar40p (40 layers, range used 40m)
OTHER SENSORS Combined GPS, accelerometer, magnetometer
HIGHLIGHTS OF THE DV SYSTEM

AUGSBURG

University of Applied Sciences Augsburg

Car 466 **Pit 12-B** Germany

Celebrating the team's 10th anniversary in 2021 StarkStrom Augsburg e.V.this year present the result of 4 years development time and their fastest autonomous race car – Zapp DV. The team was part of Formula Student Driverless from day one. Since then, the team improved every year creating better, stronger and faster autonomous race cars which are able to sense their environment and calculate trajectory in real time while dynamically estimating and adjusting speed.

DRIVERLESS ELECTRIC

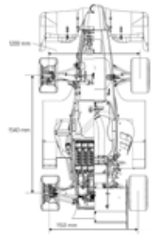
FRAME CONSTRUCTION CFRP sandwich monocoque with fully laminated AL front hoop and steel main hoop
MATERIAL CFRP prepreg with aluminium honeycomb core
OVERALL L / W / H 2940mm / 1450mm / 1211mm
WHEELBASE / TRACK (Fr / Rr) 1535mm / 1250mm / 1200mm
WEIGHT WITHOUT DRIVER (Fr / Rr) 102kg / 103kg
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / Wheel Hubs FR, FL, RR, RL / 35kW
COMBINED ACCUMULATOR CAPACITY 4,26
BRAKE SYSTEM 4 disc brake system, self developed rotors with 232mm diameter front and 228 rear
PROCESSING UNITS dSPACE Micro Autobox II | ZOTAC MAGNUS EN72070V
PERFORMANCE OF PUs 5734 GFLOPS
POWER CONSUMPTION OF PUs 330 W
CAMERAS Basler dart daA1600-60uc (S-Mount) 2x
RADAR N/A
LIDAR Hesai Pandar40P
OTHER SENSORS Kistler S-Motion L
HIGHLIGHTS OF THE DV SYSTEM Fully automatic LiDAR-Camera registration, YOLOv3 camera cone detection, edge-detection for LiDAR, sensor fusion using projected LiDAR points in the camera image, particle filter SLAM, graph-search based trajectory planning, Pure Pursuit and MPC path tracking

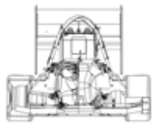
BARCELONA

PT University of Catalonia - Engineering School of Barcelona

Car 454 **Pit 37-B** Spain

Back in 2019, under the name of DRIVERLESS UPC, the team presented our first driverless vehicle, which was capable of finishing all the dynamic events. Two years latter, progress has been made to achieve a competitive level. We are really excited to compete with the best teams here at FSG and show what we at BCN eMotorsport and our awesome, incredible, fantastic, beautiful, breathtaking and beloved XALOC are really capable of.





DRIVERLESS ELECTRIC

FRAME CONSTRUCTION One-piece CFRP & Al Honeycomb monocoque with integrated aluminium front hoop.
MATERIAL Prepreg CFRP (twill 200 and UD 300 g/m2) and aluminium honeycomb. Al 6063 T6 FH
OVERALL L / W / H 2870mm / 1440mm / 1150mm
WHEELBASE / TRACK (Fr / Rr) 1540mm / 1200mm / 1150mm
WEIGHT WITHOUT DRIVER (Fr / Rr) 114kg / 133kg
NUMBER OF MOTORS / LOCATION / MAX POWER 1 / Rear / 100kW
COMBINED ACCUMULATOR CAPACITY 7,48kWh
BRAKE SYSTEM 4-Disk system, 179.5mm outer diameter
PROCESSING UNITS Nvidia Jetson Xavier and DX-1000 i7-6700TE (Skylake) 2.4GHz processor
PERFORMANCE OF PUs 5726 GFLOPS
POWER CONSUMPTION OF PUs 210 W
CAMERAS Two DFK33UX252. Global shutter, USB 3.0, 640x480 to 2048x1536 pixels
RADAR n/a
LIDAR Velodyne VLP-32C
OTHER SENSORS Two INSS+GNSS (Vectornav VN-300 and SBG Ellipse).
HIGHLIGHTS OF THE DV SYSTEM High range perception system with a reliable color and position detection with three different Computer Vision algorithms followed by an accurate map estimation. Stable planning and global trajectory optimization to reach the highest possible speeds, which serve as inputs of a predictive controller that takes into account the vehicle dynamics.

BUDAPEST

Budapest University of Technology and Economics

Car 414 **Pit 47-B** Hungary

BME Formula Racing Team was founded in 2007 by students of TU Budapest as the first Formula Student team of Hungary. In 2020 we built a new EV car. Managed to achieve 500 test km during the autumn. For 2021 we decided to use this relatively stable and robust car as a base for our new DV car. At FSG 2021 we are competing in driverless category, with a single goal: finishing every driverless dynamic event.

DRIVERLESS ELECTRIC

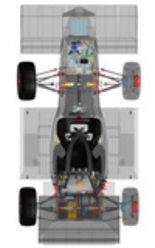
FRAME CONSTRUCTION Single piece CFRP monocoque
MATERIAL Sandwich structure: prepreg layers (200g/m^2 twill, 120 g/m^2 UD)
OVERALL L / W / H 2968mm / 1405mm / 1016mm
WHEELBASE / TRACK (Fr / Rr) 1540mm / 1200mm / 1160mm
WEIGHT WITHOUT DRIVER (Fr / Rr) 120kg / 120kg
NUMBER OF MOTORS / LOCATION / MAX POWER 2 / Rear left, rear right / 35 kW, 35 kW
COMBINED ACCUMULATOR CAPACITY 7.03 kWh
BRAKE SYSTEM 4-Disk system, 191 mm diameter rotors, adjustable brake balance
PROCESSING UNITS Jetson Xavier
PERFORMANCE OF PUs 1500 GFLOPS
POWER CONSUMPTION OF PUs 300 W
CAMERAS 2xBasler acA2040-120uc mono camera
RADAR -
LIDAR 2xVelodyne VLP 16
OTHER SENSORS Bosch MM 5.10 IMU
HIGHLIGHTS OF THE DV SYSTEM Lidar sensor, and mono camera based perception running on Jetson Xavier. EKF Sensor fusion. 40m viewing distance. Custom online trajectory optimalisation algorithm based on trajectory curvature.

DARMSTADT

Technische Universität Darmstadt

Car 842 **Pit 19-B** Germany

The TU Darmstadt Racing Team was founded in 2005 and is attending FSG since its beginning. 2011 the Team switched to electric cars, and 2017 decided to go driverless. 40 students are currently working on the electric and the driverless project. Since last year we build a car designed for the participation in electric and driverless class. This year the focus of the autonomous system was the enhancement of the sensor pipeline.



DRIVERLESS ELECTRIC

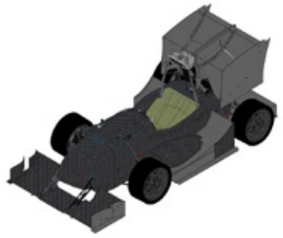
FRAME CONSTRUCTION One-shot monocoque
MATERIAL Carbonfiber Prepreg with aluminium honeycomb
OVERALL L / W / H 2994mm / 1454mm / 1201mm
WHEELBASE / TRACK (Fr / Rr) 1534mm / 1378mm / 1331mm
WEIGHT WITHOUT DRIVER (Fr / Rr) 98kg / 106kg
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / One motor per wheel / 4x 35,4kW
COMBINED ACCUMULATOR CAPACITY 5.81kWh
BRAKE SYSTEM 4-Disk System, self developed rotors with 220mm diameter front and rear
PROCESSING UNITS i7-9700K, RTX2060-6G
PERFORMANCE OF PUs 6452,4 GFLOPS
POWER CONSUMPTION OF PUs 255 W
CAMERAS 3x Matrix Vision - mvBlueFOX3
RADAR n.a.
LIDAR Velodyne
OTHER SENSORS n.a.
HIGHLIGHTS OF THE DV SYSTEM Watercooled CPU and GPU, GraphSLAM using g2o, cone detection using YOLOv5

DEGGENDORF

Deggendorf Institute of Technology

Car 444 **Pit 06-A** Germany

Fast Forest is the Formula Student team of the Deggendorf Institute of Technology, founded in 2008. Starting with the past season, the team agreed on building a DV and EV car in one. Therefore, we are facing the DV challenge at FS Germany for the first time with our Jenny 12GDX. New innovations make our lovingly called GhostDriver (GD) more reliable on the track without affecting the driver during EV competition. At this point we would like to thank our sponsors for supporting us.



DRIVERLESS ELECTRIC

FRAME CONSTRUCTION CFRP monocoque, aluminium front hoop, steel main hoop and braces
MATERIAL CFRP, aluminium honycomb core, rohacell foam
OVERALL L / W / H 2913mm / 1347mm / 1110mm
WHEELBASE / TRACK (Fr / Rr) 1540mm / 1194mm / 1210mm
WEIGHT WITHOUT DRIVER (Fr / Rr) 96kg / 99kg
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / 4x wheelbase / 12,3kW at 1200 RPM

COMBINED ACCUMULATOR CAPACITY 7,032kWh
BRAKE SYSTEM 4-Disk system, self developed rotors with 204mm diameter, adjustable brake balance
PROCESSING UNITS NVIDIA Jetson AGX Xavier
PERFORMANCE OF PUs 11000 GFLOPS
POWER CONSUMPTION OF PUs 30 W
CAMERAS 1, 20m 96°, ZED 2 stereo camera
RADAR n/a
LIDAR n/a
OTHER SENSORS Xsens MTI-670
HIGHLIGHTS OF THE DV SYSTEM all driverless parts are designed removable, Driverless parts below the fornt of the car, Aeordynamic packing of the cameras and the communication unit at the mainhoop

HAMBURG

Hamburg University of Technology

Car 878 **Pit 46-B** Germany

The egn20 is the most innovative and forward-thinking car e-gnition has ever build. In the coming years FSG is looking to integrate driverless technology into every car participating in the event. We decided to start this integration one year early. The egn20 is able to run EV and with a quick change of the steering wheel and front wing it is capable to drive DV as well. The steering actuation is fully integrated into the steering wheel and easily exchangeable with a quick release.

DRIVERLESS ELECTRIC

FRAME CONSTRUCTION Monocoque structure with prep- reg and aluminium honeycomb core
MATERIAL Unidirectional fibers M21T800S + different kinds of aluminium honeycomb structure
OVERALL L / W / H 2935mm / 1422mm / 1175mm
WHEELBASE / TRACK (Fr / Rr) 1530mm / 1200mm / 1150mm
WEIGHT WITHOUT DRIVER (Fr / Rr) 112kg / 142kg
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / Every wheel / 35 kW, 35kW, 35kW, 35kW
COMBINED ACCUMULATOR CAPACITY 6,216kWh
BRAKE SYSTEM self developed rotors 222mm diameter, lasersintered self manufactured brake callipers
PROCESSING UNITS Intel Core i7-6700K, NVIDIA Jetson TX2 module
PERFORMANCE OF PUs 1231 GFLOPS
POWER CONSUMPTION OF PUs 350 W
CAMERAS „2 x Basler - daA1600-60ucArea Scan Camera with Global Shutter, USB 3.0, Res: 1600 x 1200 pixels
RADAR n/a
LIDAR „4x Ibeo Lux 2010. 4 Layer rotating mirror LIDAR scanner (3 forward and 1 rearward)
OTHER SENSORS 1x Xsens - MTi-G-710-GNSS/INS (IMU)
HIGHLIGHTS OF THE DV SYSTEM The integration of the DV components without generating disadvantages for each of the disciplines. Creation of a structured electrical/mechanical overall system by merging components that were previously added separately.The egn20 can be changed form EV to DV configuration and vice versa with a few steps.

HAMBURG

University of Applied Sciences Hamburg

Car 469 **Pit 34-B** Germany

For the first time, Hawks Racing participates at FSG with two cars. Our H14 („Vicky") from 2018 will be back on the racetrack - once again debuting a completely new powertrain, as after 17 years of manufacturing combustion cars, we are presenting our first ever electric car with self-driving features. Commencing almost three years of development, we are proud to accompany our combustion vehicle, H16 („Valeria"), and to take our first steps into an electric and autonomous future at Hawkenheim.

DRIVERLESS ELECTRIC

FRAME CONSTRUCTION Full body CFRP / aluminum sandwich monocoque with bolted additional parts
MATERIAL 200 gsm twill 2/2 E323, 150 gsm UD E340 prepregs, EN AW 5056 honeycomb, IG-F110 foam
OVERALL L / W / H 2640mm / 1420mm / 1069mm
WHEELBASE / TRACK (Fr / Rr) 1550mm / 1200mm / 1200mm
WEIGHT WITHOUT DRIVER (Fr / Rr) 111kg / 169kg
NUMBER OF MOTORS / LOCATION / MAX POWER 1 / rear center / 5kW
COMBINED ACCUMULATOR CAPACITY 1,08 kWh
BRAKE SYSTEM 4-Disk-system, self designed, rotors with 250mm diameter, adjustable bias bar
PROCESSING UNITS Intel NUC (NUC8i7BEH) + Jetson AGX Xavier
PERFORMANCE OF PUs 89 GFLOPS
POWER CONSUMPTION OF PUs 65 W
CAMERAS 1x Basler acA1440-73gc, 63.7° horiz, 50° vert, global shutter, 1440x1080 pixels @ 73 FPS, color
RADAR none
LIDAR 1x Ouster OS1-64, 360°-LiDAR with 64 layers (opening angle 45°). Horizontal resolution 0.18°
OTHER SENSORS optical ground speed sensor (Kistler Correvit SFII-P), dual antenna GPS and IMU (Vectornav VN-300)
HIGHLIGHTS OF THE DV SYSTEM CV basecar converted to EV-DV with 48V tractive system, fully redundant pneumatic EBS, steering system attached at tie rods, independent cone detection pipelines for camera and lidar sensors with downstream fusion of both results, diverse sensor setup for state estimation (ground speed + wheel ticks + IMUs + GPS), dual compute units

KARLSRUHE

Karlsruhe Institute of Technology

Car 421 **Pit 43-B** Germany

„One team - two cars": KA-RaceIng is designing and manufacturing an FSD and FSE car in 2021, competing in both classes. In our 5th Driverless generation, we focused on developing a new aerodynamic package and reducing weight to increase the vehicle's performance. A completely new sensor setup combined with software changes increased our perception range and accuracy. New algorithms for SLAM, planning and control improved our dynamic performance significantly. See you on the race track!

DRIVERLESS ELECTRIC

FRAME CONSTRUCTION CFRP sandwich monocoque, manufacturing method:VARI
MATERIAL HT, IMS and HM carbon fibres, aramid twill, HM Zylon UD, Altropol Neukadur resin
OVERALL L / W / H 2907mm / 1455mm / 1180mm
WHEELBASE / TRACK (Fr / Rr) 1530mm / 1220mm / 1150mm
WEIGHT WITHOUT DRIVER (Fr / Rr) 106kg / 104kg
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / Front Right, Front Left / 30kW
COMBINED ACCUMULATOR CAPACITY 5,22kWh
BRAKE SYSTEM 4 floating rotors and two piston calipers on each wheel, pneumatic actuated EBS
PROCESSING UNITS Intel Core i7-9700K (8 Core) Google Coral Edge TPU coprocessor
PERFORMANCE OF PUs 36 GFLOPS
POWER CONSUMPTION OF PUs 100 W
CAMERAS 2x IDS UI-3160CP Rev. 2.1 with 5mm Kowa LM-5JCM + 1x Basler dart daA1600-60uc with 5.5mm Evetar
RADAR n/a
LIDAR Hesai Pandar40P
OTHER SENSORS xsens IMU MTi G710, Kistler Correvit SFII ground speed sensor, Maxon EC 32 flat with Hall sensors
HIGHLIGHTS OF THE DV SYSTEM With a 360° LiDAR and 3 cameras, our perception system for detecting cones combines low power use with a high range of 40m and high accuracy. Even in Autocross, with parts of the map still unknown, we optimize our trajectory while driving. Our control system automatically learns from its errors and follows the given path with high precision.

LISBOA

Universidade de Lisboa - Instituto Superior Técnico

Car 450 **Pit 31-B** Portugal

FST Lisboa is the oldest and most active Formula Student Team in Portugal. It has been around since 2001. Since the beginning of the 2020 season, the team has embarked on the journey of creating the first autonomous racecar in the team's history, and in Portugal. The FST10d, a revolution of the FST09e, is eager to hit the racetrack and compete among the best of the best.

DRIVERLESS ELECTRIC

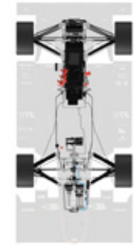
FRAME CONSTRUCTION Composite single-piece mono- coque built with 2 negative carbon fiber moulds
MATERIAL Carbon fiber sandwich structure with Honey- comb, Rohacell and 3D core as the core
OVERALL L / W / H 2987mm / 1442mm / 1185mm
WHEELBASE / TRACK (Fr / Rr) 1540mm / 1200mm / 1200mm
WEIGHT WITHOUT DRIVER (Fr / Rr) 125kg / 126kg
NUMBER OF MOTORS / LOCATION / MAX POWER 2 / Outboard wheel motors / 35kW, 35kW
COMBINED ACCUMULATOR CAPACITY 7.98kWh
BRAKE SYSTEM 4 - floating disk system, self developed rotors with 178mm OD, ajustable brake balance
PROCESSING UNITS Intel Core i7-8700T, Nvidia GTX 1060 6GB
PERFORMANCE OF PUs 230G, 4.4T GFLOPS
POWER CONSUMPTION OF PUs 150 W
CAMERAS LUCID Triton 3.2 MP Sony IMX265 CMOS, 2048 x 1536, 35.4 FPS
RADAR
LIDAR Ouster OS1-16 Gen1, 16 channels, 0.51° vertical resolution, -16° to 16°
OTHER SENSORS Xsens GNSS/INS MTi-670
HIGHLIGHTS OF THE DV SYSTEM LiDAR focused perception with Camera assisted color classification, through the means of Convolutional Neural Networks. Graph based SLAM, with a powerfull state estimator. SVM based path planner.

MÜNCHEN

Technical University of Munich

Car 431 **Pit 40-B** Germany

The TUfast Racing Team from the TU Munich consists of 90 Team members who designed and build one new race car this season. The main goal was to turn the Driverless and Electric cars into a new concept. And so, this season, we have started a new era with us. The xb021 is the first of our cars that can drive both autonomously and with a driver. The integration of the autonomous components into our existing system was a challenge that we mastered together. Feel free to visit us at the competition!



DRIVERLESS ELECTRIC

FRAME CONSTRUCTION Prepreg CFRP Monocoque
MATERIAL High Strength IM fiber, HM fiber, Aluminium
OVERALL L / W / H 3002mm / 1450mm / 1165mm
WHEELBASE / TRACK (Fr / Rr) 1650mm / 1225mm / 1225mm
WEIGHT WITHOUT DRIVER (Fr / Rr) 61kg / 90kg
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / One in each wheel / 35.3 kW per motor
COMBINED ACCUMULATOR CAPACITY 6.18kWH
BRAKE SYSTEM 4-Disk system, self-developed floating disks, 193 outer diameter, aluminum milled calipers
PROCESSING UNITS AMD Ryzen V1807B, Coral Mini PCIe Accelerator
PERFORMANCE OF PUs 5661 fp16 GFLOPS
POWER CONSUMPTION OF PUs 56 W
CAMERAS 2 x Basler daA 1920-160uc, mono-cameras
RADAR
LIDAR 1 x Ouster OS1-64, 60 m, 360 degree, Mid-Range High Resolution Imaging Lidar
OTHER SENSORS 1xIB6 IMU
HIGHLIGHTS OF THE DV SYSTEM Synchronised & motion calibrated Cameras & LiDAR; Wheel rotations, IMU & GPS for estimating car's state; FastSLAM for making global map of environment; robust & computationally fast Local planner & curvature optimization based global planner on loop closure; robust & fast reacting stanley controller; non-linear MPC in testing phase.

MÜNCHEN

University of Applied Sciences München

Car 413 **Pit 16-B** Germany

Autonomous driving is now one of the most rapidly developing sector of automobile industry all over the world. We keep up with the modern times and every year concept, build and present new upgraded models of driverless vehicles. Our PWd4.20 became much more accurate this year. With our new camera setup, we detect cones much more precicely and increase the overall performance significantly. We're not planning on killing every cone ever again!

DRIVERLESS ELECTRIC

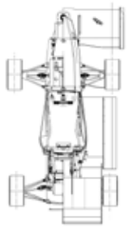
FRAME CONSTRUCTION Monocoque with tubular Front & Mainhoop
MATERIAL CFRP Sandwich Structure with aluminium core
OVERALL L / W / H 2887mm / 1395mm / 1147mm
WHEELBASE / TRACK (Fr / Rr) 1540mm / 1150mm / 1128mm
WEIGHT WITHOUT DRIVER (Fr / Rr) 115kg / 105kg
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / FR, FL, RR, RL / 28KW
COMBINED ACCUMULATOR CAPACITY 7,3kWh
BRAKE SYSTEM AP Racing two piston calipers, AP Racing master cylinders 14/22mm
PROCESSING UNITS NVIDIA Jetson Xavier
PERFORMANCE OF PUs 30012,75 GFLOPS
POWER CONSUMPTION OF PUs 100 W
CAMERAS 4x Basler Ace AcA1920-50gc , 2x Basler ace aca2440-75uc
RADAR n/a
LIDAR n/a
OTHER SENSORS 1 x Ground Speed Sensor Kistler Correvit SFII P, 1 x Bosch MM5.10-R Acceleration Sensor, 1 x Vector-Nav VN-300 INS
HIGHLIGHTS OF THE DV SYSTEM self implemented stereo camera setup with stereo matching. self developed and trained supervised algorithm for object detection. Accurate clustering and localisation based on multiple sensors and self implemented algorithms. Self implemented software stack for monitoring system parameters and sensor data.

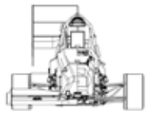
PRAGUE

Czech Technical University in Prague

Car 467 **Pit 06-B** Czech Republic

eForce DV01 is the first czech autonomous vehicle designed by eForce FEE Prague Formula in its two years of existence. Our vehicle is based on FSE07, an eForce monopost originally designed for the season of 2018. The autonomous system is run on Zotac and among others consists of FastSLAM used for vehicle localization and a robust path planning algorithm which supplies a path to be traced by Stanley control algorithm. Sensor inputs are collected from three stereocameras and a single lidar device.





DRIVERLESS ELECTRIC

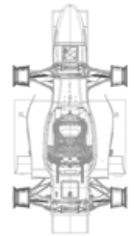
FRAME CONSTRUCTION Carbon fiber sandwich with tubular steel roll hoop and aluminium fronthoop
MATERIAL Rohacell foam (floor/top 15mm,side 20mm..)
OVERALL L / W / H 2860mm / 1592mm / 1174mm
WHEELBASE / TRACK (Fr / Rr) 1535mm / 1296mm / 1230mm
WEIGHT WITHOUT DRIVER (Fr / Rr) 91kg / 118kg
NUMBER OF MOTORS / LOCATION / MAX POWER 2 / Rear Right, Rear Left / 35kW, 35kW
COMBINED ACCUMULATOR CAPACITY 9,547kWh
BRAKE SYSTEM 4-Disk self developed rotors, AP Racing master cylinders, adjustable BB, ISR brake caliper
PROCESSING UNITS Zotac ZBOX MAGNUS EN72080V
PERFORMANCE OF PUs 10100 GFLOPS
POWER CONSUMPTION OF PUs 340 W
CAMERAS Stereolabs Zed, Intel Realsense Depth Camera D435i (2x)
RADAR
LIDAR Ouster OS1-64
OTHER SENSORS SBG Systems Elipse Dual INS
HIGHLIGHTS OF THE DV SYSTEM Despite being the first driverless formula built by eForce Driverless, DV01 contains several advanced features: - triple-camera setup to cover a wide field of view; - position of the cones estimated using homography which is automatically computed from fitting a plane to LiDAR pointclouds; - efficient real-time SLAM system based on FastSLAM

STUTTGART

Baden-Württemberg Cooperative State University Stuttgart

Car 477 **Pit 09-A** Germany

The DHBW Engineering builds electric vehicles since 2009. After a two-year development period, we introduce our first driverless vehicle. We modified our electric vehicle form 2019 with all necessary DV components including two cameras and a LiDAR sensor and integrated our autonomous system into the vehicle. Nine bachelor students of the fields Computer Science and Mechatronics worked on the development of our autonomous software, another six members on the electrical and mechanical DV hardware.



DRIVERLESS ELECTRIC

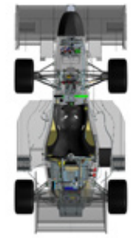
FRAME CONSTRUCTION Carbon fibre monocoque with integrated front hoop.
MATERIAL HM, HT and IM carbon fibers, aluminium honeycomb.
OVERALL L / W / H 2874mm / 1527mm / 1145mm
WHEELBASE / TRACK (Fr / Rr) 1530mm / 1220mm / 1220mm
WEIGHT WITHOUT DRIVER (Fr / Rr) 83kg / 115kg
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / FR, FL, RR, RL / 38
COMBINED ACCUMULATOR CAPACITY 6,98
BRAKE SYSTEM Floating, Steel X46Cr13, hub mounted, 184 mm outer diam., 160 mm inner diam.
PROCESSING UNITS ES910, Intel i7-9700K, RTX2080
PERFORMANCE OF PUs 11024 GFLOPS
POWER CONSUMPTION OF PUs 853,8 W
CAMERAS 2, 20m, 110°, Matrix Vision Blue Cougar X
RADAR 0
LIDAR 1, 40m, 80°, Ouster OS1 Gen2 64 Gradient Configuration
OTHER SENSORS Novatel PwrPak7D
HIGHLIGHTS OF THE DV SYSTEM Robust software pipeline starting with cognitive system, localization, planning up to controlling. Steering motor integrated in steering linkage and weight optimized EBS.

STUTTGART

University of Stuttgart

Car 426 **Pit 25-B** Germany

2021 marks the 12th anniversary of the GreenTeam and the 4rd time we participate at Hockenheim with our driverless car. Within the last eight months this team has transformed the previous year's vehicle, the D0711-3, to a more performant autonomous vehicle, the D0711-4. One camera and one LiDAR, EKF SLAM and a stanley control enable our car to excel on the track.



DRIVERLESS ELECTRIC

FRAME CONSTRUCTION Carbon fiber sandwich structure monocoque
MATERIAL Aluminium honeycomb sandwich panel
OVERALL L / W / H 3000mm / 1440mm / 1200mm
WHEELBASE / TRACK (Fr / Rr) 1540mm / 1200mm / 1200mm
WEIGHT WITHOUT DRIVER (Fr / Rr) 80kg / 85kg
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / One at each Wheel / 32.5 kW per Motor
COMBINED ACCUMULATOR CAPACITY 3.2kWh
BRAKE SYSTEM 4-Disk system, self developed steel brake disk
PROCESSING UNITS Speegoat Baseline as Vehicle Dynamics ECU, Vecow EVS1100 as Autonomous System ECU
PERFORMANCE OF PUs 6000 GFLOPS
POWER CONSUMPTION OF PUs 610 W
CAMERAS Matrix Vision mvBlueFox 2089-aC
RADAR
LIDAR Ouster OS1
OTHER SENSORS
HIGHLIGHTS OF THE DV SYSTEM Sensor concept consisting of one camera and one LiDAR, EKF-SLAM, Model Predictive Control

TRONDHEIM

Norwegian University of Science and Technology

Car 463 **Pit 22-B** Norway

Revolve NTNU was founded in 2010. We developed two combustion cars, before switching to electric in 2014 and had our first 4wd electric car in 2016. Since 2018 we have been developing both an autonomous and an electric racecar each year. Last year's vehicles were unfortunately never completed, so we are really looking forward to showing you everything we have been working on over the past two years. See you at FSG.

DRIVERLESS ELECTRIC

FRAME CONSTRUCTION CFRP Two-Piece Monocoque
MATERIAL M 2x2 twill prepreg and HM UD prepreg with Foam & ALUHC core sandwich panel
OVERALL L / W / H 2870mm / 1400mm / 1185mm
WHEELBASE / TRACK (Fr / Rr) 1530mm / 1200mm / 1180mm
WEIGHT WITHOUT DRIVER (Fr / Rr) 96kg / 105kg
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / Hub mounted / 37 kW
COMBINED ACCUMULATOR CAPACITY 6.8 kWh
BRAKE SYSTEM 4-Disk system, self developed rotors, ISR 22-048/9 callipers, adjustable brake balance
PROCESSING UNITS Self developed processing unit with Intel i9-9900
PERFORMANCE OF PUs 499 GFLOPS
POWER CONSUMPTION OF PUs 105 W
CAMERAS N/A
RADAR N/A
LIDAR Hesai Pandar P40
OTHER SENSORS VectorNav VN-300 INS
HIGHLIGHTS OF THE DV SYSTEM Autonomous systems are crafted in C++ and Python with ROS. Detection with single LiDAR and PCL. ESKF State Estimation using IMU and dual GNSS with pose feedback from graphSLAM. Path planning using particle filter. Coupled MPCC controller seeking optimal wheel angles and torques, maximizing progress around track. Tested using in-house simulation.

ZÜRICH

Swiss Federal Institute of Technology Zurich

Car 433 **Pit 46-A** Switzerland

AMZ Racing was founded in 2006 by students of ETH Zurich. Since 2010 AMZ focuses on electric vehicles and collaborates with the Lucerne University of Applied Science and Arts. AMZ took the opportunity to transform their electric vehicles into autonomous race cars, when Driverless was first introduced in 2017. The 2019 driverless team consists of an diverse and international team of Master's students from Robotics, Electrical Engineering, Mechanical Engineering, and Computer Science.

DRIVERLESS ELECTRIC

FRAME CONSTRUCTION Single piece CFRP monocoque
MATERIAL CFRP & AFRP pre-preg (Twill and UD), aluminum honeycomb sandwich
OVERALL L / W / H 2932mm / 1422mm / 1156mm
WHEELBASE / TRACK (Fr / Rr) 1530mm / 1220mm / 1220mm
WEIGHT WITHOUT DRIVER (Fr / Rr) 97kg / 100kg
NUMBER OF MOTORS / LOCATION / MAX POWER 4 / On all wheels / 38.44kW
COMBINED ACCUMULATOR CAPACITY 6.2kWh
BRAKE SYSTEM Self-developed aluminum calipers, adjustable brake balance, proportional valve in the rea
PROCESSING UNITS CPU: Intel Quad-Core Xeon E3-1505M V6, GPU: NVIDIA GeForce RTK 3060
PERFORMANCE OF PUs - GFLOPS
POWER CONSUMPTION OF PUs 210 W
CAMERAS 3 Basler cameras with a combined opening angle of 135° and overlapping FOVs
RADAR -
LIDAR Hesai Pandar 20 & 64
OTHER SENSORS INS with dual antenna GNSS, non-contact optical speed sensor
HIGHLIGHTS OF THE DV SYSTEM Fully redundant sensor pipelines providing robustness against single sensor failure. Multi-level estimation methods leverage probabilistic cone observations. Different control algorithms are optimized to meet the requirements of the respective dynamic disciplines.

Formula Student Worldwide

1222 teams – 64 nations – 5 continents – one passion

Every year students from various disciplines share their enthusiasm for the competition. The various venues are visited annually by hundreds of student teams. The Formula Student community is growing steadily and other countries are joining in with their own competition. Every year at the Hockenheimring, Formula Student Germany is hosting a joint meeting for all Formula Student organisers, in order to share and develop the competition further.

1222 Teams – 64 Länder – 5 Kontinente – eine Leidenschaft

Jedes Jahr teilen weltweit Studenten unterschiedlicher Fachrichtungen ihre Begeisterung für den Wettbewerb. Die verschiedenen Austragungsorte werden jährlich von hunderten studentischen Teams besucht. Die Formula Student-Gemeinschaft wächst stetig und weitere Länder schließen sich mit einem eigenen Wettbewerb an. Im Rahmen der Formula Student Germany findet normalerweise jedes Jahr ein Meeting aller weltweiten Formula Student Organisationen auf dem Hockenheimring statt, um den Wettbewerb gemeinsam weiterzuentwickeln.

Formula SAE
Lincoln & Electric
Lincoln Park, NE
Competition: C E

Formula SAE
Canada
Barrie Molson Centre
Competitions: C E

Formula SAE
Michigan
07.07.2021 – 10.07.2021
Michigan International Speedway, MI
Competition: C

Formula SAE
Brasil
ECPA – Esporte Clube Piracicabano de Automobilismo
Competitions: C E

FS
Germany
16.08.2021 – 21.08.2021
Hockenheimring
Competitions: C E D

FS
UK
21.07.2021 – 25.07.2021
Silverstone
Competitions mixed: C E

FS
Austria
25.07.2021 – 29.07.2021
Red Bull Race Track in Spielberg
Competitions: C E

FS
Spain
02.08.2021 – 08.08.2021
Circuit de Barcelona-Catalunya, Montmélo
Competitions: C E

FS
Netherlands
04.07.2021 – 08.07.2021
TT Circuit Assen
Competitions: C E

FS
East
07.08.2021 – 11.08.2021
Hungaroring in Mogyoród, Ungarn
Competitions: C E D

Formula SAE
Italy
11.10.2021 – 13.10.2021
Riccardo Paletti Circuit, Varano 'de Melegari, Parma
Competitions: C E D

FS
Czech
26.07.2021 – 01.08.2021
Autodrom Most test track
Competitions: C E D

FS
China & FSEC
Xiangyang, Hubei province / Zhuhai, Guangdong province
Competitions: C E D

Formula
Bharat
20.01.2022 – 25.01.2022
Kari Motor Speedway in Coimbatore
Competitions: C E

Formula SAE
Korea
Gunsan-si, Jeollabuk-do
Competitions: C E

Formula SAE
Japan
07.09.2021 – 11.09.2021
Ogasayama Sports Park ECOPA
Competitions mixed: C E

Formula SAE
Australasia
09.12.2021 – 13.12.2021
Winton Motor Raceway, Rural City of Benalla, Victoria
Competitions: C E

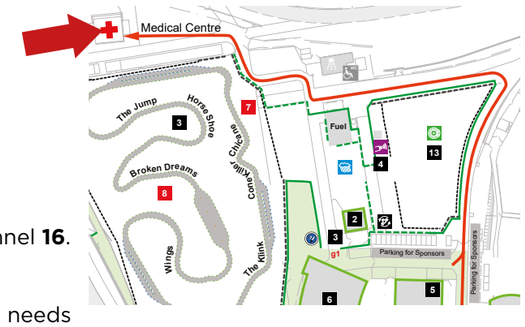
World Ranking Lists

C https://fs-world.org/C/

E https://fs-world.org/E/

EMERGENCY INFORMATION

Minor Injury
Medical Centre:
Please accompany the injured person to the Medical Centre.
Emergency aid is provided there.
The Medical Centre is occupied whenever the Pits are open.



Severe Injury
Contact someone with a two-way radio:
Every Official and Security has two-way radio.
Ask them to call the Medical Centre or an ambulance on channel **16**.

Call an ambulance:
Call an ambulance yourself if someone is severely injured and needs urgent help. The Emergency Number for every phone and mobile phone is **112**.

During dynamics:
On the days that the dynamics are running, an ambulance is on site during the dynamic events.
They are located next to the Medical Centre and are marked on the Event Plan in blue.
To contact them, ask someone with a two-way radio (Official, Security) to call them.

Hospital:
Krankenhaus (Schwetzingen), Bodelschwinghstrasse 10,
68723 Schwetzingen, phone: +49 (0) 6202/84-30

https://fsg.one/hospital

Emergency Numbers
In case of an emergency call **112**.
This number works with each phone, also with mobile phone or coin-operated telephone as international GSM-standard. It is alway free of charge.

112

Officials

Event Control - Ann-Catrin Leschniewski	+49 (151) 560 747 02
Back Office - Sven Grundner	+49 (151) 560 747 03

(In case of an emergency please call 112 and afterwards Ann-Catrin or Sven.)

Emergency Call Contents
The emergency control centre will ask you some questions to ensure proper help for you. To support you at your call, here are some standard questions and some hints for your answers in English and German.

Who is calling? (Wer ruft an?)
Say your name and your telephone number for callbacks. Digits in German: 0 (null), 1 (eins), 2 (zwei), 3 (drei), 4 (vier), 5 (fünf), 6 (sechs), 7 (sieben), 8 (acht), 9 (neun)

Where did it happen? (Wo ist es passiert?/Wo ist es geschehen?)
the event site has the adress "Hockenheimring, Sachshaus, Am Motodrom", make it more precise!:
pit lane (Boxengasse), dynamic area (Fahrerlager);
the adress for campsite C2 near the Motodrom Hotel "Hockenheimring, Zeltplatz C2 beim Motodrom Hotel"
and for campsite C3 on the other site of the highway "Hockenheimring, Zeltplatz C3 an der Continental Straße"

What happened? (Was ist passiert?/Was ist geschehen?)
accident (Unfall), traffic accident (Verkehrsunfall), fire (Feuer), fall (Sturz), explosion (Explosion)

How many people are affected? (Wie viele Personen sind betroffen?)
1 (eins), 2 (zwei), 3 (drei), 4 (vier), 5 (fünf), 6 (sechs), 7 (sieben), 8 (acht), 9 (neun), 10 (zehn)

What kind of injury has happened? (Welche Verletzung liegt vor?)
fracture (Knochenbruch), bleeding (Blutung), unconsciousness (Bewusstlosigkeit), burn (Verbrennung), electric shock (Stromschlag), suffocation (Ersticken), heart attack (Herzinfarkt), shock (Schock)

Don't hang up after answering these questions! Wait to hear if the control centre has further questions!

FORMULA STUDENT GERMANY 2021

BASF We create chemistry
BMW
MINI
ROLLS-ROYCE MOTOR CARS LTD
BOSCH Invented for life
Brunel
DAIMLER
faurecia
automotive engineering iav
MAGNA
MAHLE
MathWorks
PORSCHE
SCHAEFFLER
SIEMENS
SKF
TE connectivity
TESLA
VDI
VW
ZF

Supporter: fishfarm netsolutions | Gross-Funk | Hockenheimring | Kube Ingenieurbüro
Maxim Integrated Products | RIEDEL Communications | SLV Mannheim