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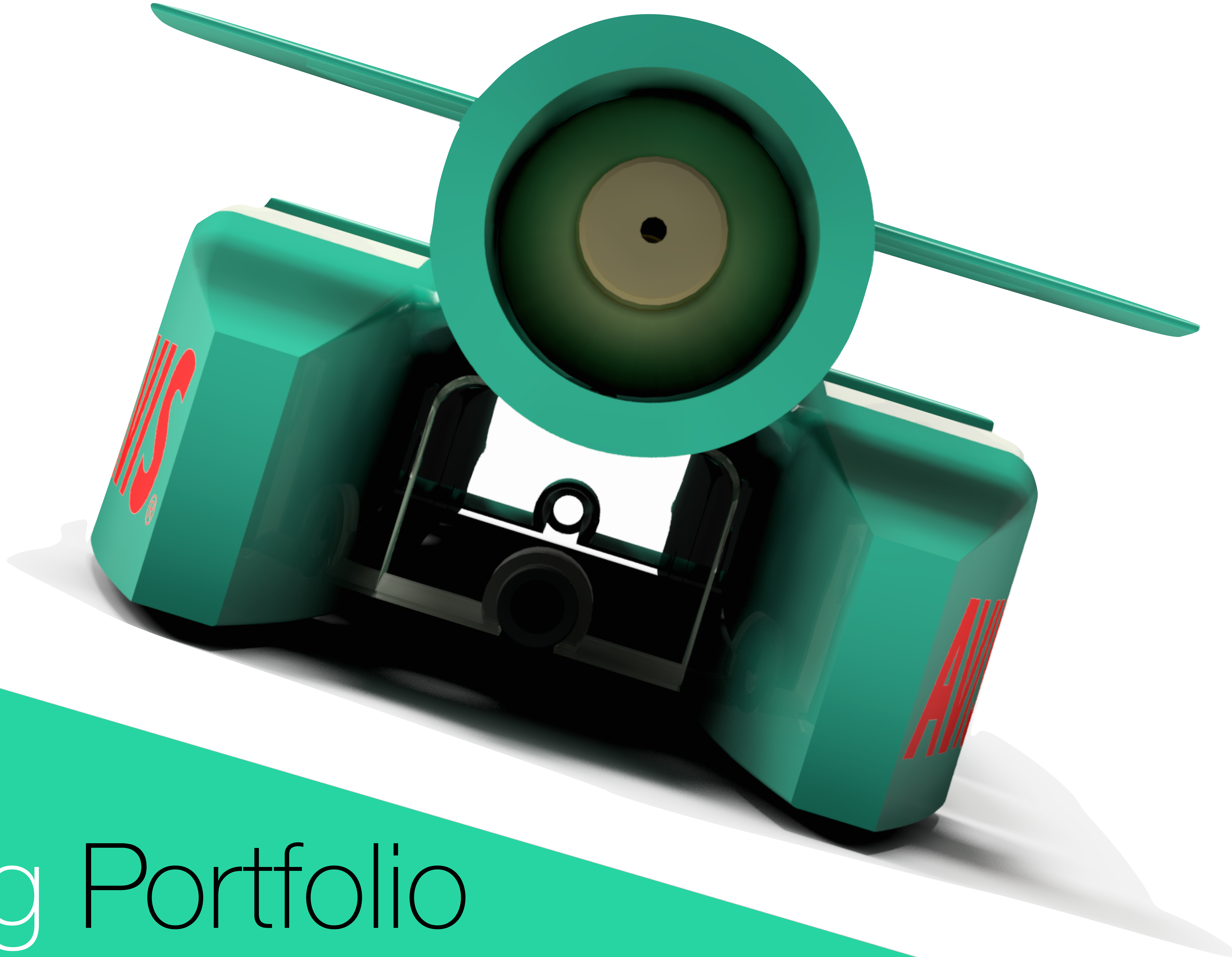
ELLINOGERMANIKI AGOGI

AR acceleracing



Engineering Portfolio

Introduction

Naming protocol

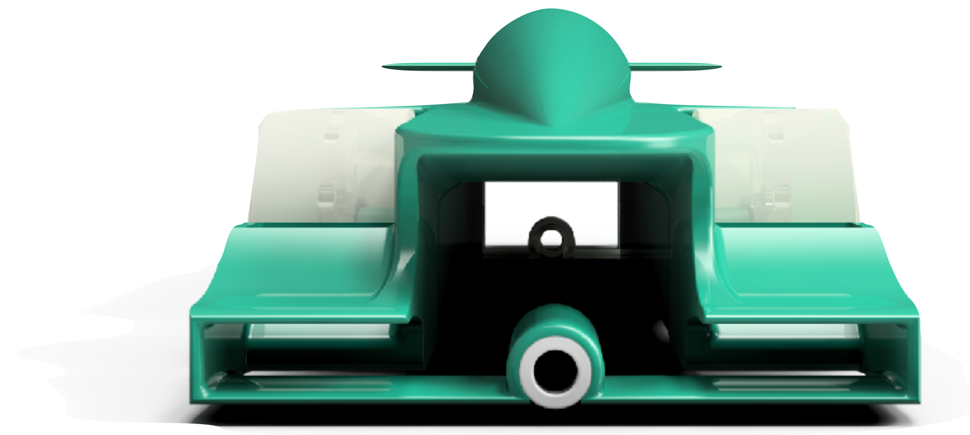
CRM = Cholevas Racing Motorsport
FP = Final Prototype
DP = Development prototype
r = revision
Rass = Rear airfoil support system
Rwss = Rear wheels support system

CRM design philosophy

Our basic design principle is to minimize all forces acting on the car with a direction different than the one of the movement of the car. We tried to reduce the aerodynamic drag by minimizing the frontal area, the angle of all surfaces, the drag produced by the underbody tunnel and finally the frictions of the rolling system and tether line guides.

Final Prototype 6 (FP6) design

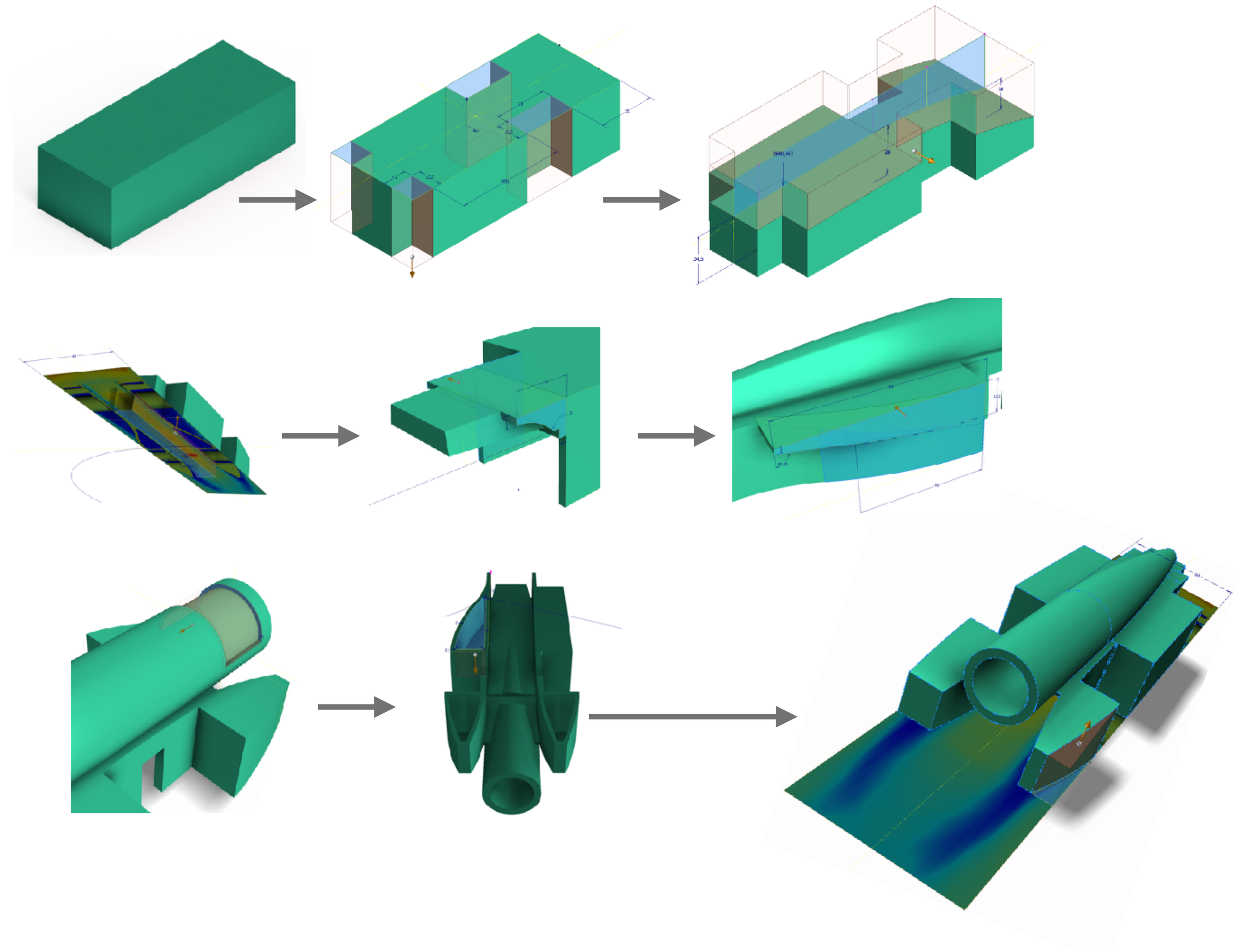
Our current model CRMotosport FP6 is the product of evolution and R&D based on our 5 previous models. It consists of the main body, the nosecone, the rwss, the rass, the tether line guides, the bearings and the wheels.

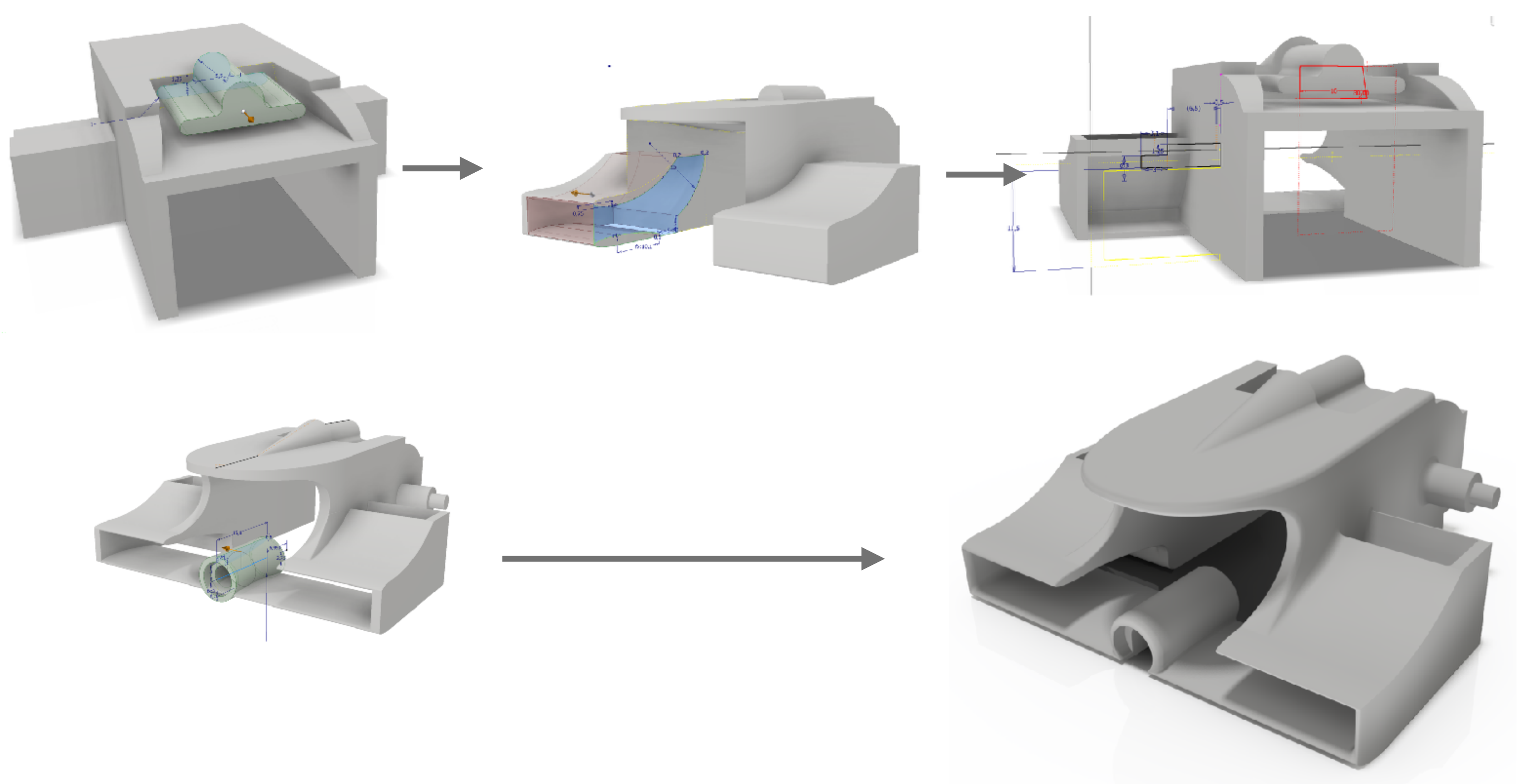


CAD Design FP6

Body

The first step in creating the car body, was the design of the F1 block. We used a single spline and extrude command to create the entire curve from the nose to the rear pods. In order to design the wheel holes we chose the lower plane of the model and drew two rectangles in the respective positions with a depth of 15.5mm and a width of 44mm and 32mm for the front and rear respectively. The extrusion command made these holes three-dimensional. Next we started designing the nose cone socket where we used the loft, extrude and extrude-cut commands to ensure perfect fit of the two parts. For tunnel design we used a series of extrusions. The reason we opted to use the Extrude over the Loft command is to ensure precision in tunnel dimensions and strict adherence to our initial conceptual design. A innovative idea we had, was to CFD test the model and the insert the image of the tunnel during the test, it the sketch of the tunnel. Then we redesigned the tunnel so that it follows the maximum angle without having flow separation at the same time, based on the CFD tests. A point of differentiation of our car is the side pod curvature. To achieve this we used the extrude function twice to create two separate curves, which we later joined using six variable fillets. The final result proved to be aerodynamic, limiting tire wake. The rear wheel support system was also built using initially the extrude and extrude cut functions and then the loft and extrude commands to create the position of the chamfer hole. The rear airfoil support system slot was designed on top of the chamfer hole. The tunnel walls serve also as the inner surface of the rear pods thus simplifying the overall construction. Using six 2D sketches and a series of extrusions, we removed all the excess material around the rear pods. Finally, using the extrude command, cavities were formed inside the rear pods and side pods, contributing to the balanced distribution of the weight. Finally we have applied the necessary ordinary and variable filets so that the .stp file delivered to our CNC partner, Lasertech, is compatible with it's state-of-the-art 5-axis CNC milling machines.





Nosecone

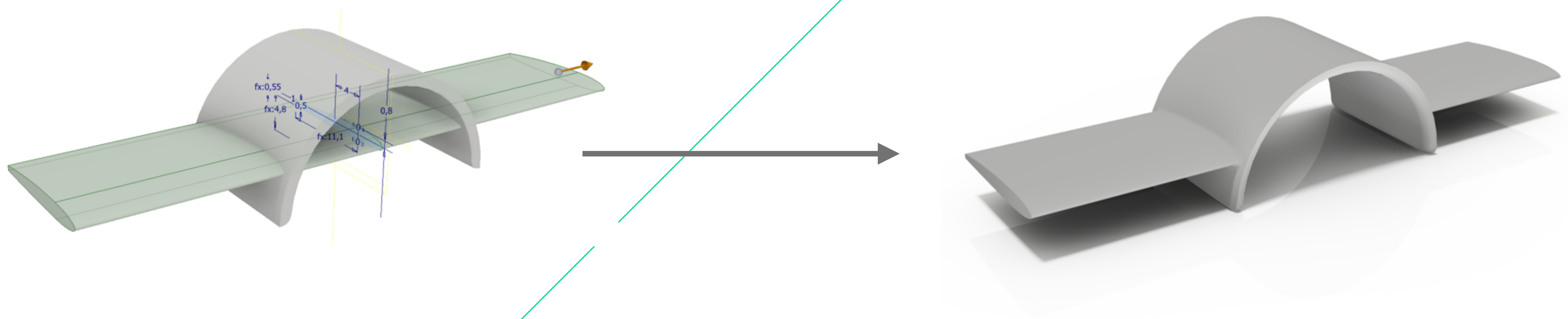
The front nose cone consists of 2 dedicated front airfoils, a tether line guide and wheel axis. Design emphasis was given in improving the aerodynamic performance while ensuring nose cone robustness so as to survive without damage the deceleration and stopping phase. Another key design feature is the glue-less attachment of the nose cone to the car body which allows easy change of damaged nose ones with new ones and thus reducing service penalties. We started the design of the nose cone by creating the basic outline using 2D sketch mode. All CRM parts consist of"Fully-Constrained" only sketches in order to minimize Inventor errors during changes of values at the part's "Parameters" table. At a next step we made a series of 2D and 3D sketches and the Extrude and Loft commands, to finish the centre part of the nose cone. Then we made a quite complicated 2D sketch which is responsible for the creation of the whole front pods, using again Extrude as the main command to bring two dimensional sketches to three dimensions. We completed the front section by Extruding the front airfoils and revolving the tether line's home 2d sketch. We created a very complicated loft(-cut), using a series of 2D sketches and 2D rails created on custom 2D planes. The mechanism that joins the nose cone with the body was at last finished after the extrusion of the relevant 2D sketch (Image____). We revolved the 2D sketch of the 2 front axles using as a reference the axis of rotation of the wheels. Finally we created fillets where needed to further improve car's aerodynamic performance. The reason we always do the fillets at the end is to leave intact the part geometry during design.

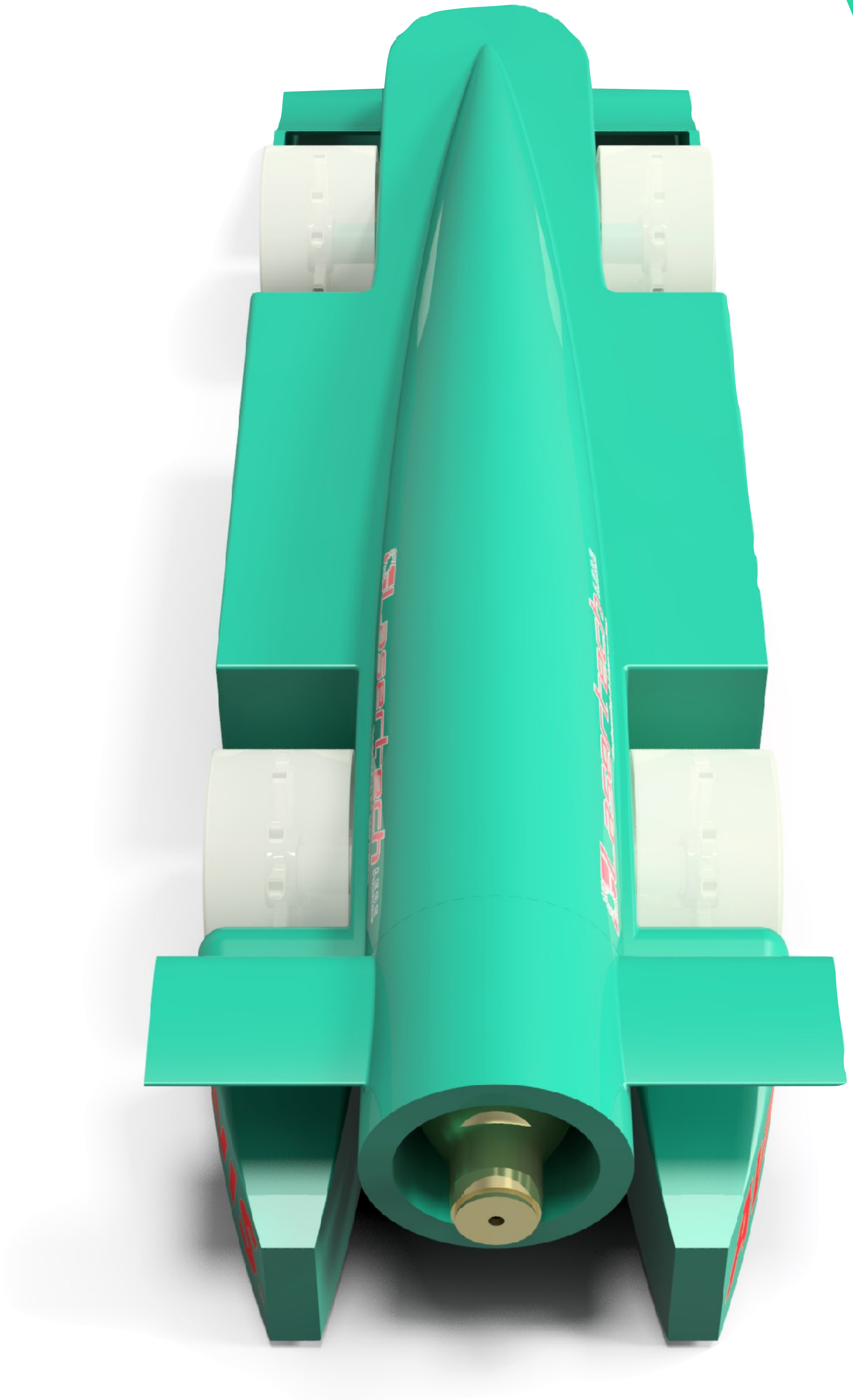
acceleracing

CAD Design FP6

Rear Airfoil Support System (RASS) Design

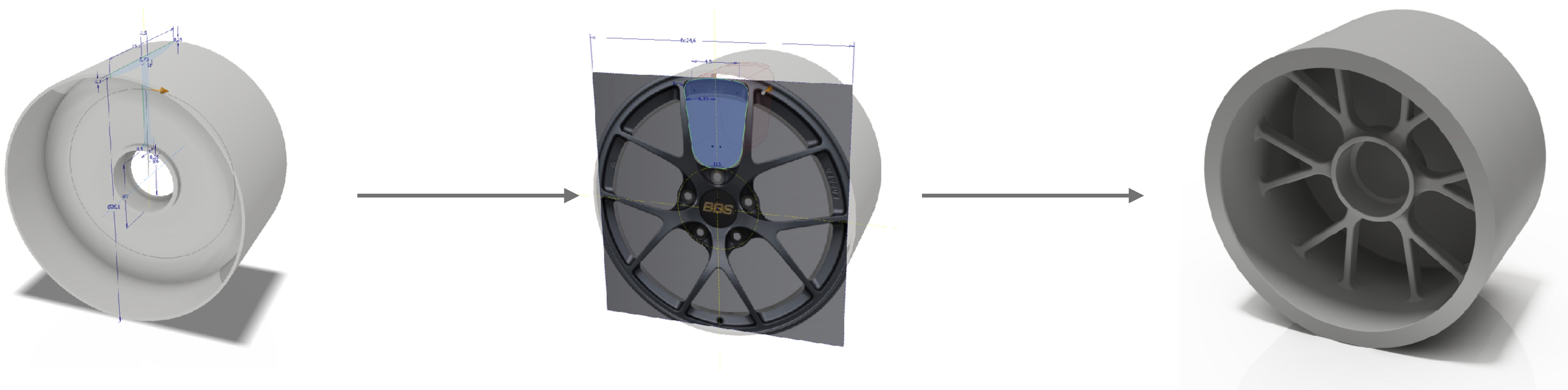
Similar to nose cone, we designed three different versions of the RAS, one with a positive, one with a negative and one with zero angle of attack. Thus, we could evaluate how an inclination or the geometry of the spoiler could affect our car's performance on the track. At first, we designed two homocentric circles on a two-dimensional plane and converted them into semi circles with the trim command. Using them as a base, we shaped the spoilers and finally, we expanded our design in three dimensions using the extrude command.





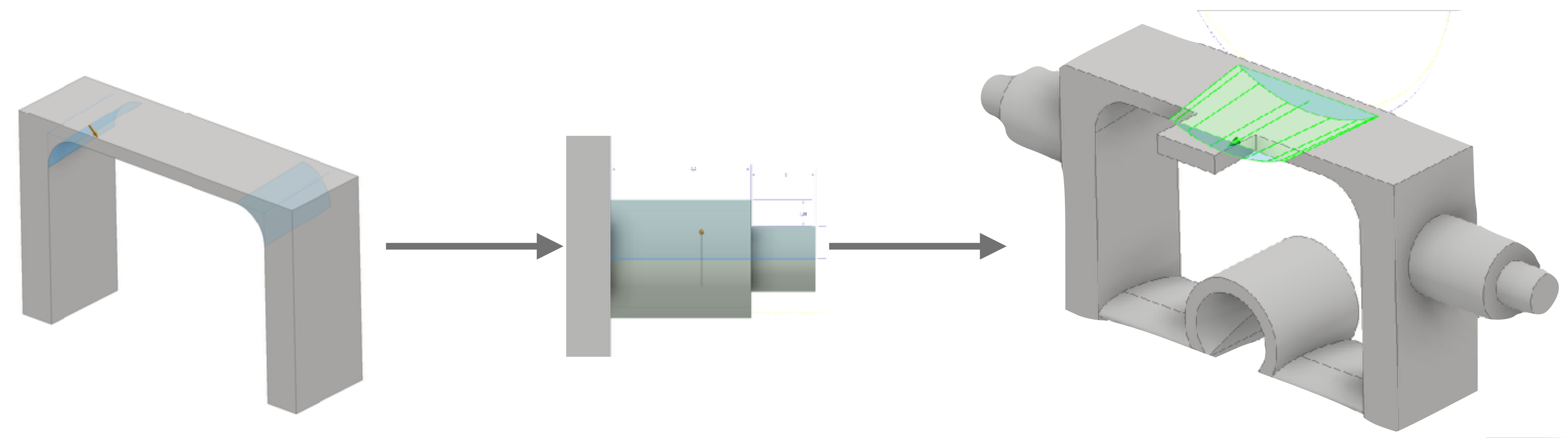
Wheel Design

Following our rolling system philosophy which is presented on the R&D section of the portfolio, we created a miniature of the wheel BBS performance FI-R, used by many teams in GT endurance races for many years. Using the revolve function, we revolved the basic design of the wheel around its rotation axis. We inserted an image of a real wheel in the program Autodesk Inventor and, with the help of the spline function, we copied its shape. Finally, we created the bores for the bearings and the necessary fillets. The wheel has a diameter of 26mm and a width of 15mm. However, due to that small size, the bearing is forced to spin with a bigger angular speed, causing stronger friction forces, which slow the car down. But on the other hand, the frontal surface of the car is smaller and consequently the drag force, the tire wake and the wheel inertia, allowing a better race start.



Rear wheel support system (RWSS) design

This part plays a crucial role on the car performance. It consists of a small spoiler which the second tether line slot positioned right in its middle. Around this part we formed some innovative small overhangs to ensure ensures that WSS is perfectly fitted on the main body. Using the loft command, we shaped the overhang and the associated recess, which have a special form. Moreover, we ensured that the WSS follows the continuous curvature of the wind tunnel. For the spoilers and the tether line slot we used the functions extrude and revolve respectively. We completed the design of that part of the car by copying the front wheel axles of the nose cone. Finally, we applied the required fillets and converted the part in a. stl format.



FP6 Design

Rearpods

The target of our rear pods is to eliminate turbulence in the rear of the car. We designed the car with a big wheelbase, restricting the rearpod area to only 35mm. We realize early on that it would be more important to keep high pressure on the tunnel than having flow separation in the rear. That's the reason why the rear pods are not designed to have a complete drop shape. This shape is widely known by the Mercedes concept IAA.

Wheels

Our primary target when designing the wheels was to minimize inertia in order to maximize the conversion of capsule gas energy into kinetic energy of the car and consequently speed. The design of our wheels is based on those of Formula 1.

Bearings

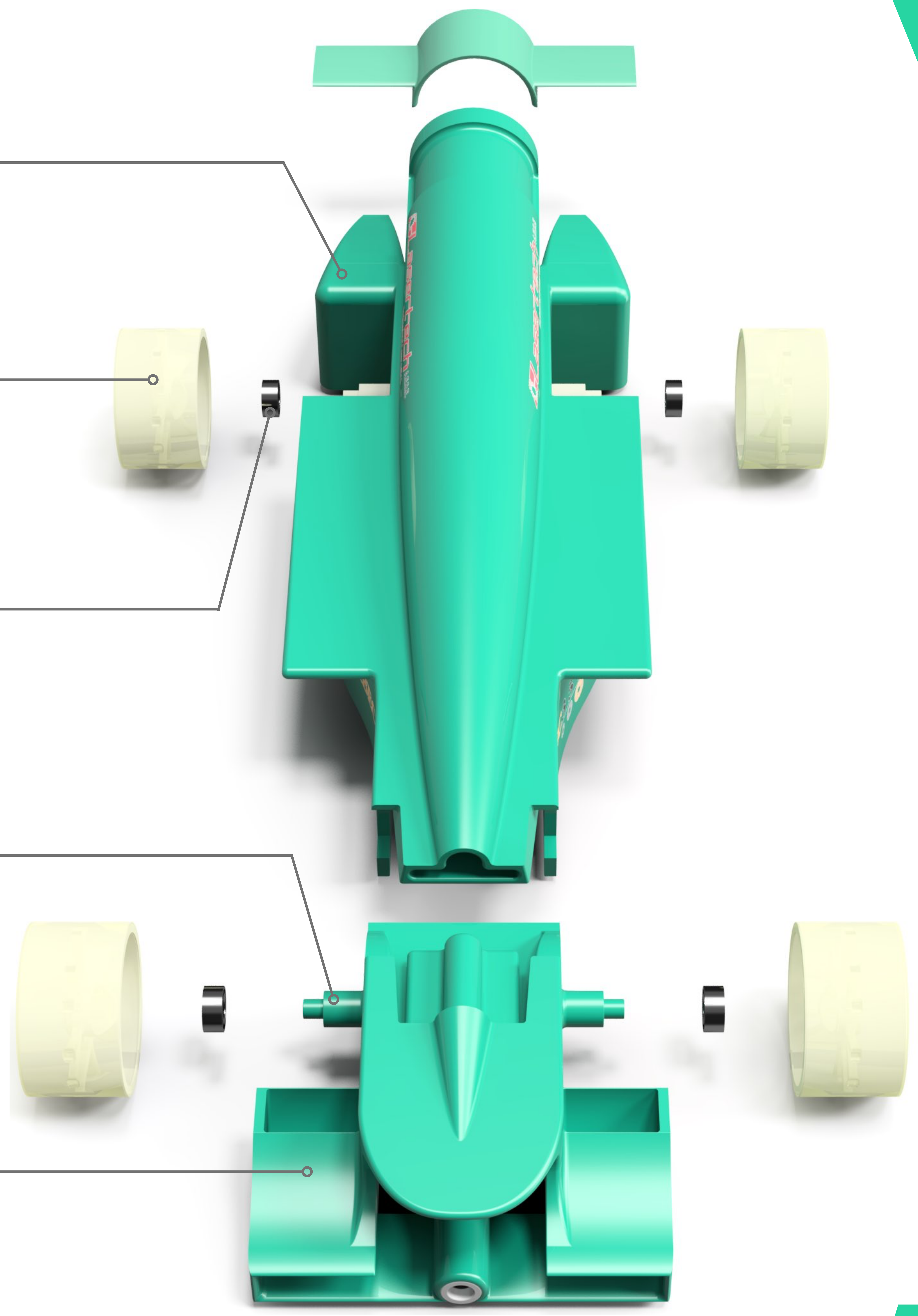
The bearings are one of the most critical parts for the performance of the car, For this reason, we have chosen state of the art silicon nitride bearings for the wheels.

Axles

The car has four axles, one for each wheel. Their goal is to support the bearings so that the wheels are stable and do not come into contact with the body of the car. Moreover, they are constructed so that the air flows optimal through the Bernoulli tunnel.

Nosecone

The nosecone of our car is designed to have a parabolic curve shape using the appropriate equations for the curve. It is said that it is the most efficient shape under Mach 1 speed and our research at 39 km/h shows that. The shape is also inspired by the Ferrari F138. Its target is to direct the air over and under the car without creating high pressure and vortexes. Goal of the nose cone is to guide the air evenly around the front wheels and to the back of the car to avoid turbulent air flux. Its shape is like the Ferrari F138. Furthermore, it leads a large amount of air underneath the car, to make it more aerodynamic.



FP6 Design

Tether line guides

We chose to adapt the optional 2 tether line guides on the car, because they offer a drastic increase in stability. They also minimize steering during the race, which helps the car to use more kinetic energy (produced by the gas capsule) to accelerate further and faster. Tether line guides on the other hand, create friction. In order to minimize friction we fitted Teflon O rings in the tether line guides as Teflon has a CoF of only 0.11.

Underbody tunnel

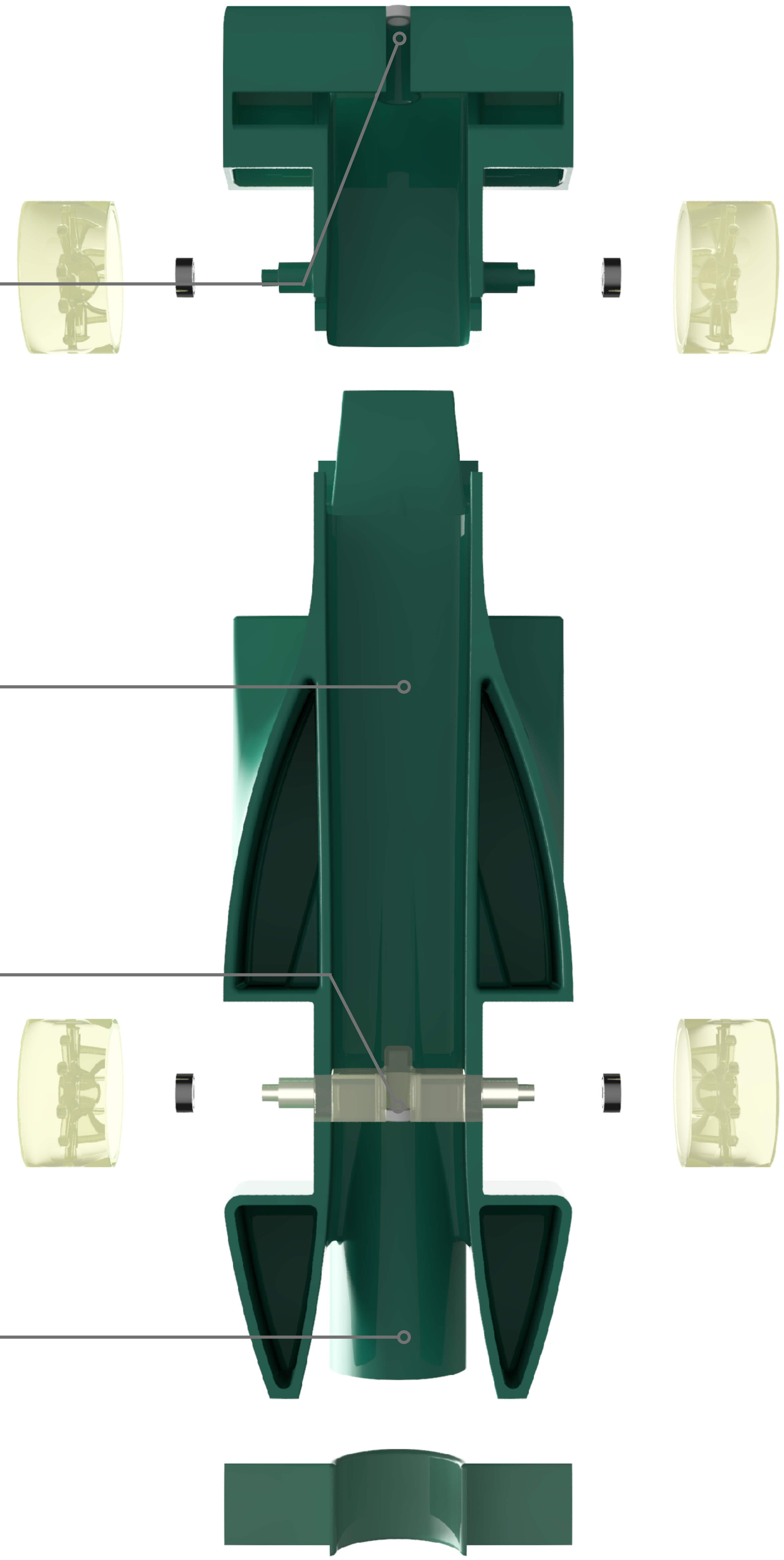
The underbody tunnel takes advantage of the Bernoulli effect to make the LERD system work by directing the low pressure to the high pressure air on the canister area. It's also designed to raise the car's center of gravity and minimize rotational forces during launching (Center of gravity - page 9)

Rear wheels support system

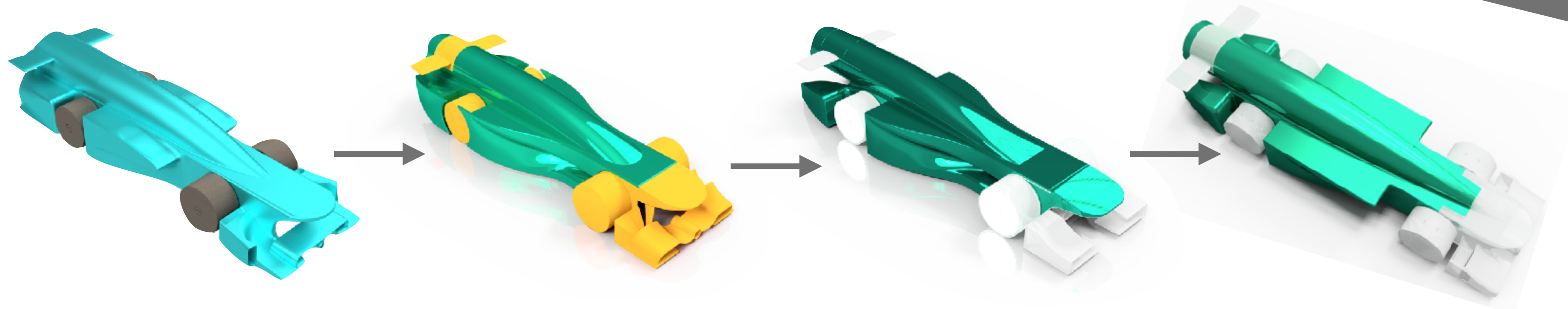
This part is responsible for the support of the rear wheels and and of the bearings. Its proper design allows the even flux of the air through the wind tunnel. It is one of the critical parts of the car.

Loft

Inside the loft there is the cavity where the CO2 capsule is fitted. It is designed in such way that distracts the air flow from the rear wheels to avoid causing extra turbulence.



Evolution of the FP's



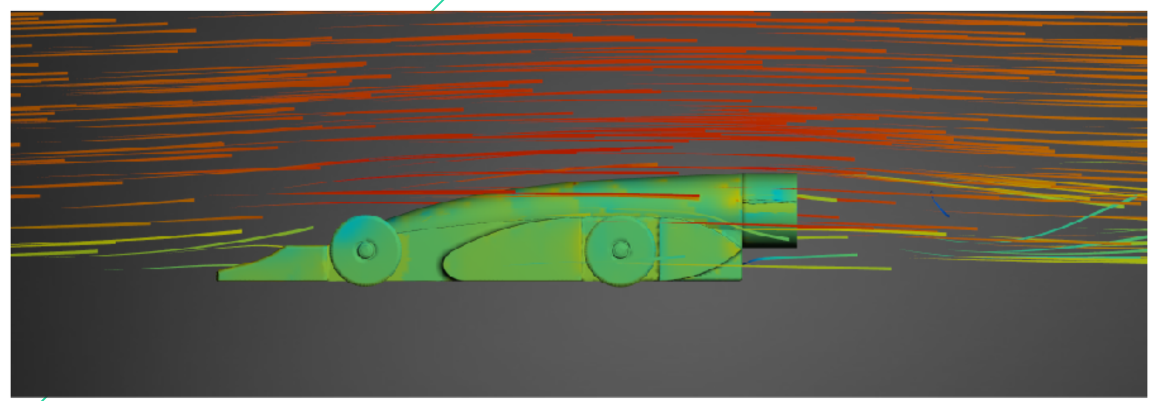
CRM FP3

Year of design: 2017/18

Advantages: good centre of gravity, minimal tyre wake, low frontal area

Drawbacks: fragile nose cone, hard to construct, hard to assemble

Philosophy: After research on weight distribution and vehicle kinematics we raised the centre of gravity to reduce moment of inertia produced by the acceleration of the vehicle. Also added 2 tyre wake reducers and tunnel to reduce the frontal area and rear pods to minimize the vortexes in the rear because of their special shape.



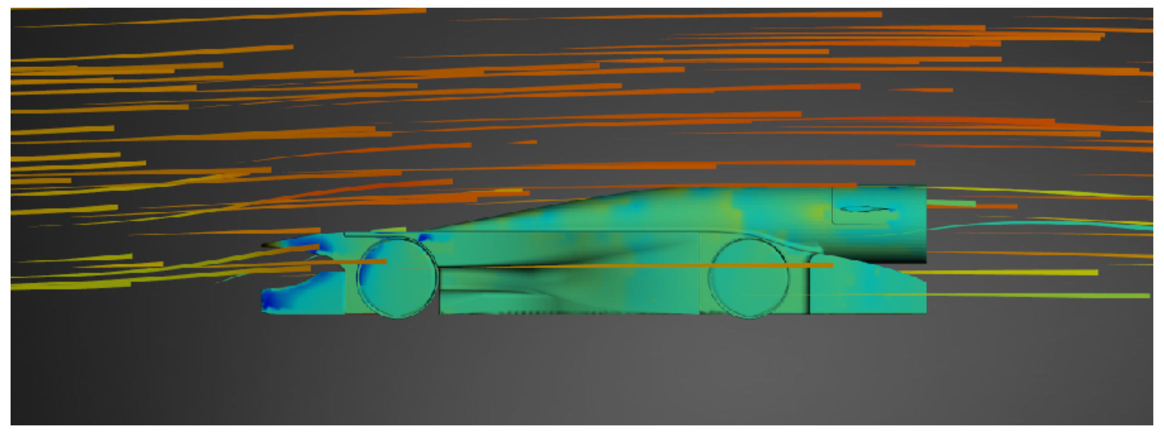
CRM FP5

Year of design: 2017/18

Advantages: good centre of gravity, minimal tyre wake, low frontal area

Drawbacks: fragile nose cone, hard to construct, hard to assemble

Philosophy: After research on weight distribution and vehicle kinematics we raised the centre of gravity to reduce moment of inertia produced by the acceleration of the vehicle. Also added 2 tyre wake reducers and tunnel to reduce the frontal area and rear pods to minimize the vortexes in the rear because of their special shape.



CRM FP6

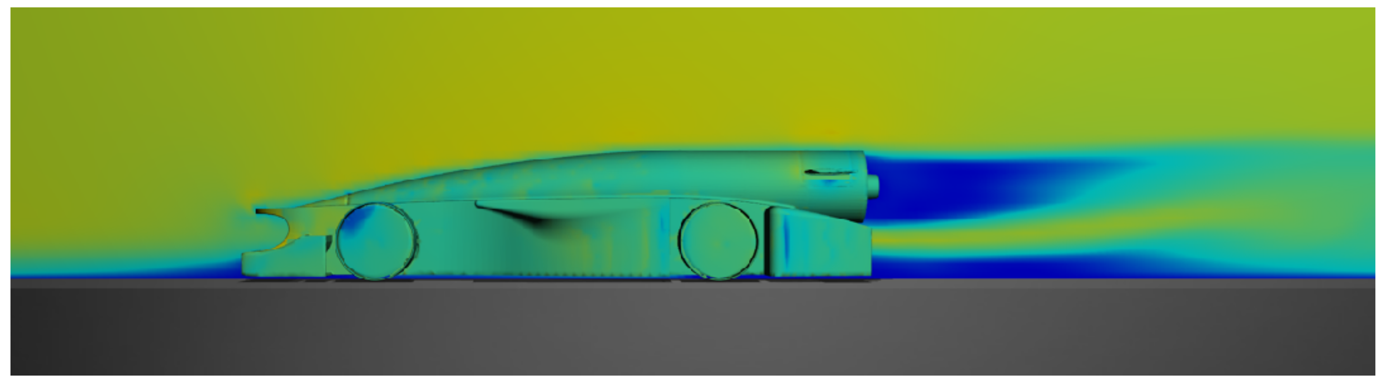
Final Model

Year of design: 2018

Advantages: better centre of gravity, lower frontal area, less fragile, completely repairable

Drawbacks: harder to construct, very hard to design, more rear vortexes

Philosophy: first on our list was to improve the repairability and endurance of the car. The parts have increased contact surface area to avoid the addition of glue. We reduced the frontal area as much as we could, improving the positioning of the CoG. The rolling system has 25% less parts in order to increase the simplicity of the design and the rigidity.



CRM FP3	10 m/s	20 m/s
100% resolution	0,58	60
200% resolution	61	61
300% resolution	62	63
CRM FP5	10 m/s	20 m/s
100% resolution	0,56	0,57
200% resolution	0,57	0,59
300% resolution	0,57	0,61
CRM FP6	10 m/s	20 m/s
100% resolution	0,49	0,52
200% resolution	0,5	0,54
300% resolution	0,52	0,54

FSI analysis

The main problem we faced during the semi-finals, was the insufficient rigidity of the FP5. We used the add-in tool "Stress analysis" in Autodesk Inventor, to calculate the appropriate thickness of our parts. We tested each part separately to avoid complexities and wrong values during and after the simulation. The studies led us to:

Increase the surface area between the front pod and the nose cone by 600%.

Increase the wheel thickness by 0.25mm or 50%.

Double the structural flex of the CRM FP5 RASS model.

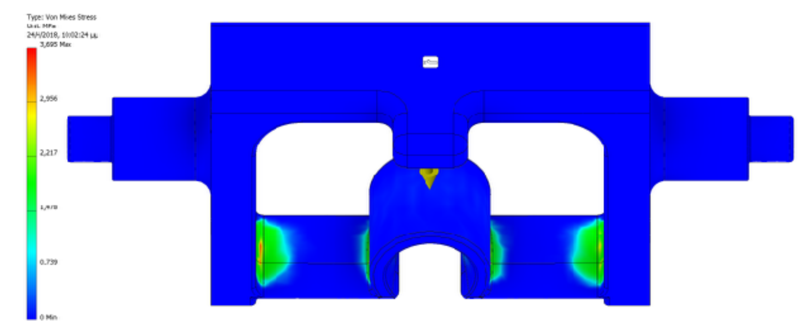
Make the two front 20mm wide airfoils, one 58mm wide airfoil, to reduce mechanical flex of the frontpods.

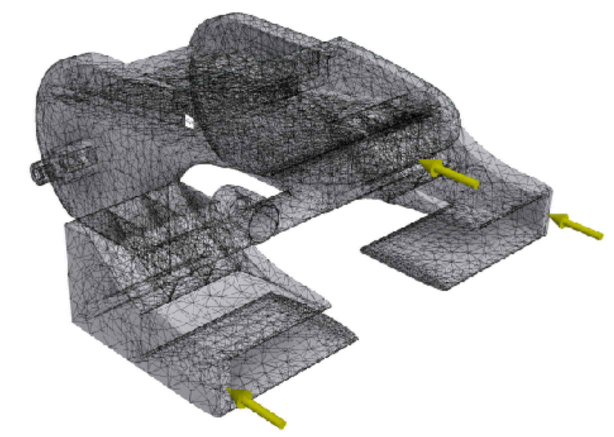
Increase by 1mm the support walls of the front axles.

Increase the tunnel Thickness by 1mm

*The comparison is between the FP5 and FP6 Model

(Simulation Mesh = Max. / Material mechanical properties = According to Denford, Prototypa and Abec357 / Yield strength)





Improvements

Minas, the designer of our team, is now learning the ANSYS software, which is known for its complexity. We estimate that by the time the design of the world finals car will be completed, the knowledge of the program will be sufficient to simulate and measure all the forces acting on the car with very little deviation.

Research and Development

Forces and Phenomenons

Downforce

In a moving vehicle, the ground effect is caused by low pressure zones beneath the car. They are occurred, if the velocity of the air moving under the car is higher of the speed of the air moving above the car. Then, due to an effect called Bernoulli effect, a low-pressure zone under the car is occurred. Thereby, there is a vertical force acting upon the car pushing it down. In addition, this kind of force can be caused in a spoiler of the car, if it is designed so, that the air below the wind must cover a smaller distance than the air above, therefore the air below it moves faster causing a low pressure zone under the wing. So, a force called airfoil downforce is occurred. However, in case of airfoil downforce, there is extra drag force caused, but not in the case of the of ground effect, as the air above the car does not get involved. We designed our car in such a way, that downforce is high enough to hold the car on the track and give more stability.

Diffuser - Bernoulli Effect

The diffuser is on the back of the car. It contributes to an even enhancement of downforce, with the form of ground effect, along the whole car.

Turbulences

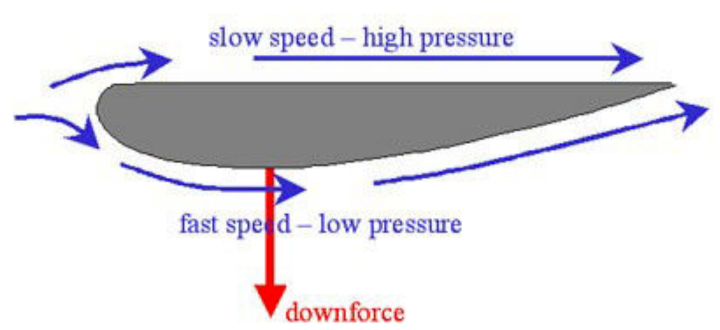
The turbulent flux of the air causes extra aerodynamic drag. However, using the vortex generators, we can use them for our own interest. We inserted those vortex generators on the front diffusers, in the place where the air has its minimal energy.

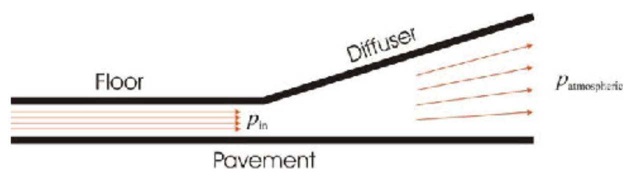
Coanda effect

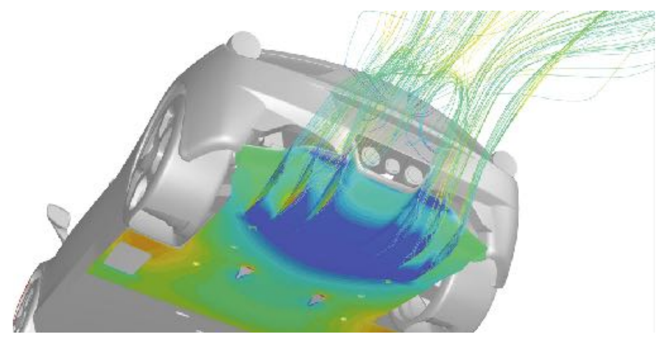
A fluid, which comes in contact with an angled area, tends to follow it's curvature instead of moving in a strait line. This happens with the difference in pressures between different areas of the model. This phenomenon is used on the whole car. That's because our car is only consists by curvatures. We took advantage of the Coanda effect while at the same time keeping the angle of the surfaces of the car, under the critical value of separation.

Stall effect

In fluid dynamics, stall effect is reducing the lift of a moving body, when the angle of attack of the fluid to the surface is changed. That happens when angle of attack exceeds a critical value. the most typical critical angle is about 15 degrees, the exact value depends upon the kind of the fluid circulating the solid.







Weight Distribution

The distribution of weight in the car directly affects its performance and behavior. That is why in motor racing, teams invest considerable amounts of money and effort to achieve the ideal weight distribution and center of gravity. We tried to design the car so that the center of gravity is as far ahead as possible, taking into consideration that the weight of the ampoule is equivalent to 50% of the total mass of the car. If the center of gravity was further back, there would be a chance that the car's nose would rise during the race start.

Furthermore, the forward shifting of the CoG contributes to the reduction of the load of each bearing. If the weight was mainly distributed to the rear wheels, then the two bearings would have to support greater forces. Assuming that the mass of the car is 75gr at the time of the race, that we have 4 ball bearings and that the center of gravity is just in the middle, each bearing would be loaded with 18.75gr. If the center of gravity was right on the rear wheels, then each of the two bearings would be charged with 37.5gr (100% increase).

In Formula 1 and all other motor sports, the center of gravity of the cars or bikes must be at the level where the resultant force is exercised. This is why muscle cars that have high grip (radial) tires and great horsepower make wheely at the start. They need very sticky tires and can not accurately follow the consecutive points of the curved track, which make a turn. This is because the force exerted on the road by the tires is at the level of the ground, while the CoG of the vehicle is extremely high due to the heavy weight of the V8 engine. That's why in wheely competitions, the front suspension of the cars is extremely elevated, making the front very high and creating moment of inertia rotating the car around the rear fat tyres.

Consequently, we made sure that the center of gravity of our car would be at the same height as the gas powered ampoule. That's why we think our car will be very competitive. If the center of gravity was low, the rear of the car would be lifted until exhaust gas was exhausted, causing huge aerodynamic drag, loss of acceleration and of course big shock during the rear impact to the racetrack.

Motorsport Research

Formula 1 is the most popular car racing amongst all motorsports. The cars participating in the race are designed with special attention to the underbody. Our team worked in order to improvise subject design feature and in specific to the diffuser.

Indycar is similar car racing taking place only in US. The sidepots and the fore airfoils are rather the major design features of these cars. In addition the racing rules are similar to "F1 in schools" competition. Our design team was inspired by subject design characteristics and tried to implement some of them into our car's design.

In the **EcoMarathon** racing the concept is the participating to the race cars to cover the longest distance with only one charge. Thus, one could see many different aerodynamic designs all aiming to improve the air flow and reduce the air resistance. Subject race is considered as a design tank for F1 makers but for our racing car too.

NHRA drag racing is very similar to "F1 in schools". In both competitions the cars have to cover a certain straight distance at the minimum possible time. Therefore the details at the starting position are very important. Our team examined a variety of different acceleration methods through ProMod and Top Fuel, designs that are participating in NHRA Drag Racing, trying to further improve our team's model.

NASCAR is the most popular race within US motorsports. The design of utilized cars is quite different compared to "F1 in schools" mainly due to their moderate aerodynamic factor. Thus, subject design features did not affect our team's

Research and Development

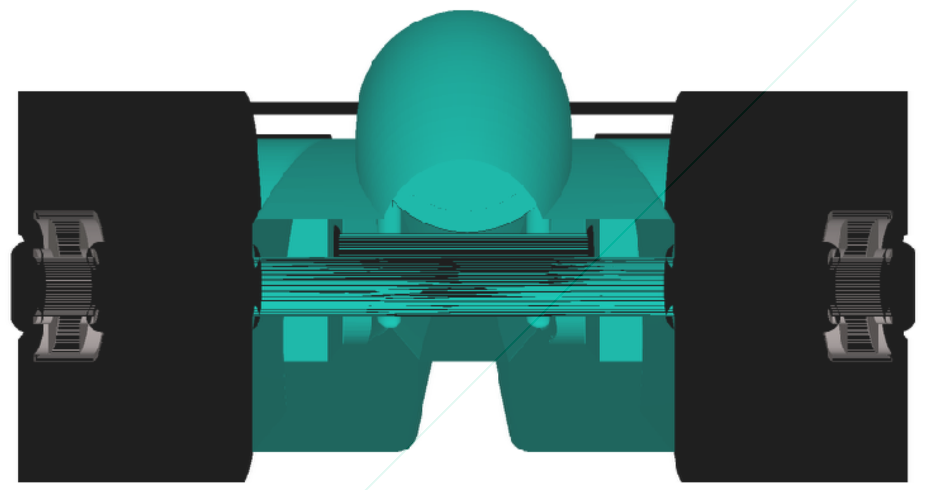
Design Evolution

Design 1

This Design was used on the FP1, FP2 models

Parts per car:

- 4 Wheels
- 2 Axles
- 4 Bearings



Advantages

- Simple
- Very durable
- Easy to manufacture

Drawbacks

- Not aerodynamically efficient
- High moment of inertia
- Very heavy

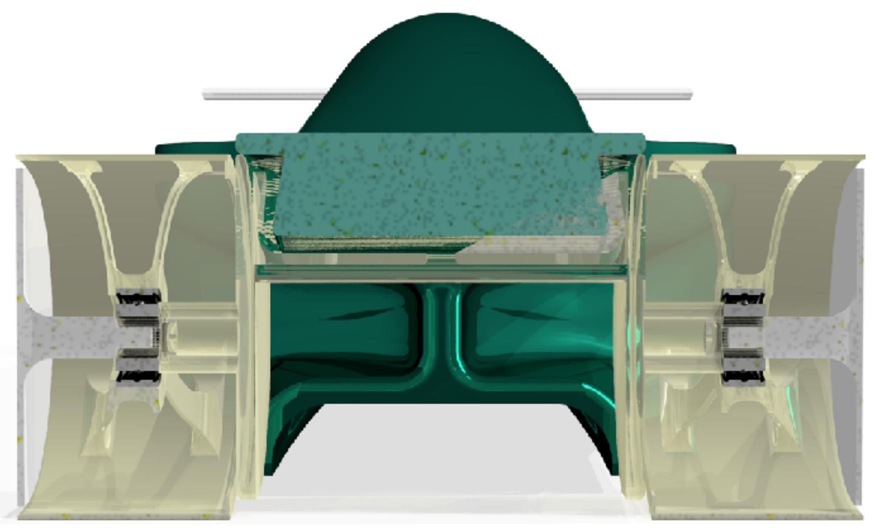
Philosophy: *Make a simple and durable design based on the winning cars of that time (2016)*

Design 2

This Design was used on the FP4, FP5R1, FP5R2, FP5R3, FP5R4, FP5R5, FP5 and FP5GBE models

Parts per car:

- 4 Wheels
- 4 Wheel caps
- 4 Axles
- 4 Bearings



Advantages

- The minimum moment of inertia
- Aerodynamically efficient

Drawbacks

- Heavier
- Not stable
- Fragile wheels and caps

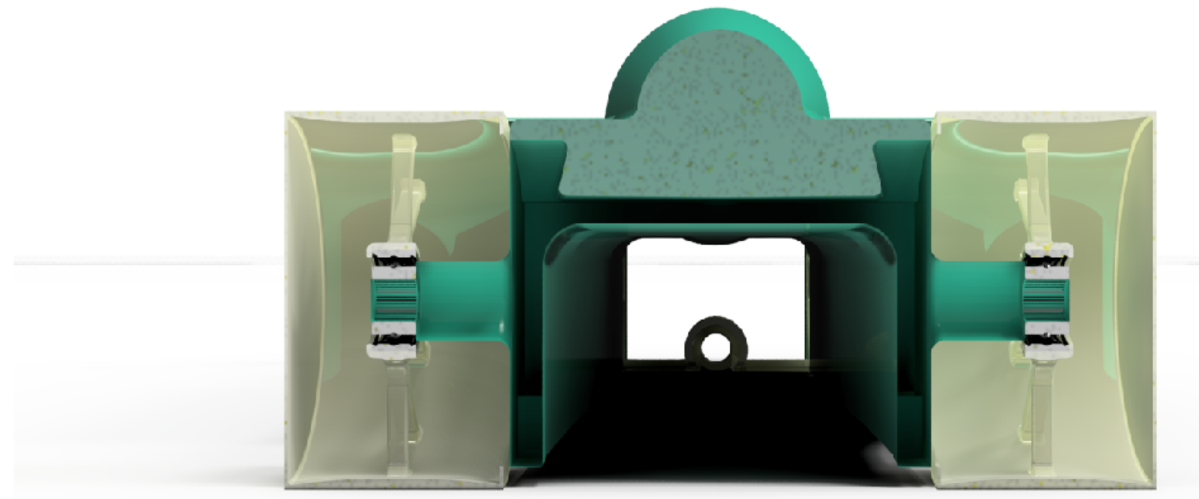
Philosophy: *Make the most aerodynamically efficient rolling system without sacrificing reduction of moment of inertia.*

Design 3

This Design was used on the FP4, FP5R1, FP5R2, FP5R3, FP5R4, FP5R5, FP5 and FP5GBE models

Parts per car:

- 4 Wheels
- 4 Axles
- 4 Bearings



Advantages

- Less complicated
- More durable
- Cheaper to manufacture

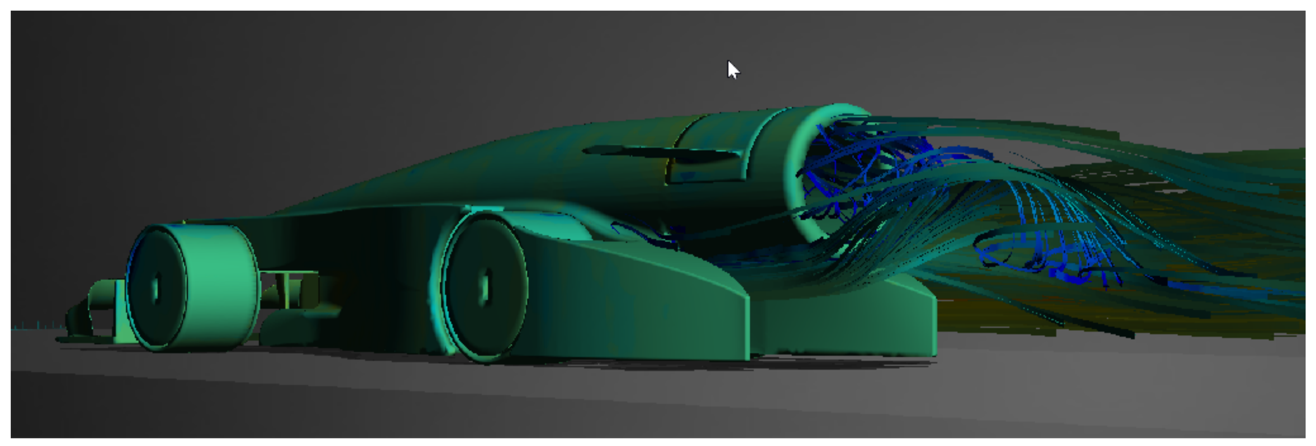
Drawbacks

- Increased moment of inertia

Philosophy: *Make a simpler and more durable design without compromising performance.*

Innovation

The LERD (Lost energy recovery design) system which is used on the FP5 and FP6 prototypes, is one of our innovations. To understand it's function, the Bernoulli effect has to be explained. The low pressure air in the rear part of the Bernoulli tunnel under the car, in addition to the high pressure gases generated by the canister, guides the air exiting the Bernoulli tunnel to "stick" right behind the canister. The gases exiting the canister force the low pressure air far away and propel the car with higher acceleration. This way we exploit even further the gases' kinetic energy without using a LERS device. In the middle of the race, when the gas is fully used, the LERD design makes a huge difference to the drag, by reducing the low pressure regions behind the car.



Reflex-Training

Using the Williams racing app for our smartphones, we tested during 2017 and 2018 our reflexes, before the 2 test days, when we had available the whole track and the triggering system for further training. 5 months after the start of the season, the chosen member reduced his reflection time by 50ms on average, which is a 25% reduction over the benchmark we had set 5 months before. Filippos, who is responsible for the website development and the graphics of the portfolios, made a reaction time measuring robot using LEGO mindstorms. The robot, combined with the Williams app, helped us choose the appropriate member for the reaction races. As a result, we increased the probabilities of a win in the knock-outs and decrease those of a DNF

We noticed during training, that the reaction times which the team member posted in the afternoon, were slower than the ones which were posted in the morning. We researched further to find the factors that affect reaction the most. We concluded that the main cause of the instability in our reactions was the energy wasted to digest food. We noticed, after a test in the first practice of the FP5, that times before the meal were 25ms slower on average. In the end, the team member responsible for the reaction time agreed not to eat during the period of the manual and knock-out races.

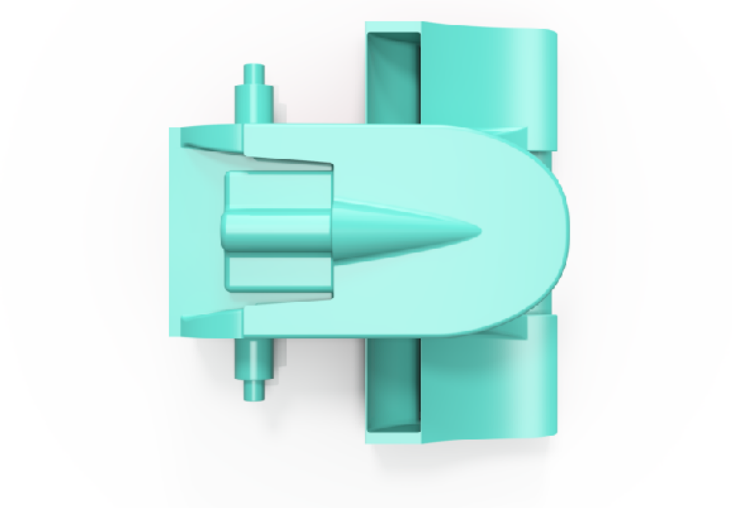
Research and Development

Choosing the final design and building materials

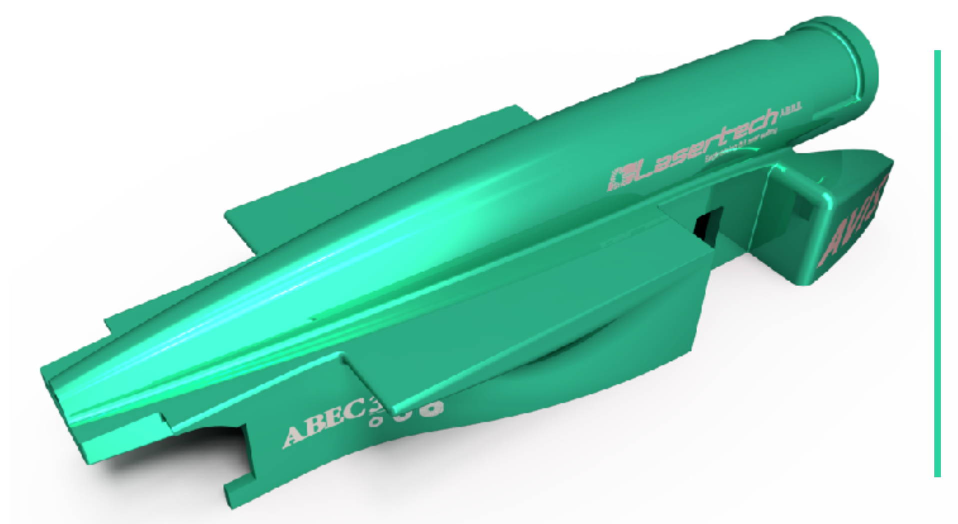
In total we designed and constructed three different nosecones, two versions of the front spoiler, three versions of the rear spoiler, three different bearings and three wheel designs. To choose the best option, we performed several tests on our track, keeping a record of the times. We tested all the possible combinations of the body parts while at the same time we practice our reaction times as well.

Rearpods
Unlike other parts of the car, their goal is not to redirect the air flux but its smooth flow over their surface

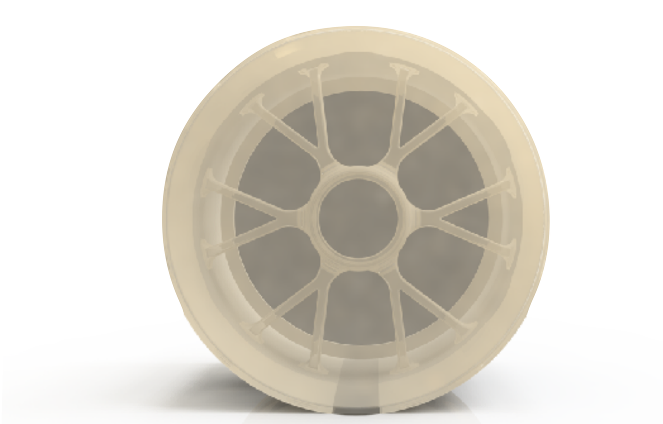
Underbody tunnel
The underbody tunnel is wider, taller and longer vs our previous model equipped with tunnel. We managed to reduce the frontal area of the car, raise the CoG further up and shift the centre of aerodynamic pressure further to the front, which is the key to making an efficient aerodynamic design with minimal rear wake. Of course this added to the already high complexity of the construction. Furthermore the tunnel produces low pressure using the Bernoulli effect, which in addition to the high pressure on the top, produces increased amounts of downforce with the car acting as an inverted airplane wing. Downforce is needed to make the car “stick” to the ground during the start, when the car reaches the peak of instability during a race. The key is to make a car with a very high Downforce to Drag ratio. We have accomplished that by keeping a good centre of pressure and avoiding flow separation in the rear.



Nosecone
Its shape is similar to that of the Ferrari F138. Its target is to direct the air flow below the car and consequently reduce drag force.

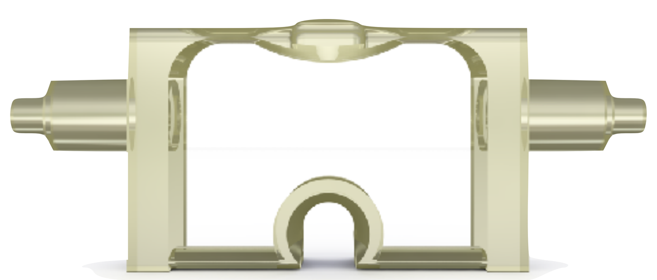


Body
The body of the car is build so that the centre of its mass is moved a little bit to the front. This contributes to its stability during the race start and an even weight distribution, same in all the four wheels, and on the same time to the decrease of friction in the bearings.



Wheels
We designed the wheels so that they have minimum inertia. Therefore, less energy, of that available from the gas capsule, must be consumed to rotate the wheels. Thus, there will be more kinetic energy available for the car. The design concept of the Formula 1 wheels is our basis for the design of our wheels. We placed the bearing at 7.75mm from the wheel contact patch so that we fully exploit the contact patch of each wheel and reduce the pressure acted upon the track. This technique is being applied on high speed downhill ski. The slow-motion footage from the tests we performed on the FP5 showed that the wheel barely rotates during the race, which makes the reduction of surface drag very important.

Bearings
We have chosen to use one instead of two bearings on each wheel as friction is reduced by 50%. Despite the fact that the bearing’s purpose is friction reduction, the component itself creates friction forces, at a lower scale. For instance, if the friction of one bearing is $F = 0.1N$ then by using two bearings the friction is doubled to $2F = 2*0.1N = 0.2N$. So we used four of them, to succeed having half of the initial friction.



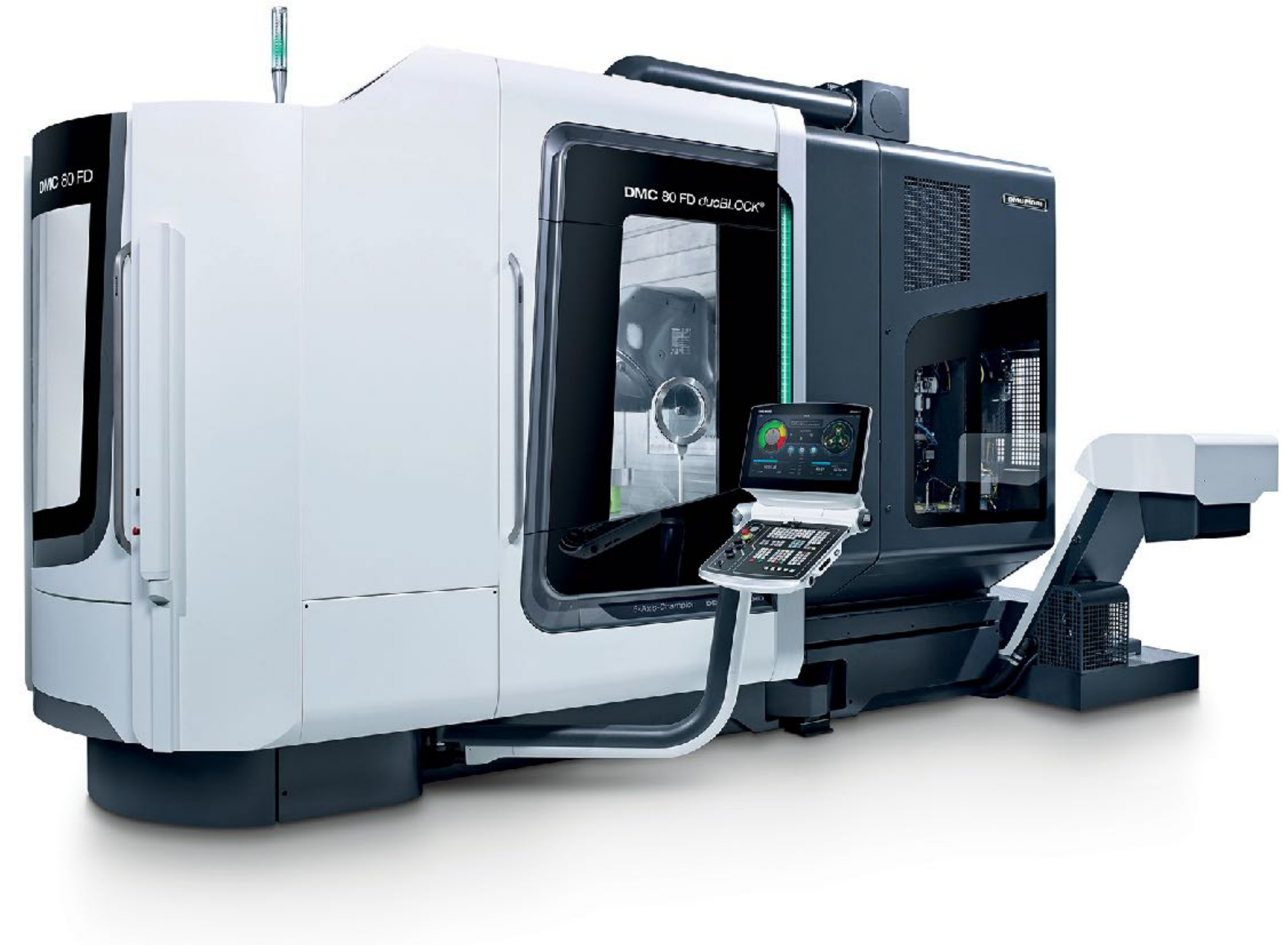
Rear Wheel Support System (RWSS)
RWSS purpose is to support the rear rolling system of our car. One mistake in the design or it’s construction is enough to destroy our laptime. We tried to make it as unyielding as possible because the RWSS of the PF5 model was flexible in the pick-up points of the axles and this changed the “suspension” geometry by giving the wheel about 2 degrees of positive camber and a little toe out. We avoided that by increasing its rigidity and making it of rectangle instead of U shape.

Construction

CAM

A company named Lasertech reached out to us, letting us know that they would like to sponsor the CNC work needed to construct the car. We visited their headquarters where they showed us their state-of-the-art 5-axis DMC branded CNC machine. This was a huge relief for us, because working on 5-axis would make the cut a lot faster and simpler (exemption: G-code). The G-code when programming in 5 axis is a more difficult because you need to program the tool to move to 2 more degrees of freedom. On the other hand nowadays artificial intelligence can program the cut with ease and rapidness. We made the model by cutting the top part and then changing side by 180 degrees. This way the tunnel is cut. The first tool we used was a 5mm Tinker and Futz drill for the basic cuts and a 0.5 mm in radius circle, thus, ensuring the perfect finishing of the model without the further need of finishing with a sandpaper.

Lasertech A.E.B.E. Engineering & Laser cutting



3D printing

For the construction of the rest of the parts we reached out to Prototypa, which specialises in 3D-Printing. We chose after our research to follow the path of 3D-printing for several reasons. Firstly, Prototypa sponsored all the prints we needed for our cars. Secondly, resin which is used to make all of our peripheral parts, is very easy to use, stable and rigid. On the other hand it's not so flexible, but we compromised in order to complete the car earlier. Finally, 3D printing, in contrast to CNC work, is a lot faster, allowing us to have our parts ready in a period of 3 days after the date of order. Last but not least, Prototypa owns the most accurate 3D scanners and 3D-printers in Greece. That allowed us to print our parts with a accuracy of 13μm, just as big as the most state of the art transistors used in computers (!)

Paint

For the finishing and the paint of our car, we reached out to Kalfakis modeling, who specializes on the painting with a air-gun. The Painting and finishing procedure had the following stages: Initially the Body was sanded with a very fine sandpaper, so that the original dimensions wouldn't be altered. Then, the body was covered with the first coat of sand, which makes the body more robust. The second layer of sand was applied before we put it in the oven to make the sand stick to the original polyurethane body. Following to the oven, the first coat of paint was applied with a special gun. We used a type of paint widely known amongst the hobbyists. It consists of a very thin layer of paint which is also aerodynamically neutral. It also secures the isolation of the body protecting it by humidity changes during the race days. The next step was to apply the last coat of paint and let it dry inside a temperature and humidity controlled environment, a clean-room. Finally, we applied a special kind of wax, reducing surface drag further. It also made the car a lot more appealing to the eye by making it reflective.

Testing

The philosophy behind the testing of the previous FP5 model was to 3D print as many different designs as possible and measure the difference in race times. This was carried out with huge success. The following tables contain the results of the tests.

Our design team concluded that the factors which affected performance the most were:

- Weight
- CoG (centre of gravity)
- Friction (tether line guides - Bearings)
- Aerodynamics.

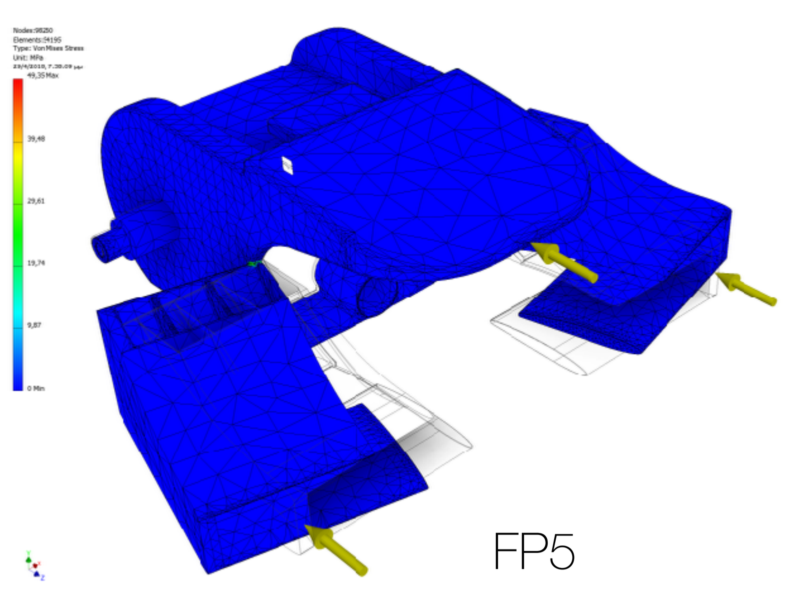
Test number	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6
Parts used	NCr1, AFr1, B1	NCr2, AFr1, B1	NCr1, AFr2, B1	NCr1, AFr2, B2	NCt2, AFr1, B1	NCt2, AFr1, B3
Race time	1,165	1,193	1,156	1,102	1,086	1,011
Consclusion	-	Nosecone 2 is slower	Airfoil 2 is faster	Bearing 2 is faster	Nosecone 3 is faster	Bearing 3 is faster

After the semi finals we chose to build a new car from the ground up again, the FP6. Before starting with the customary brainstorming procedure, we introduced a specific design protocol according to the results of the semi finals and the FP5 testing. The FP6 design protocol is shown in the table below.

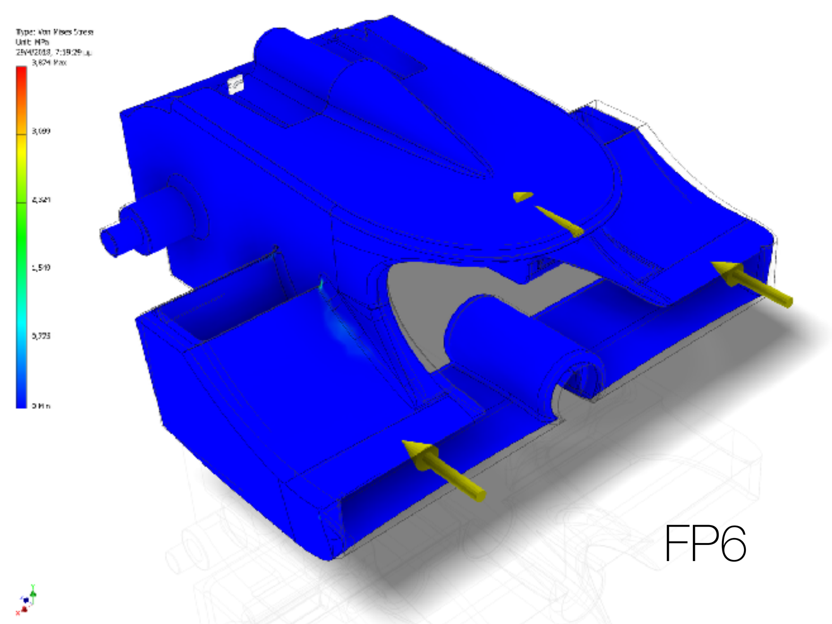
Priorities	1. Rigitity	2. Regulation	3. Weight	4. Friction	5. Repairability
1st	Wheels	Tether line guide	50.1g.	Tether line guides	Wheels
2nd	Axeles	Tether line guide	CoG	Aerodynamics	Axels
3d	Airfoils	Wheel diameter	30mm height	Bearings	Wings
4th	Nose cone	Airfoil height	75F/25R	Wheels	Nosecone

Reaction Progess	Week 1	Week 2	Week 3	Week 4	Week 5	Week 7	Week 8
Day 1	0,23	0,205	0,192	0,198	0,175	0,184	0,178
Day 2	0,215	0,194	0,186	0,175	0,189	0,197	0,166
Day 3	0,248	0,2	0,187	0,184	0,17	0,168	0,155
Day 4	0,251	0,186	0,195	0,199	0,182	0,183	0,168
Day 5	0,201	0,292	0,194	0,176	0,179	0,195	0,158
Day 6	0,214	0,22	0,199	0,204	0,182	0,175	0,166
Day 7	0,198	0,186	0,21	0,184	0,172	0,165	0,159
Average	**0,22243**	**0,21186**	**0,19471**	**0,18857**	**0,17843**	**0,181**	**0,16429**

Reflexes Result



FP5



FP6

During the FP5 testing sessions we noticed that the weakest element of our car was the front nose cone, which broke 3 out of 3 times when we tested the model on the track. Another weakness was that the wishbones, that held the wheels into position, were only 0.5mm thick. The FPt2 (test 2) prototype had updated wheels and front nose cone. What we had forgotten, was to simulate the model before the races. During the semi finals, the stiffness of the 2 front-pod segments was not enough to withstand the huge forces during the impact with the deceleration system. Moreover, the wishbone, with a thickness of just 1.5 mm, broke during it's impact with the "flying" (from it's impact with the towels) front wing. This problem resulted in 20 points penalties.

The target of the FP6 is to drastically improve the rigidity and repairing capabilities of the previous model. To accomplish that, we introduced a revised nose cone, body and rolling system designed from the ground up. The main problem of the FP5 was the front pods. They were held in place by a 20.25 mm^2 joint. The revised FP6 front nose cone has a total support area of 166 mm^2, in addition to the rigidity that the front wing offers, resulting in a drastic 600% improvement. The FSI studies we have carried out, showed that under normal conditions, the new front wing has the necessary rigidity to keep it from breaking during the races.