PORSCHE CAYMAN – 981 GT4

AERODYNAMIC DEVELOPMENT

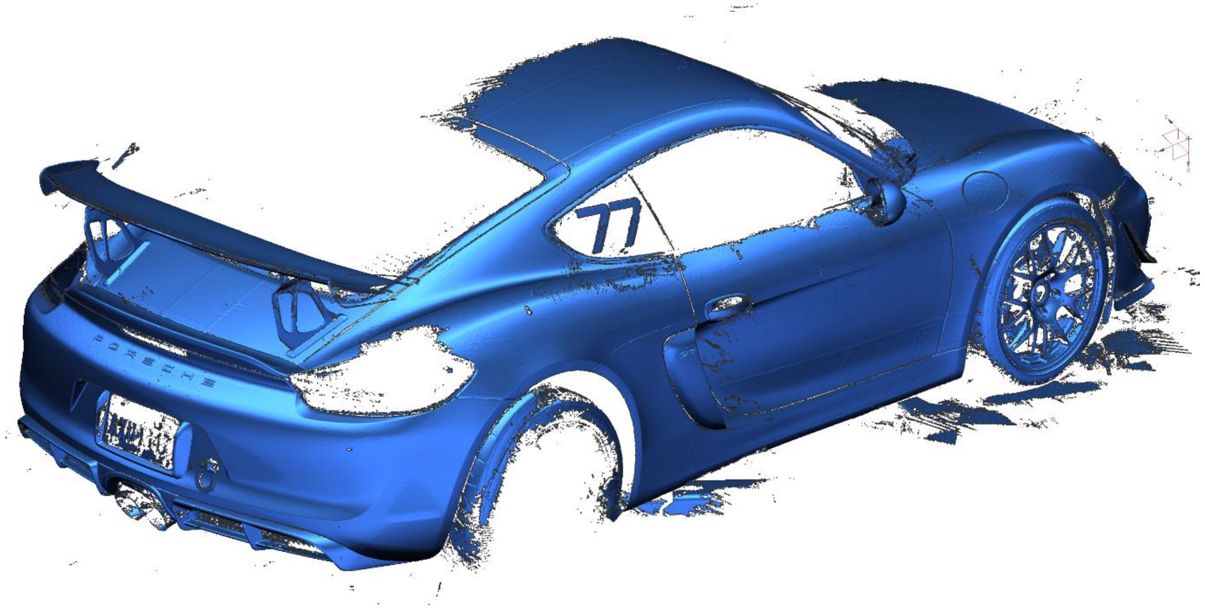
OVERVIEW

This is an informative packet on the Verus Engineering aerodynamic development of the Porsche 981 GT4 Cayman.

SCANNING THE CAR

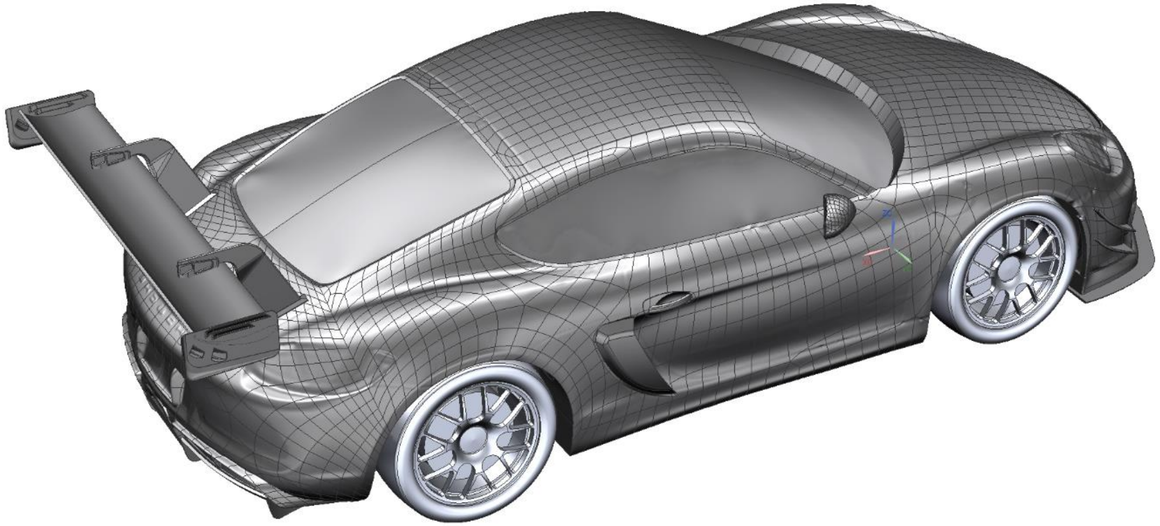
Scanning the car is used for 2 main purposes during development

1. Creating CFD Model
2. Using the scans for proper fitment of the manufactured components

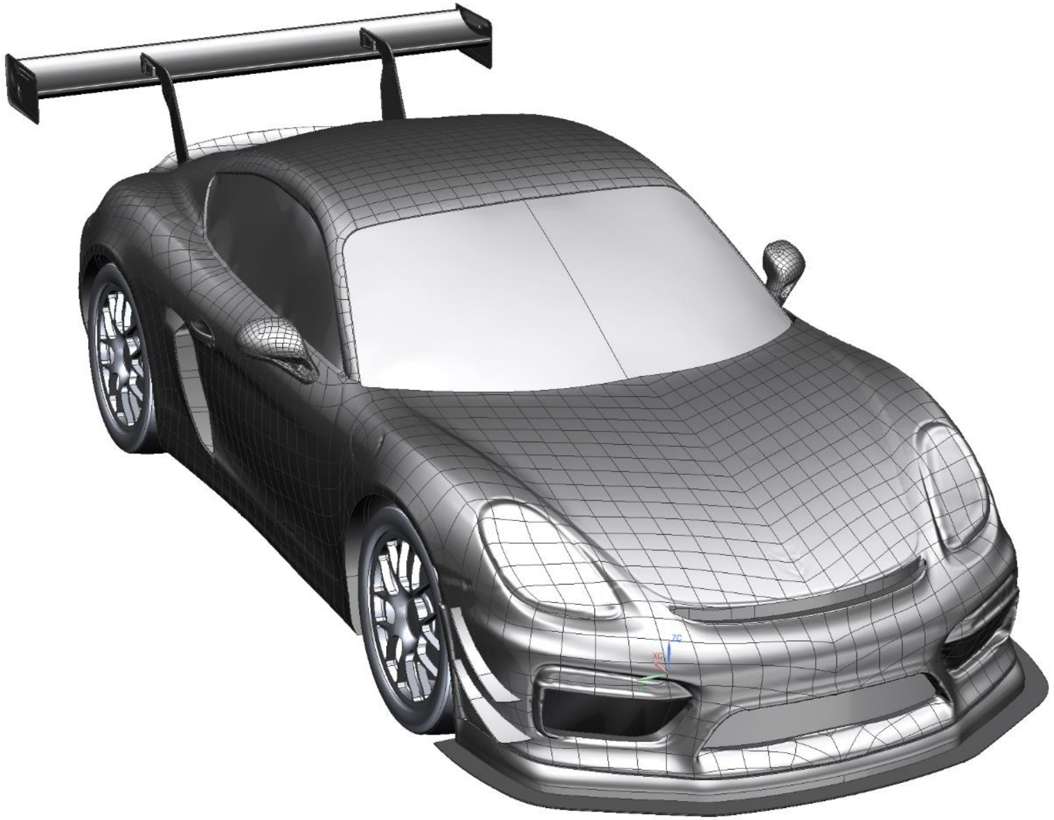


CFD MODEL

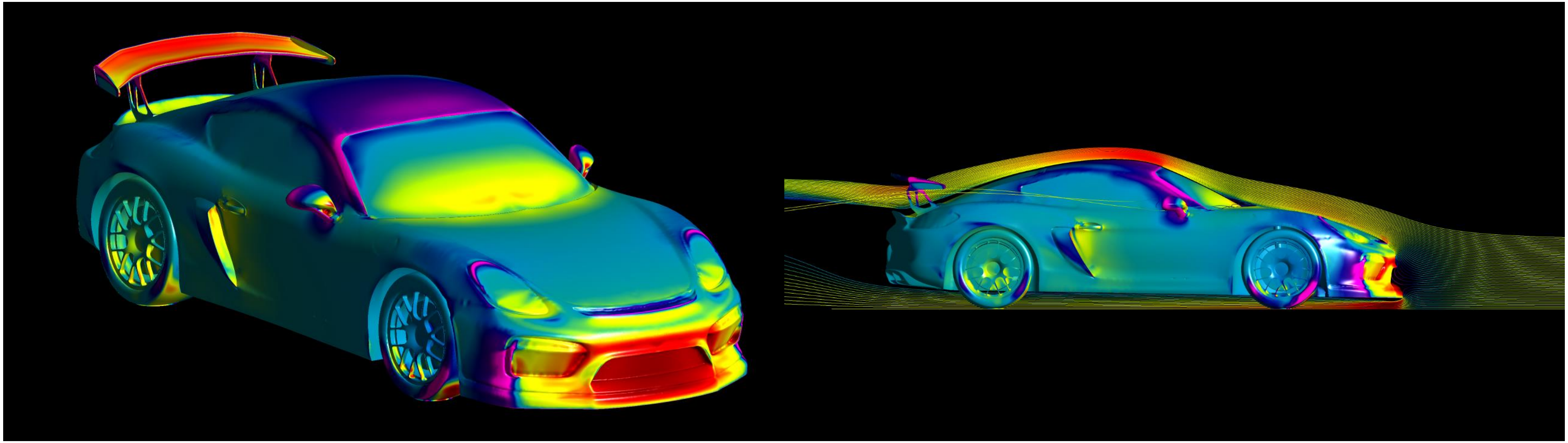
Creating a CFD model from a scan is a long and tedious process. This is done with the combination of scanning software and CAD. This is the real bottleneck of developing an aerodynamic package for a scanned vehicle.



FINAL CFD MODEL



BASELINE



Analyzing the vehicle’s baseline is the first step in the development. This gives our team the starting point and locations where improvement can be developed. From there, we can make incremental changes while watching how these changes impact drag, downforce, and aerodynamic balance.

DEVELOPMENT GOALS

The goal that we set out to achieve was an aerodynamic package that had good downforce for heavily tracked Caymans but was also very street-able. Vehicles that are street-able need to watch ride height and all underbody aerodynamic components. The main concerns for street-ability were the front splitter and diffuser strakes.

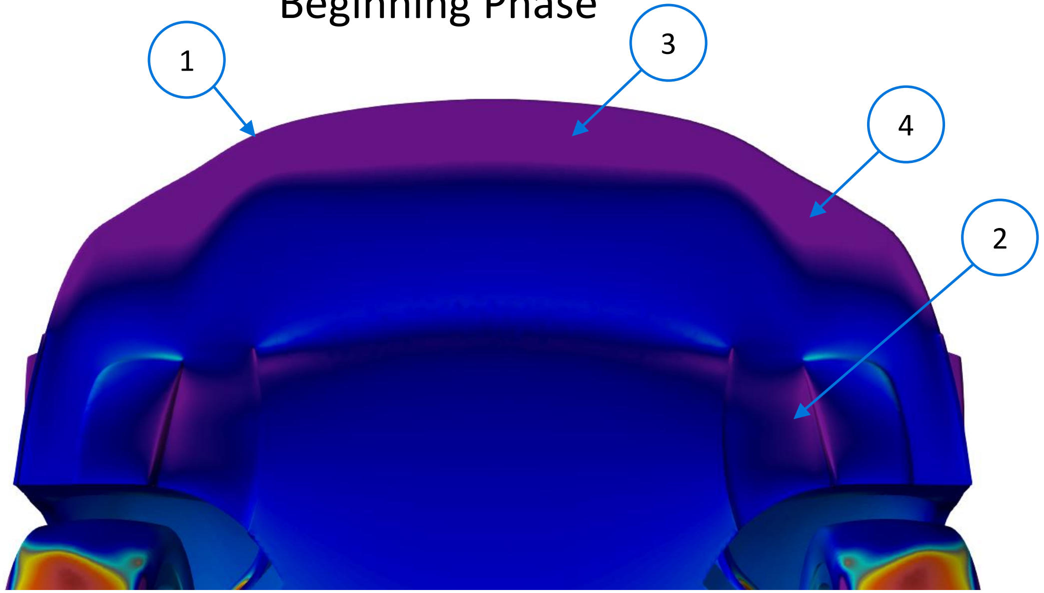
Front Splitter:
The front splitter needs to be as short as possible while still creating enough downforce to balance out the rear wing. Having a short splitter means it is less likely to hit objects on the street and the vehicle can be setup with a lower static front ride height. The air dam also needs to be short to keep the splitter high enough off the ground to not have an issue driving.

Diffuser Strakes:
Diffuser strakes can add a substantial amount of performance gain to the rear diffuser. However, they hang low on the rear of the car. To ensure this will not be an issue on the street, we made them out of a hard durable plastic. This will ensure proper function of a strake while not being concerned with damage by road obstacles.

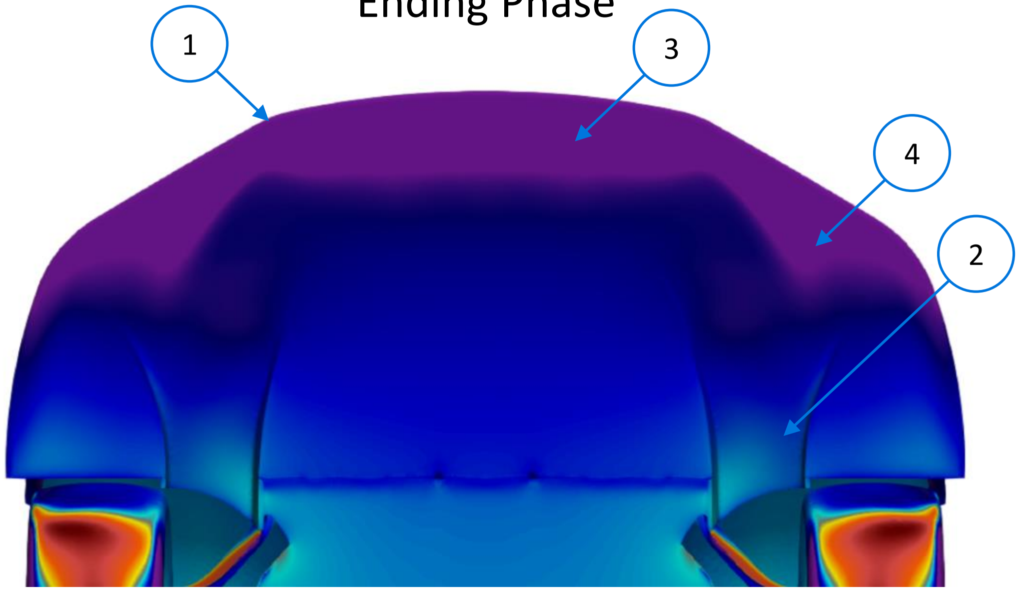
DEVELOPMENT PHASE

From the stock analysis, we went through 22 major design changes not including some minor changes in between.

Beginning Phase

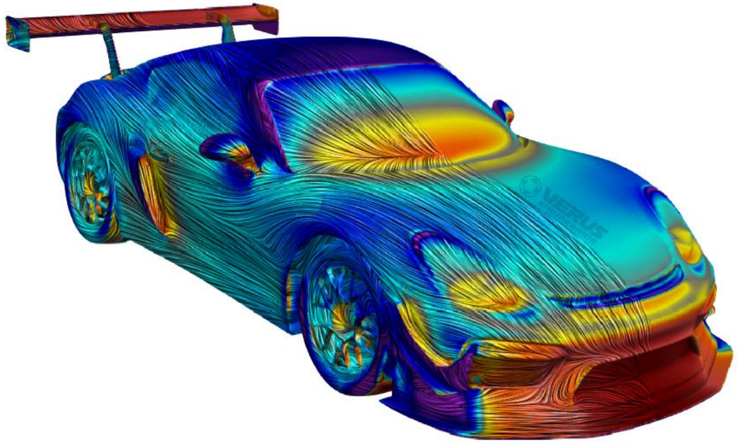


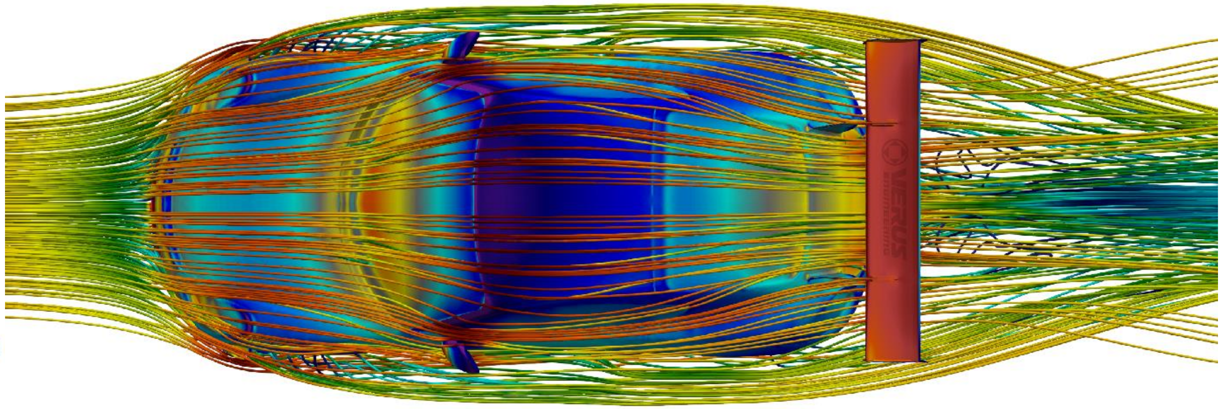
Ending Phase

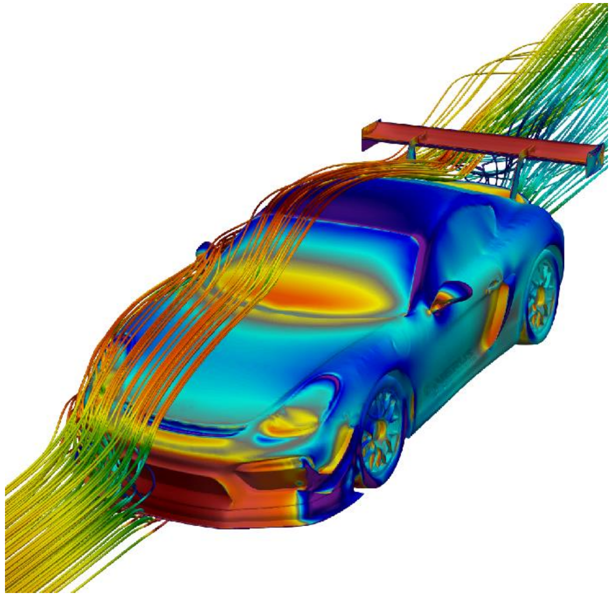


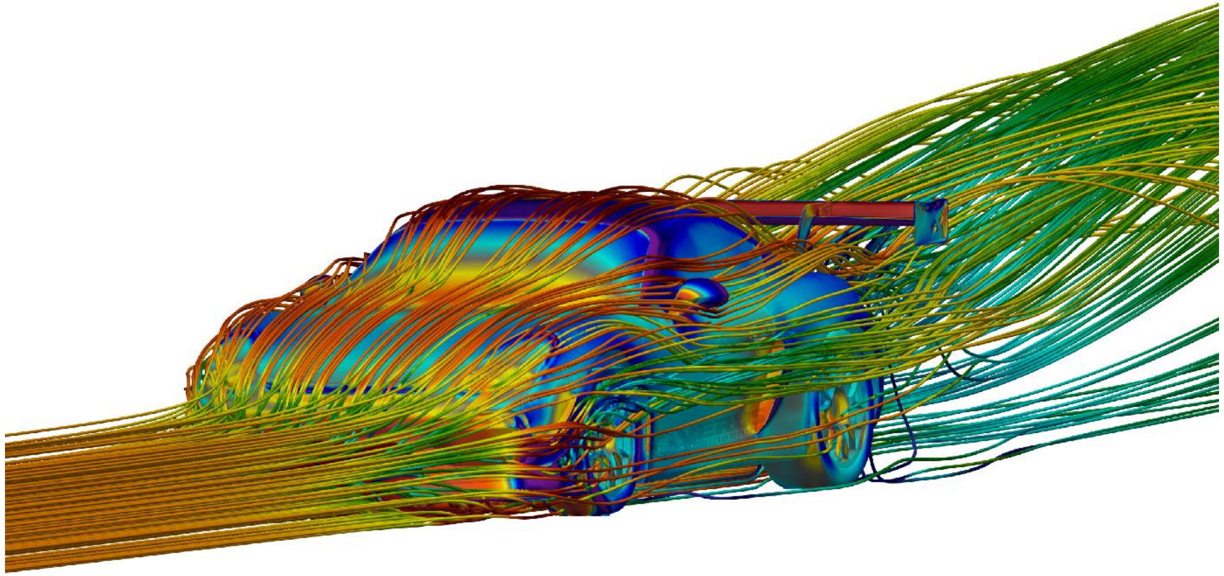
1. The shape of the overall splitter changed throughout the process to maximize downforce while keeping the splitter higher off the ground.
2. Factory diffusers replaced with much larger and more refined to maximize downforce.
3. Low pressure in the center was gained by refining the design of the underside of the splitter.
4. Low pressure gained on the side of the splitter by the new diffuser designs.

FINAL DESIGN





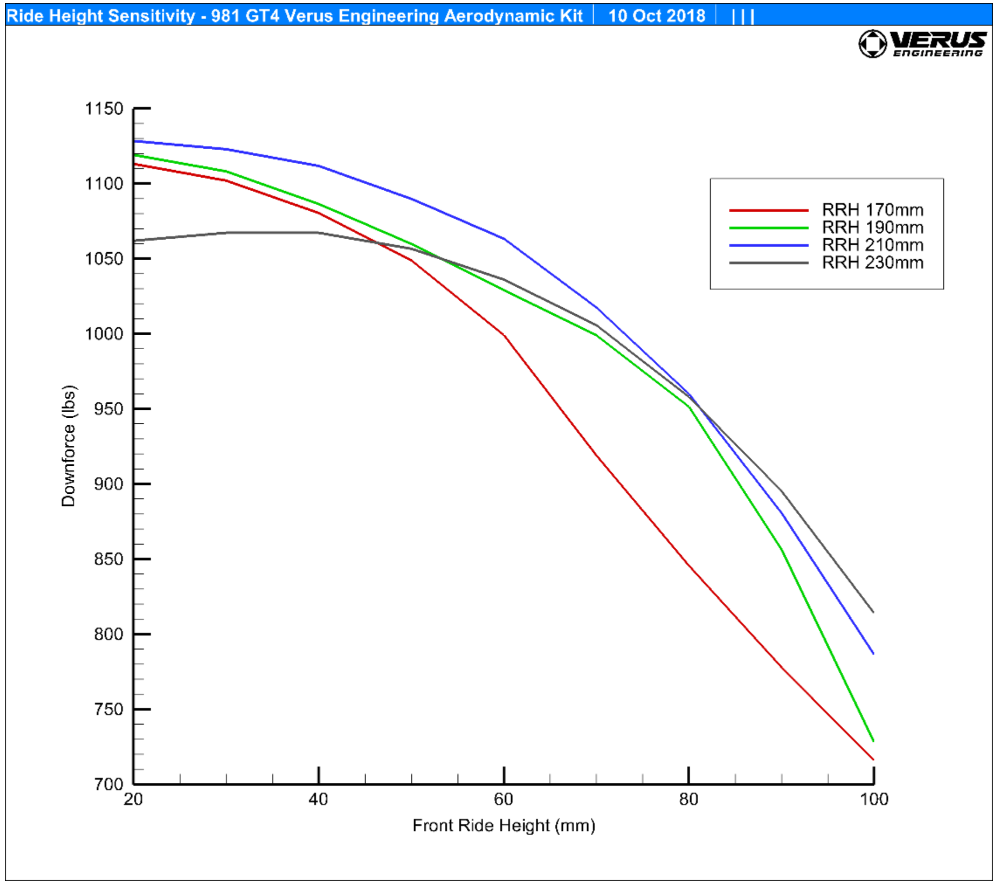




The whole system met our development goals, especially for a street-able, high downforce setup. The front splitter was kept to a minimum length with help from the front diffusers and dive planes. The rear diffuser strakes are designed to flex when impacted and also kept them as high as possible to the chassis without negatively impacting performance. The rear wing airfoil and endplates were optimized for maximum performance with a low drag penalty. Each and every component was developed to work with each other in harmony for the best aerodynamic performance available in such a package.

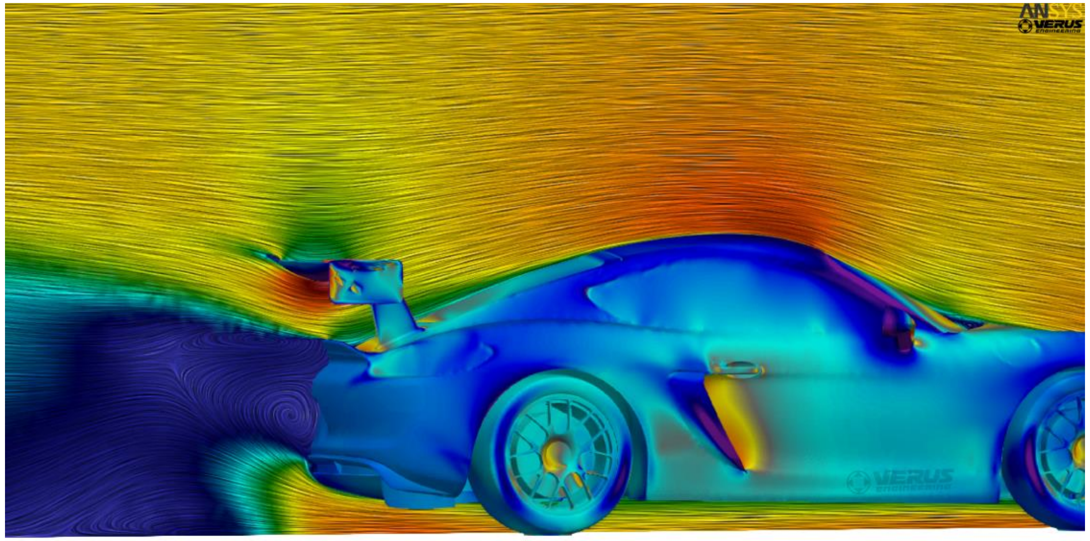
RIDE HEIGHT SENSITIVITY

One major issue with vehicles that create large amounts of downforce using the underside of the vehicle is ride height sensitivity. We studied this during development and a final ride height sensitivity map was developed before moving to prototyping phase.



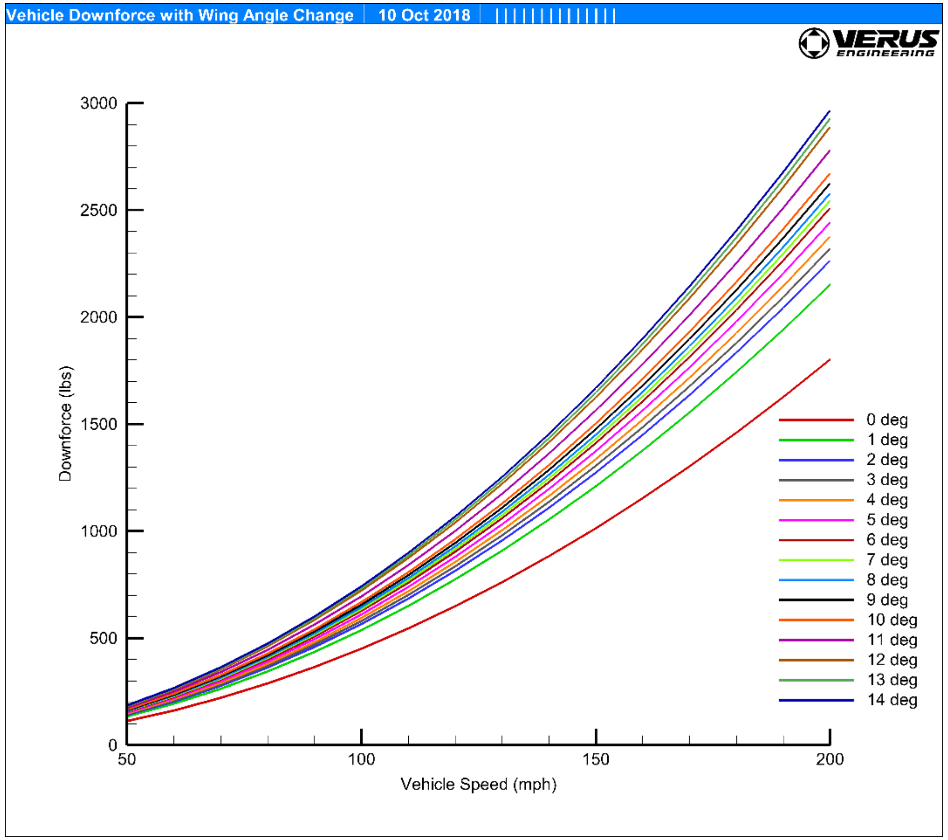
RRH = Rear ride height

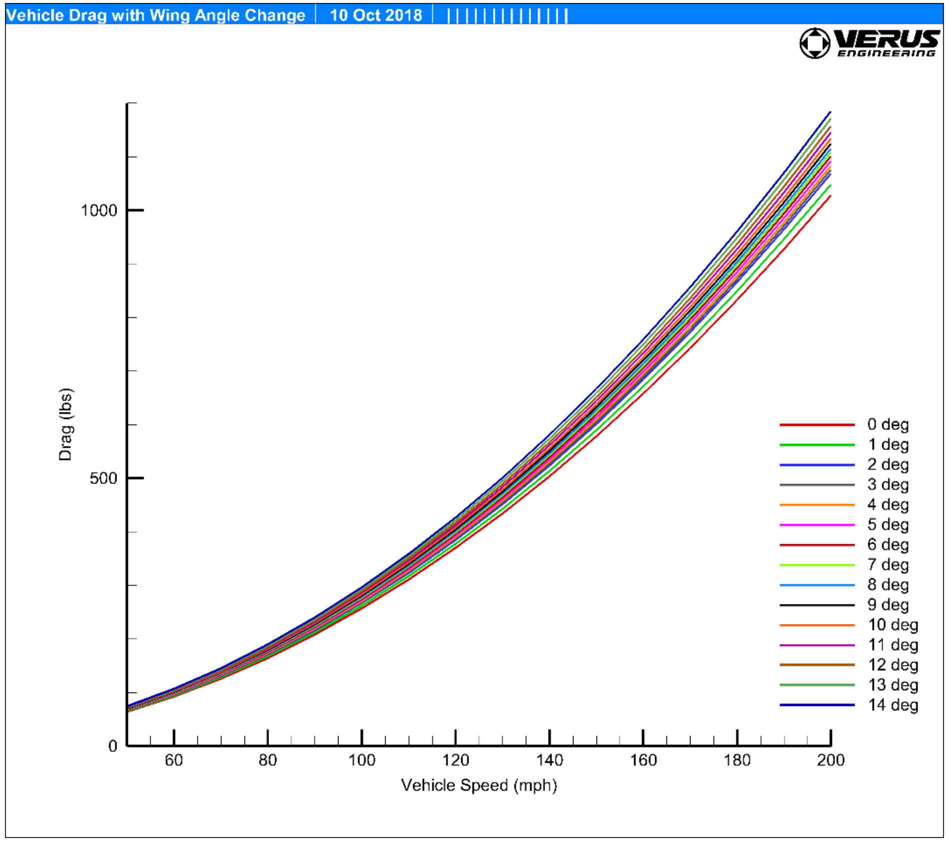
The ride height map is fairly standard looking with nothing abnormal to throw any red flags at the design. This map will also help setup the car at the track.



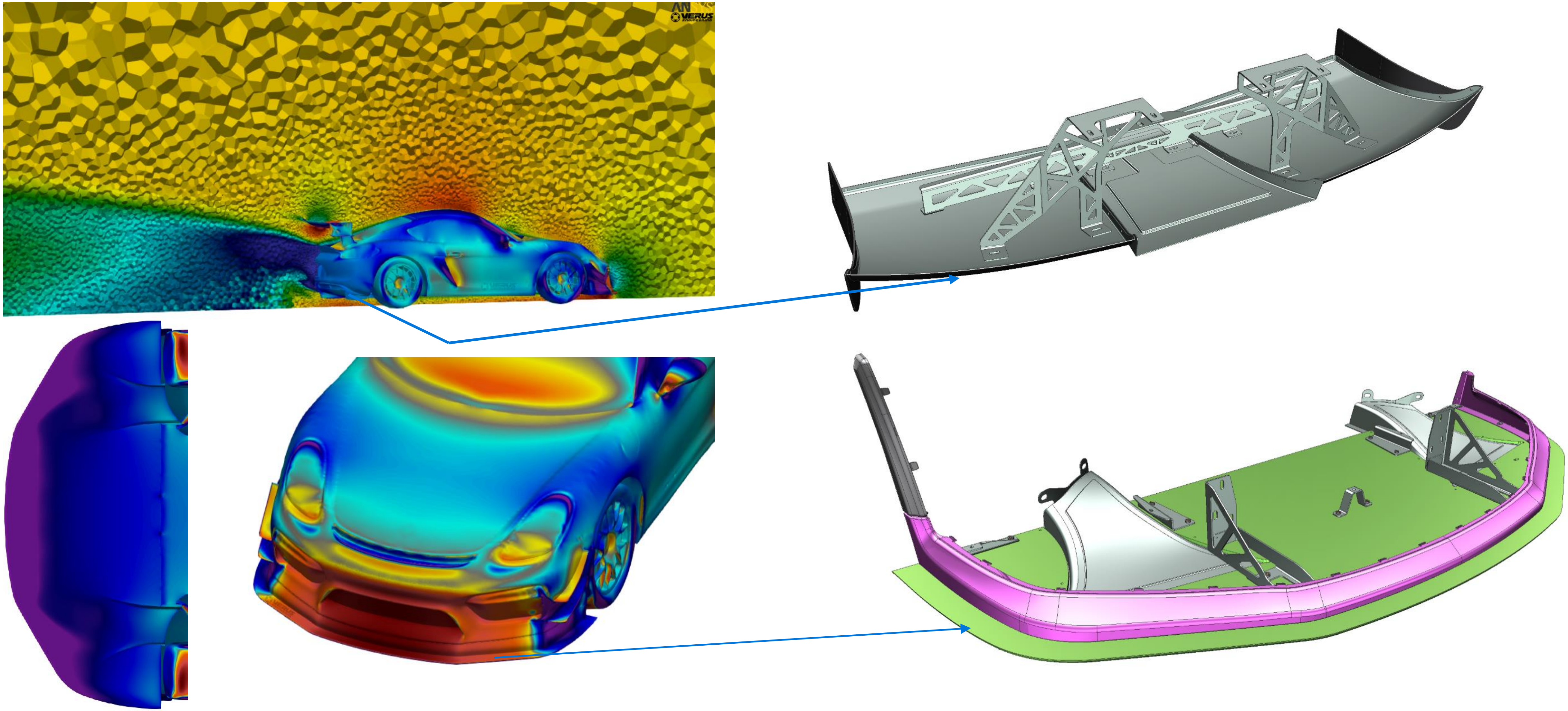
PERFORMANCE

The downforce and drag of the total car is in the maps below. Each color plots a different wing angle, but at a fixed ride height of 90mm FRH and 205mm RRH measured from the front splitter to the ground in the front and from the rear diffuser to the ground in the rear. Also note the factory car made 140 lbs of lift, which meant we had to overcome that lift to just start to make downforce.

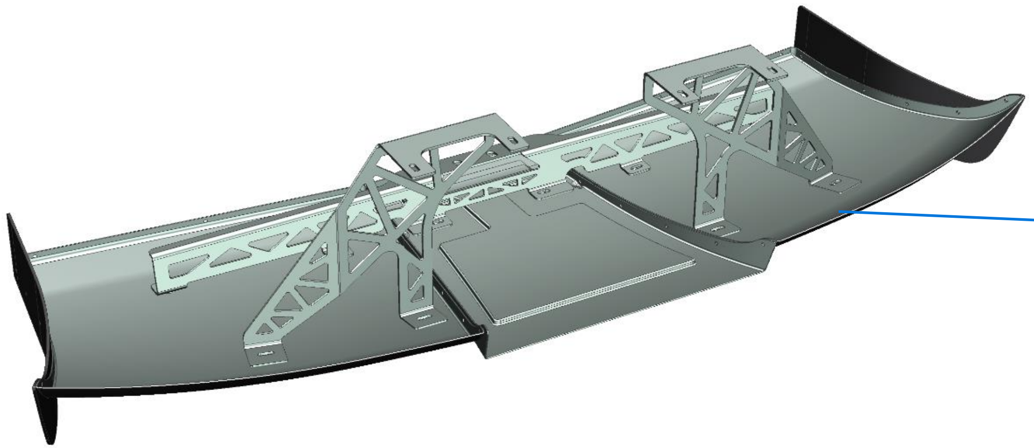


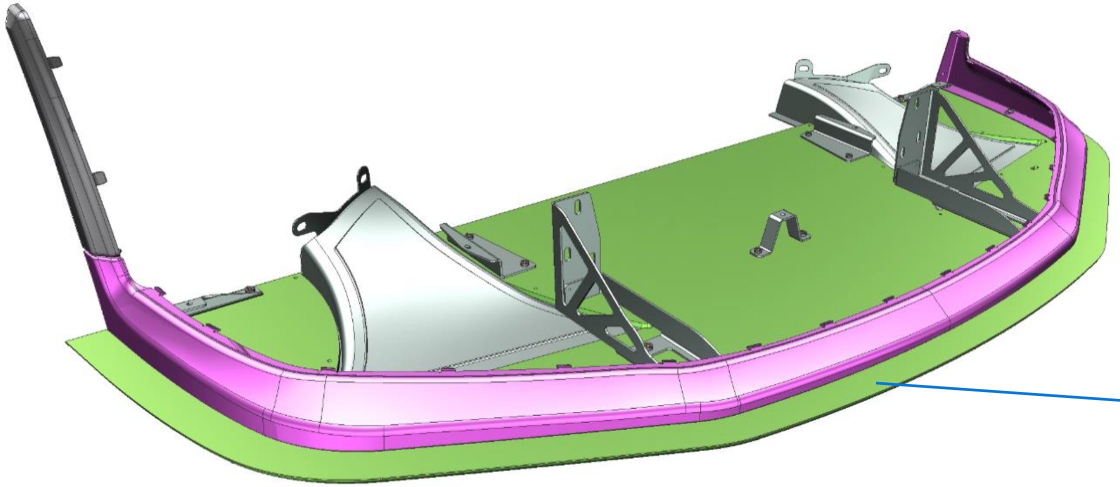


FROM CFD TO MANUFACTURING CAD



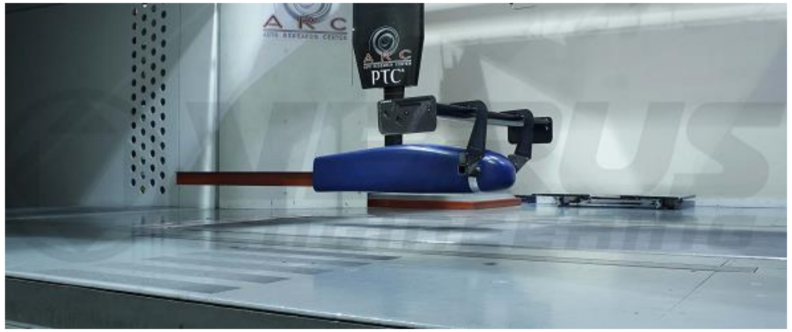
FROM MANUFACTURING CAD TO PROTOTYPES



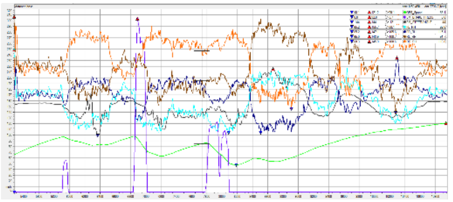


VALIDATION TESTING

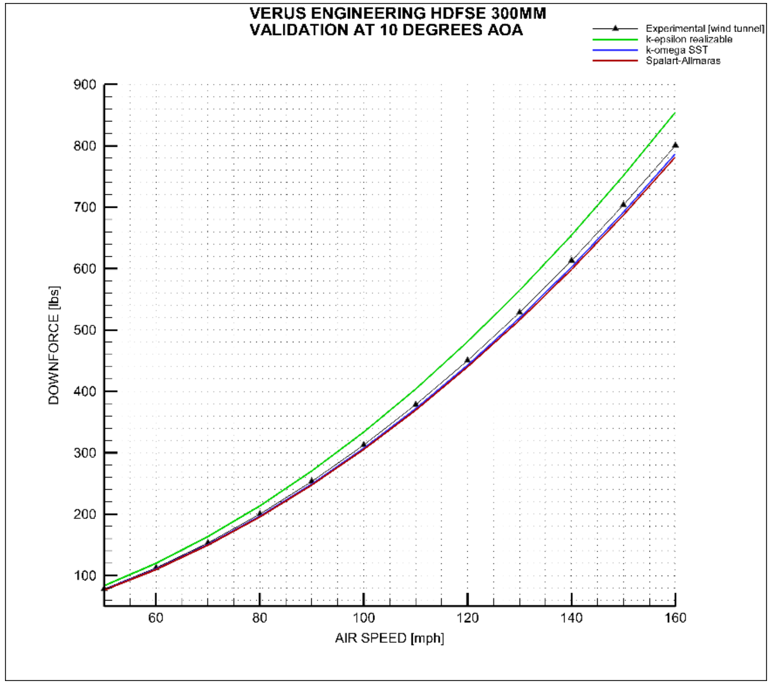
At Verus Engineering; we have spent a significant amount of effort and time validating our CFD testing. Computational Fluid Dynamics (CFD) can be ran incorrectly; we take great pride in running CFD as accurately as we can to simulate real world conditions. Below is a list of validation we have done to date.



- Wind Tunnel Validation on our 300mm Wing
- Laser Ride Height Data on Track
- Strain Gauge Analysis on Uprights (To Validate Wing Forces)
- Coast Down Testing on Various Vehicles
- Tuft Testing
- Flow Visualization Testing
- Benchmark CFD Cases

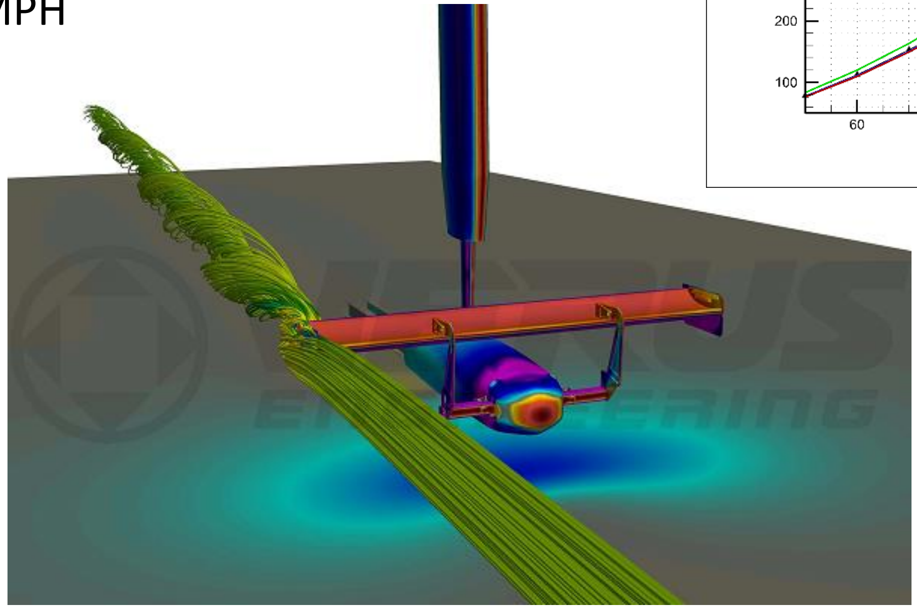


VALIDATION TESTING – WIND TUNNEL



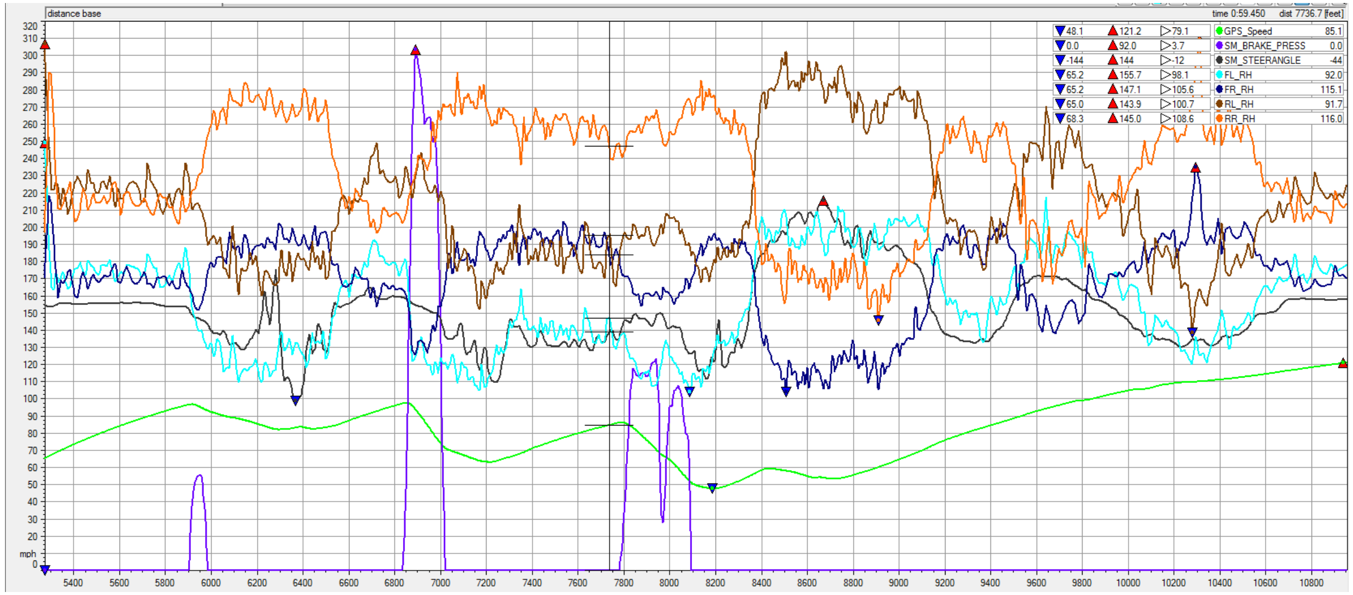
- Early 2019 we were able to wind tunnel test our 300mm Single Element Rear Wing in ARC Indy's facility. This is a state of the art wind tunnel that IndyCar, NASCAR, and various other motorsport teams utilize.

- Data between CFD and wind tunnel were less than 2% difference, signifying very accurate CFD correlation.
    - CFD under estimated downforce by 7.5lbs at 120 MPH
    - CFD under estimated drag by 1.6lbs at 120 MPH



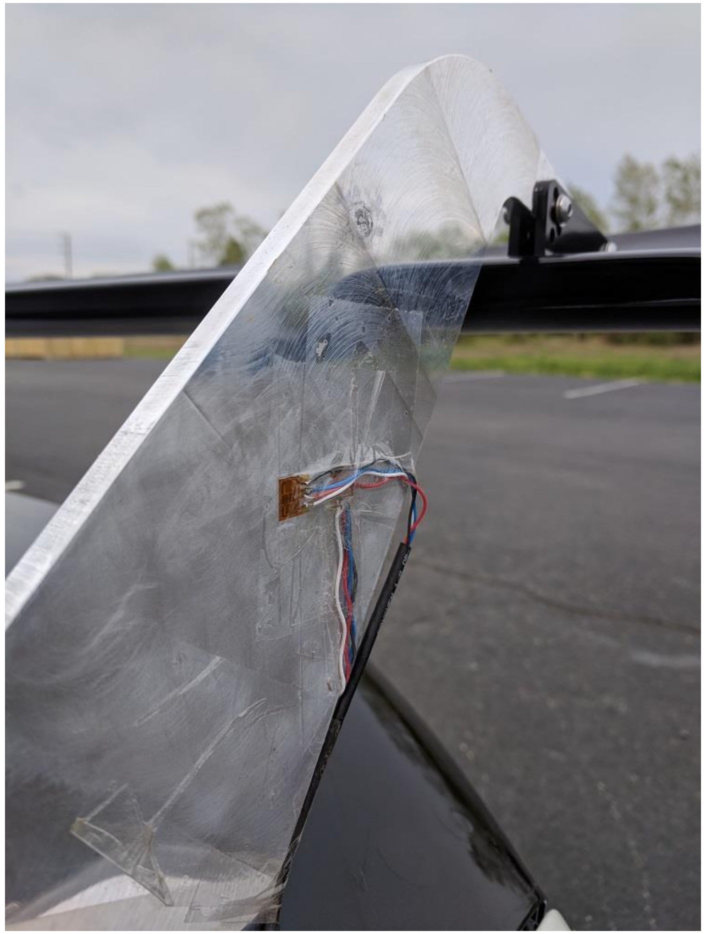
VALIDATION TESTING – TRACK TESTING

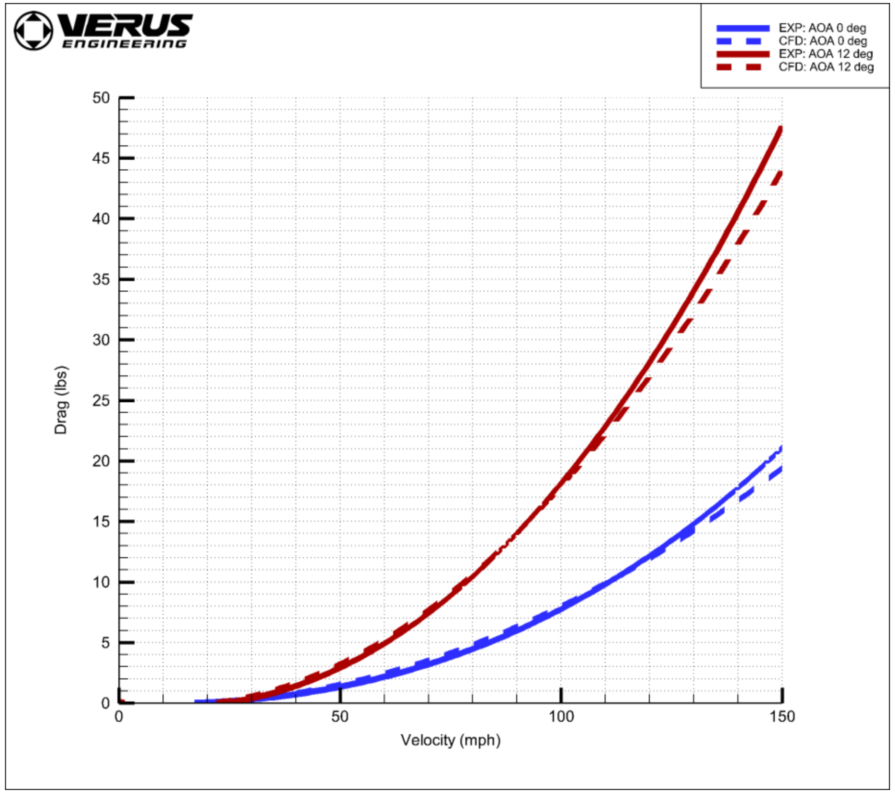
The 987.2 aerodynamic kit was fully tested on the track during the summer of 2018. The car was fashioned with a data acquisition system to collect data which included 3 laser ride height sensors.

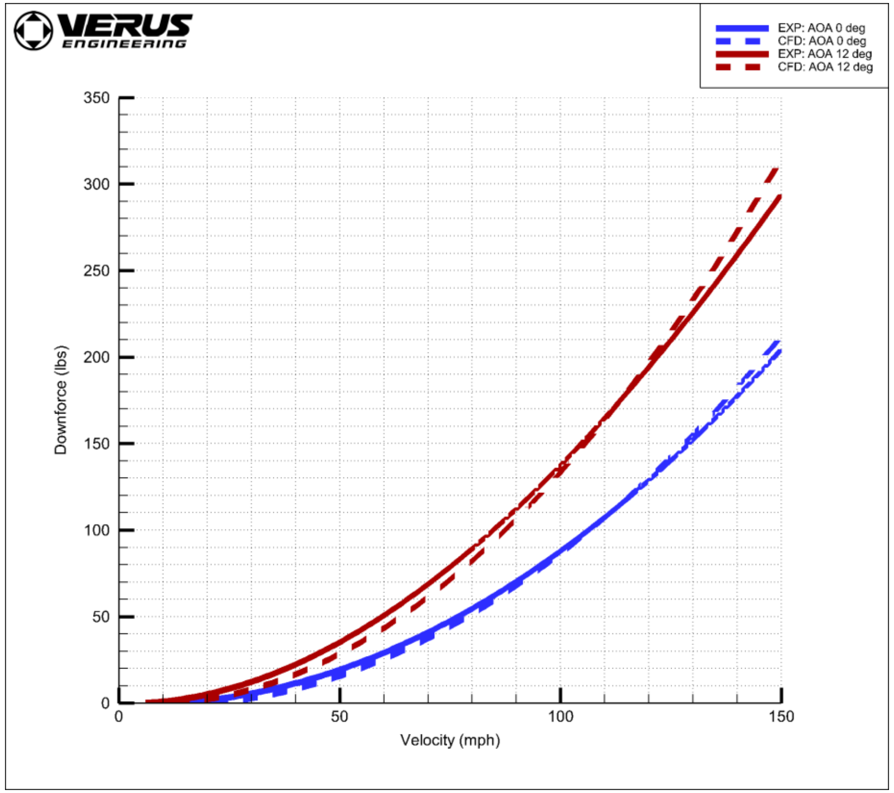


Ride heights correlated with downforce numbers when corrected for weight transfer and roll. We are still working on optimizing the suspension setup to work well with the added downforce.

VALIDATION TESTING – STRAIN GAUGE TESTING





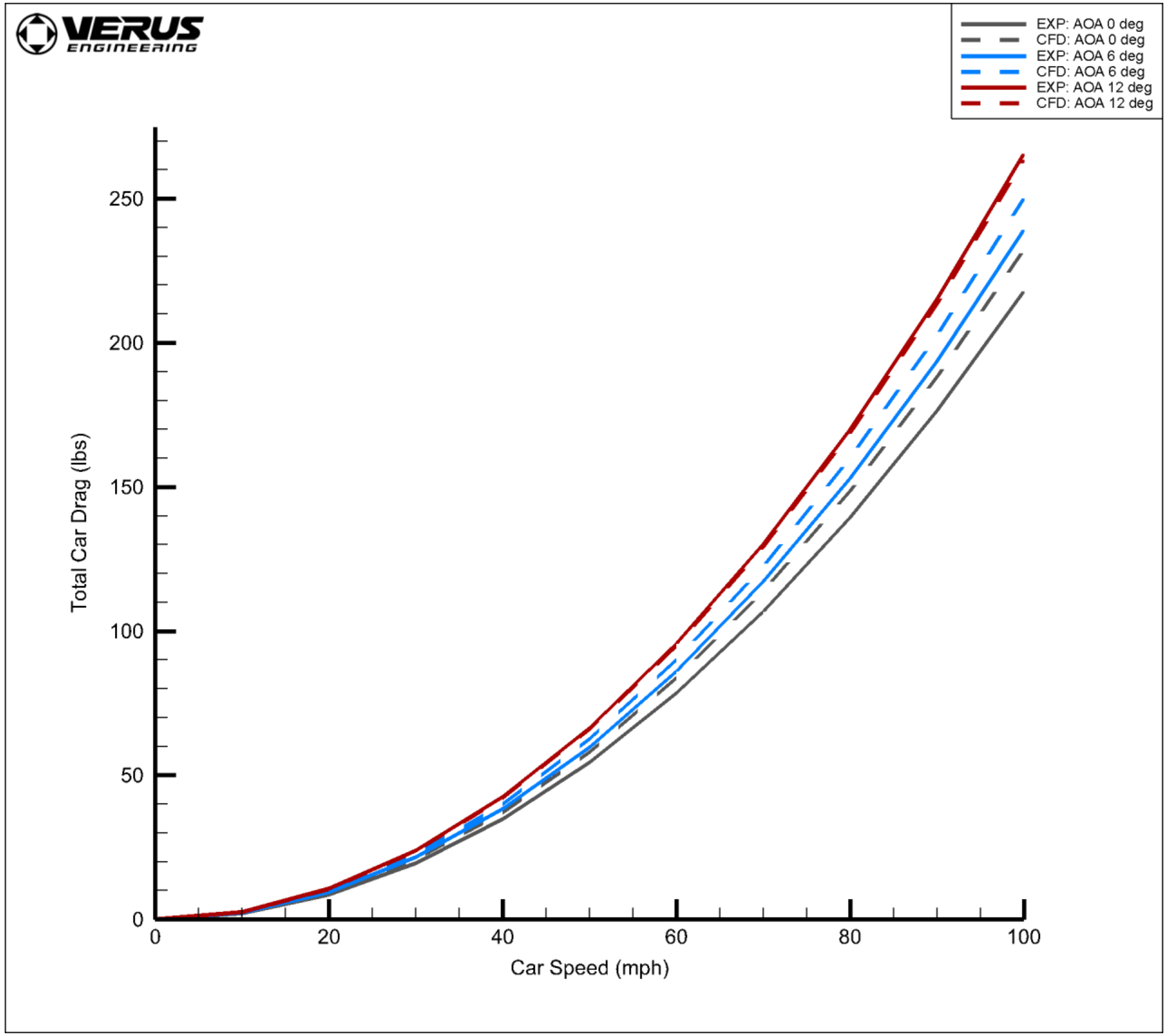


Strain gauges are used to measure the strain of a component, this data can then be calculated into forces. Strain gauges were used to measure the forces of the wing attached to the upright. This data was then compared to the simulation results generated by CFD and FEA. The real world experimental values correlated with the CFD well.

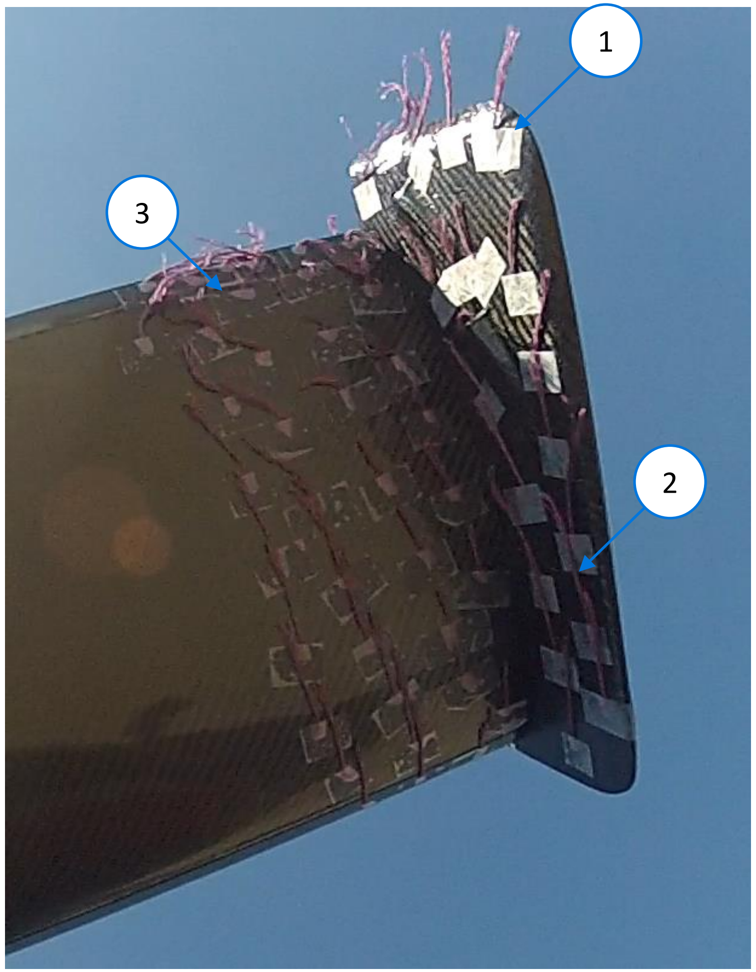
VALIDATION TESTING – COAST DOWN

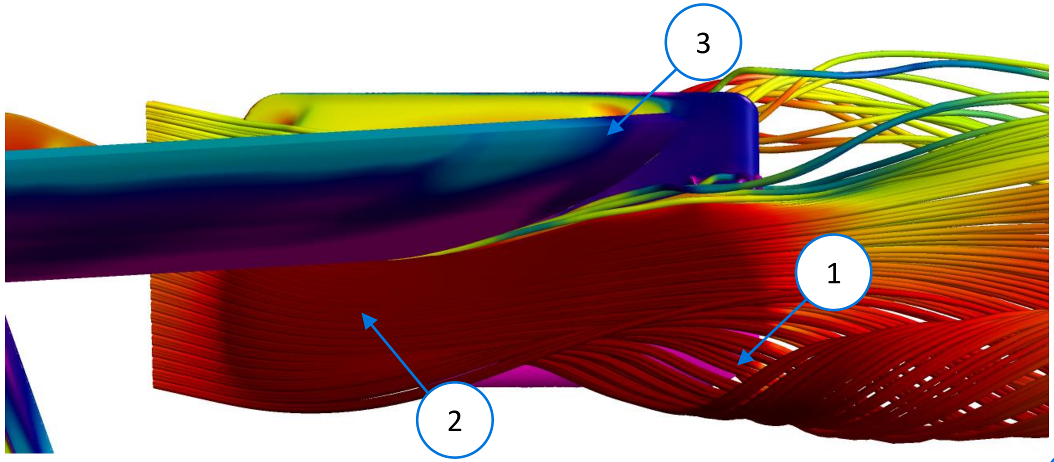
- We followed the SAE standard of coast down testing as close as we could. We coasted down from 80mph to around 10mph with 3 different cases; wing at 0 deg, wing at 6 deg ,and wing at 12 deg. The data was recorded using an AIM data logger and 4 runs were done and then averaged. Elevation changes were ignored because it could not be accurately calculated. Runs were made on the same day, at the same location, back to back.

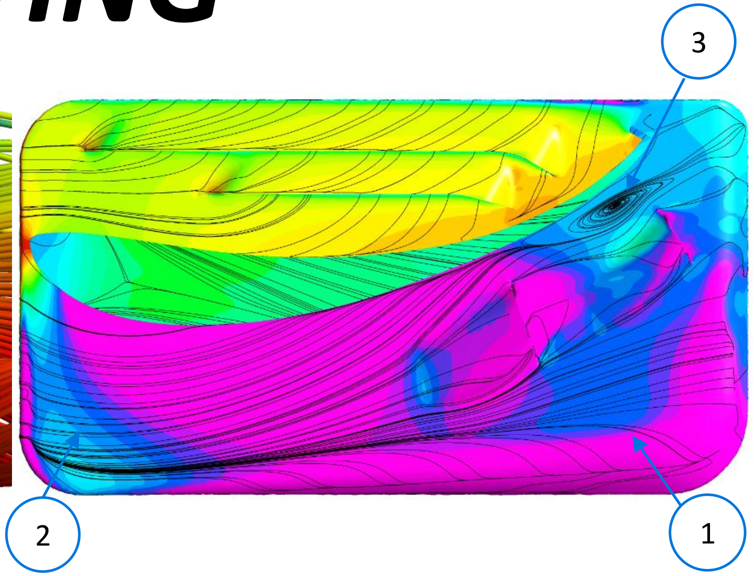
- From the coast down testing data, calculation of the coefficient of drag (cd) was completed. From this, the ability to compare simulated CFD drag to coast down testing drag was possible. Overall, the real world results correlate well to CFD estimated data.



VALIDATION TESTING – TUFT TESTING

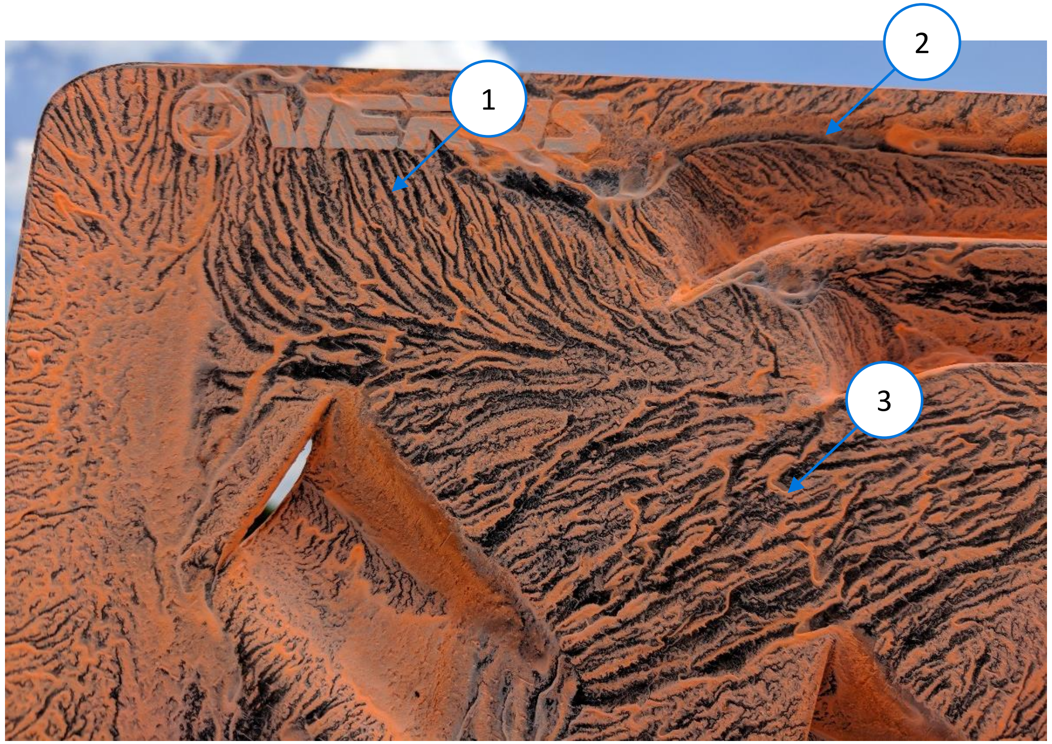


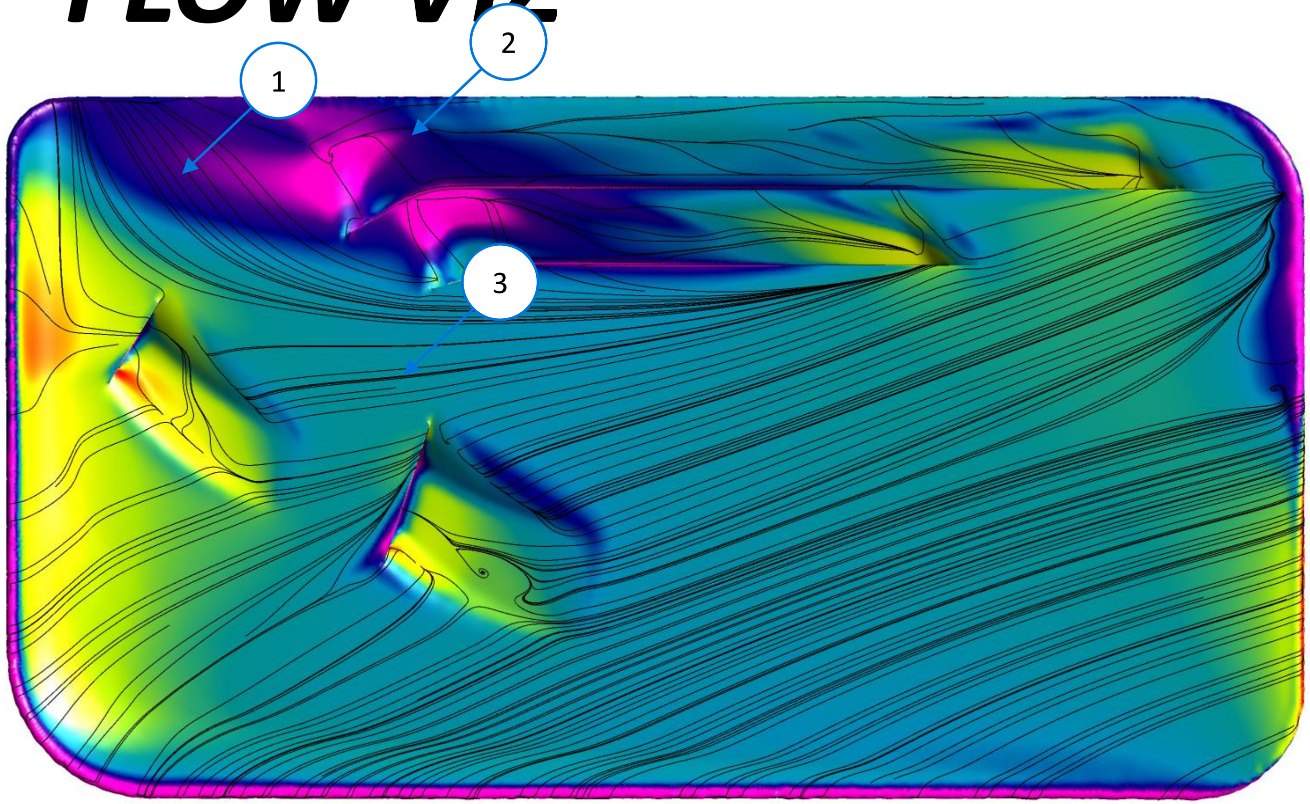




1. The airflow around the rear bottom of the endplate travels down and rear. Both CFD and tufts show this airflow and correlate well.
2. The air flow towards the front/middle bottom of the endplate travels up with the shape of the wing. Again, tufts and CFD correlate well.
3. The airflow is actually separating a little in this section. This was expected and airflow is designed to be separating in this area towards the wing's maximum angle of attack. It is better to separate at the trailing edge (soft stall) than the leading edge (hard stall). A soft stall will not have a large loss in downforce when separation occurs unlike leading edge stall. The tufts and CFD analysis again, correlate very well.

VALIDATION TESTING – FLOW VIZ





1. The flow viz and CFD flow line up very close on the endplates. The flow can be seen on both CFD and flow viz curving up and rearward on the endplate.
2. The flow viz shows substantial flow out of the slots at the top. The flow can be seen flowing upwards and then rearward at the top edge where the arrow is located and this exact same phenomenon can be seen on the CFD image.
3. The flow in both the flow viz and CFD show the flow field going rearward and down. The endplates show impressive correlation between the CFD and flow viz.

VALIDATION TESTING – BENCHMARK CFD CASES

We have used various benchmark CFD cases for benchmarking over the years. These have both CFD and wind tunnel data published which make them great for benchmarking!

- Ahmed Model
- DriveAer Model
- Perrinn LMP1
- Various Wing Profiles