V1X REAR WING

INFORMATION AND DEVELOPMENT

OVERVIEW

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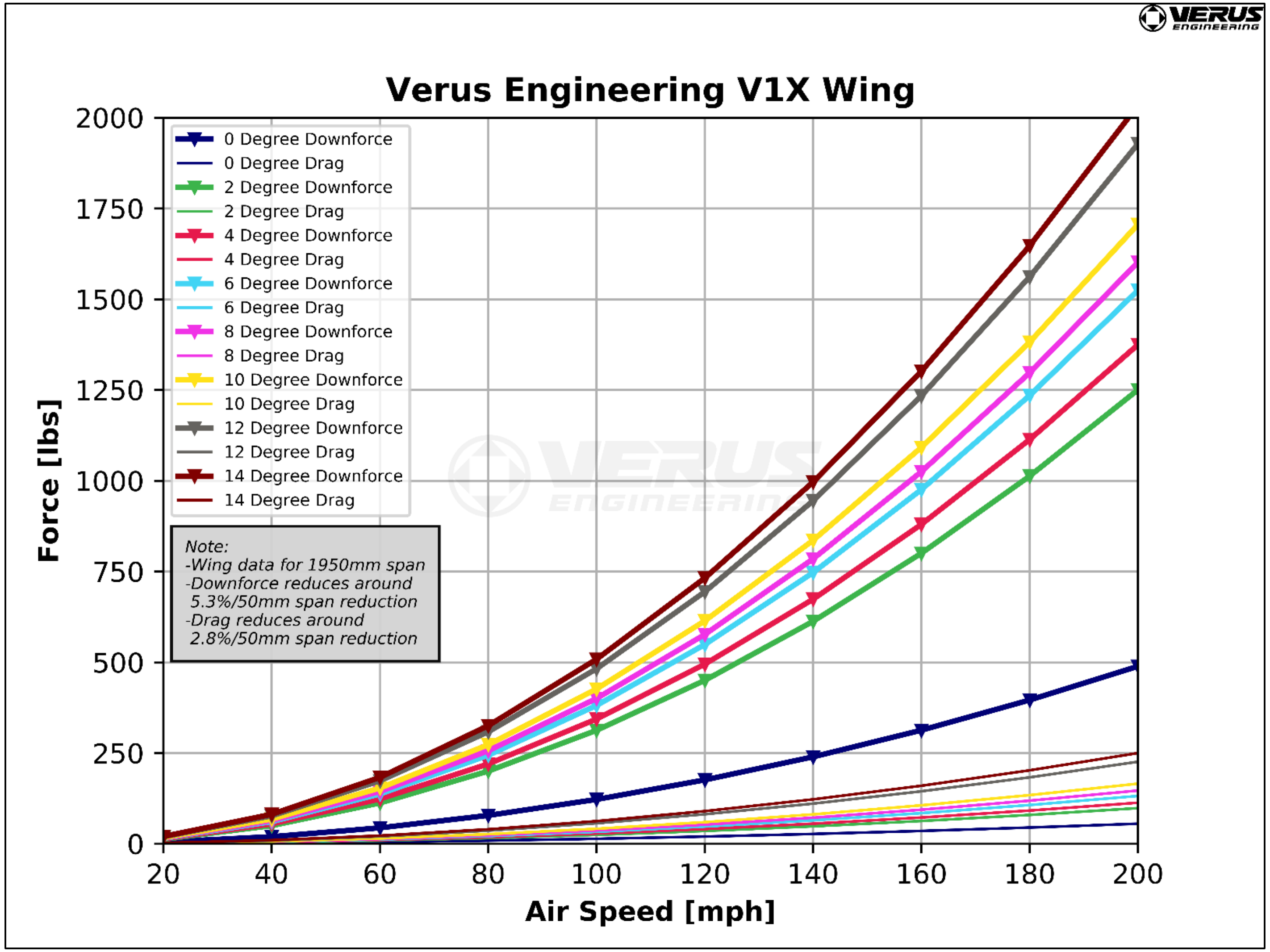
SUMMARY : AERODYNAMIC FORCES

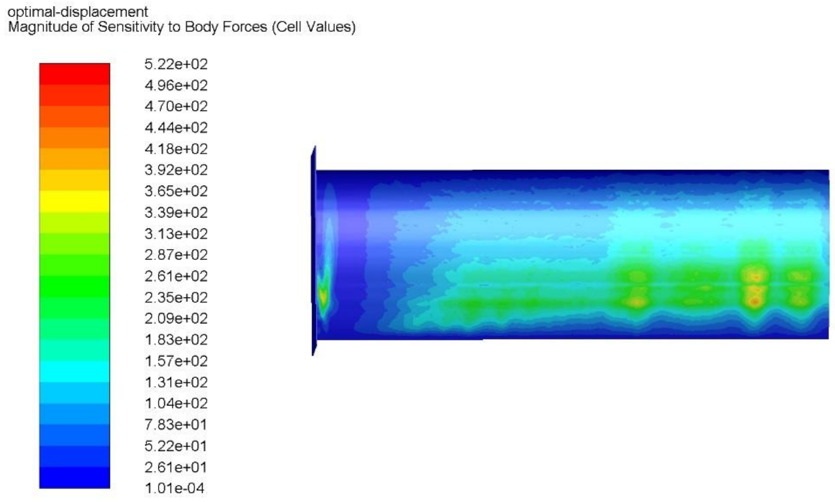


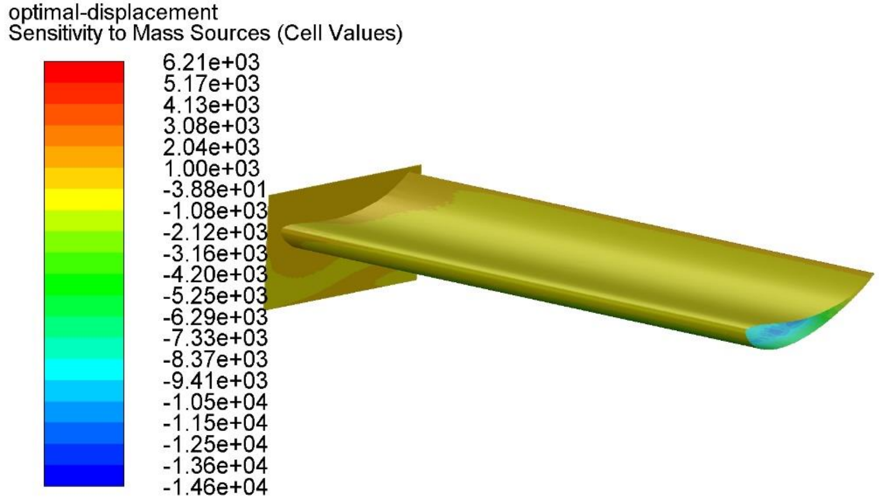
DEFINITIONS

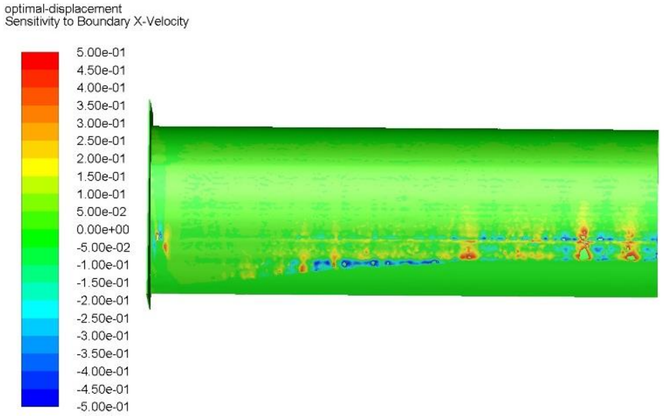
1. **Coefficient of Pressure (Cp)** = This is a dimensionless number which describes relative pressure to atmospheric pressure. A Cp of 0 equates to atmospheric pressure while a number below 0 represents low pressure and a number above 0 represents high pressure.
2. **CpX** = This is a dimensionless number which describes Cp normal to the x-direction. This helps us visualize locations which create drag. Red represents locations which are creating drag, while blue represents locations where thrust is created.
3. **CpZ** = This is a dimensionless number which describes Cp normal to the z-direction. This helps us visualize location which create downforce or lift. Red represents locations which are creating lift, while blue represents locations where downforce is created.
4. **Total Pressure Coefficient (CpT)** = This is a dimensionless number which describes total energy of the airstream. It is the sum of static pressure and dynamic pressure.
5. **Wall Shear** = This is a force per unit area due to fluid friction on the wall. This is used to visualize areas of separation and rapid changes on the surface.
6. **LIC Plot** = Line integral convolution (LIC) is used to visualize “oil” flow on the surface. It is a great way to correlate to flow vis testing and to study the flow on the surface of the vehicle.
7. **Streamline** = These are fluid tracers which are used to visualize where the air is going or coming from. These are normally colored as velocity where red is high-velocity and blue is low-velocity.
8. **Points** = One point is considered 0.001 of a coefficient. This is used in coefficient of drag (Cd) and coefficient of lift (Cl).

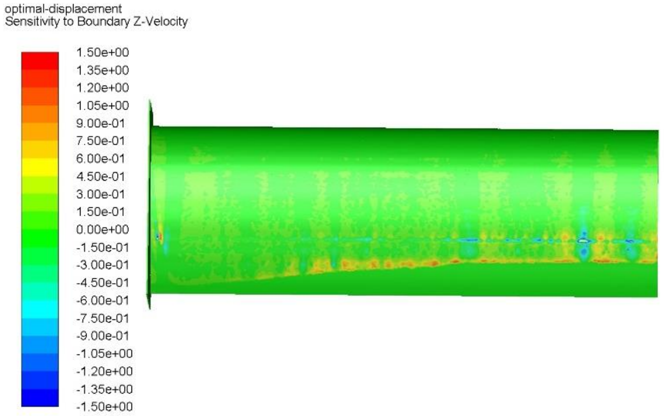
DEVELOPMENT – EARLY CFD

In the early development, CFD was used to develop and refine wing shapes with the goal of creating a convex recovery (trailing edge stall) wing. This is the best type of wing for a motorsports or automotive application as more adjustment is possible with a slow stall. This ensures no major loss in downforce or large increase in drag with minor wing change. The wing design went through many optimization loops in freestream using ANSYS Fluent's Adjoint solver and optimization.



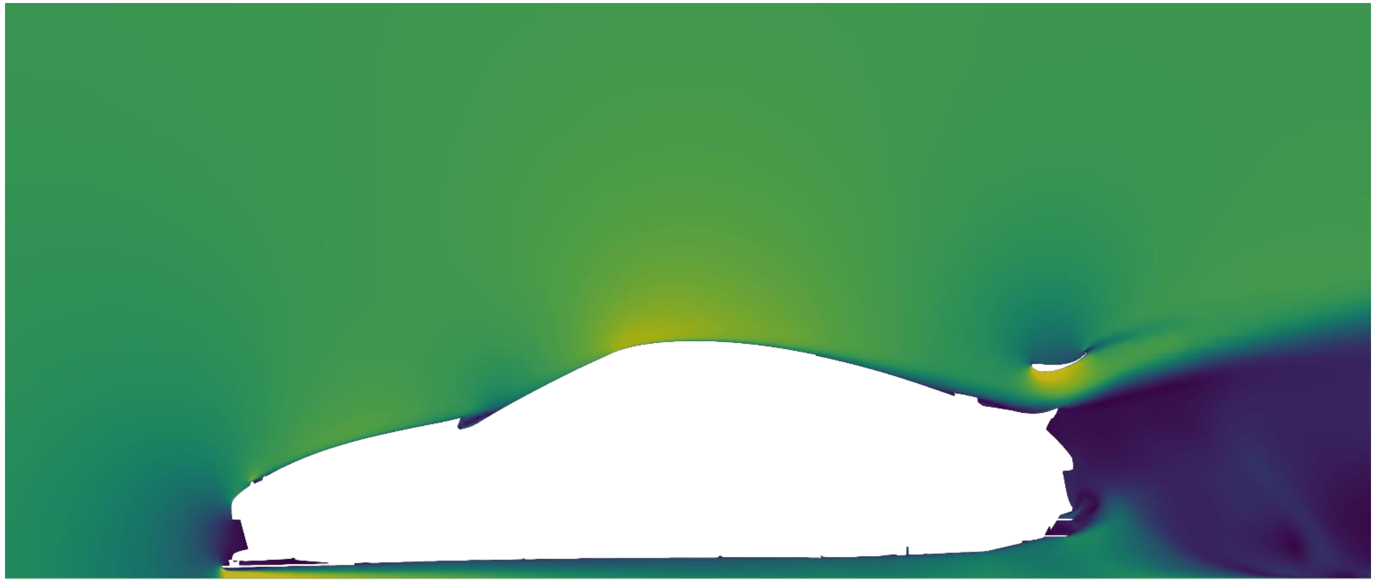


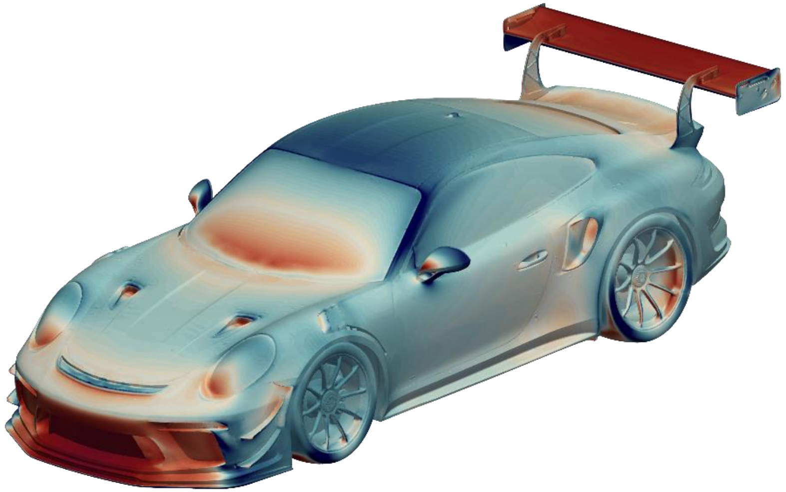


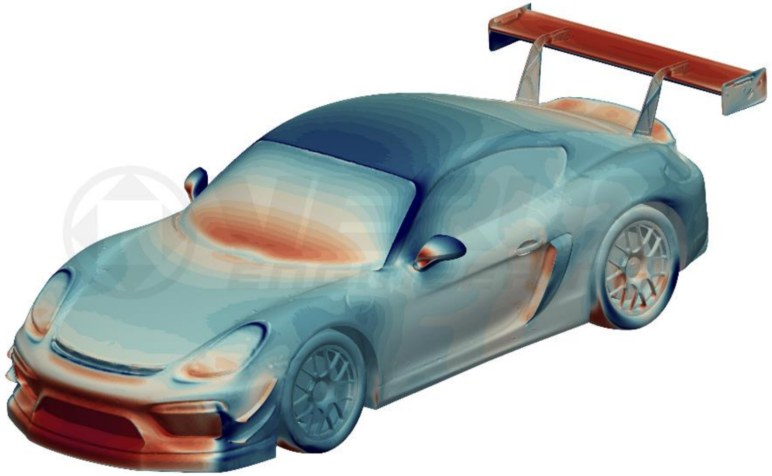


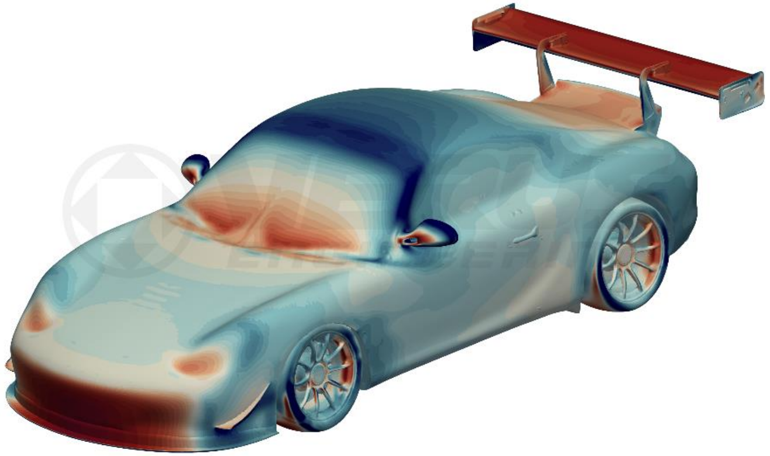
DEVELOPMENT – CFD WING REFINEMENT

The V1X was optimized on multiple different platforms. This ensures the best performance possible when installing a Verus Engineering V1X as a package or on a custom setup. The V1X is the perfect wing for motorsports applications with higher downforce in mind.

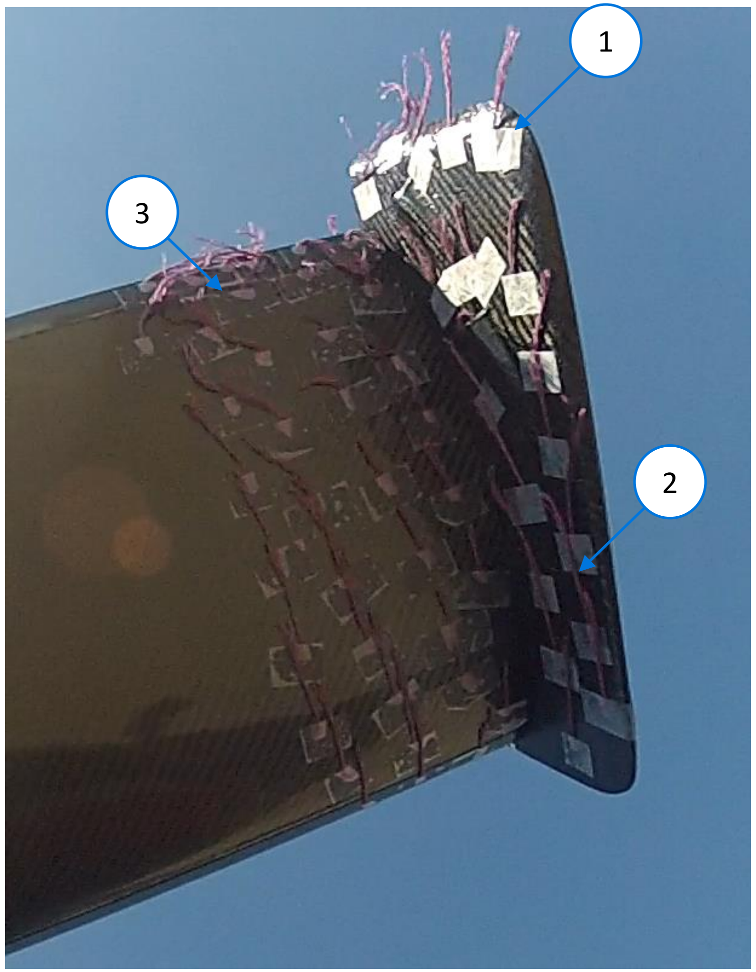


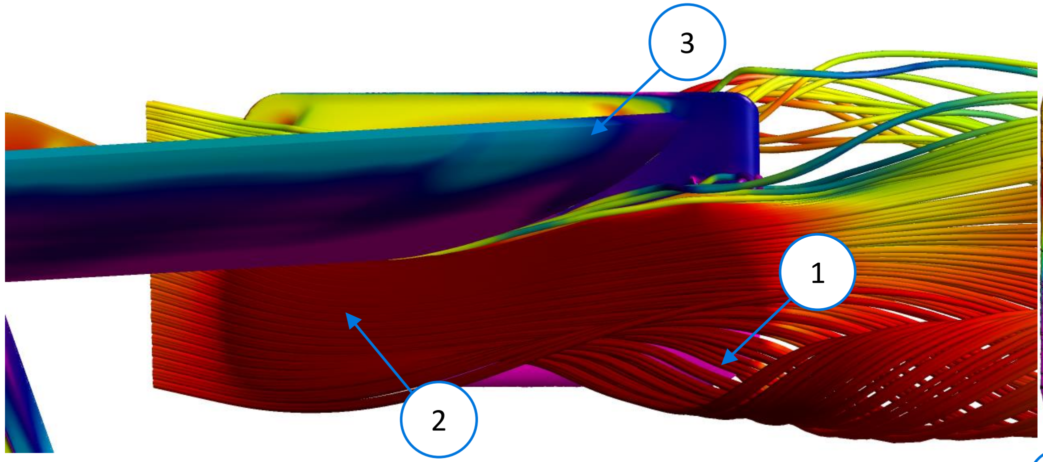


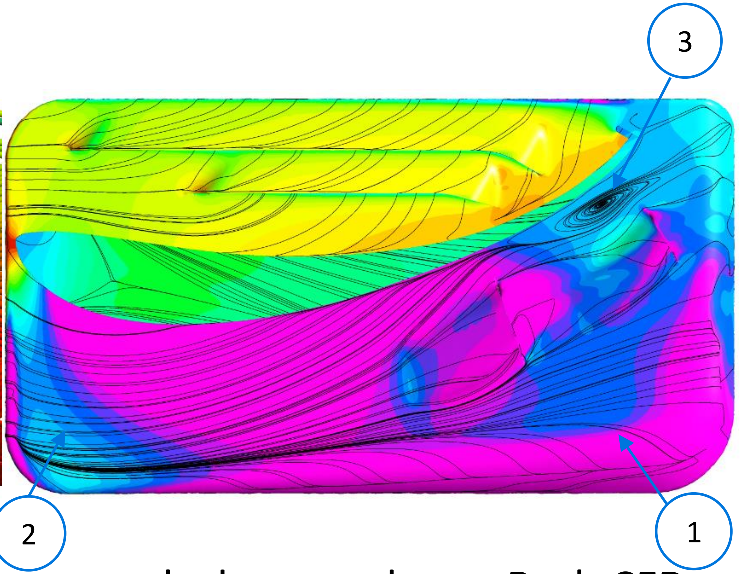




DEVELOPMENT – V1X TUFT TESTING

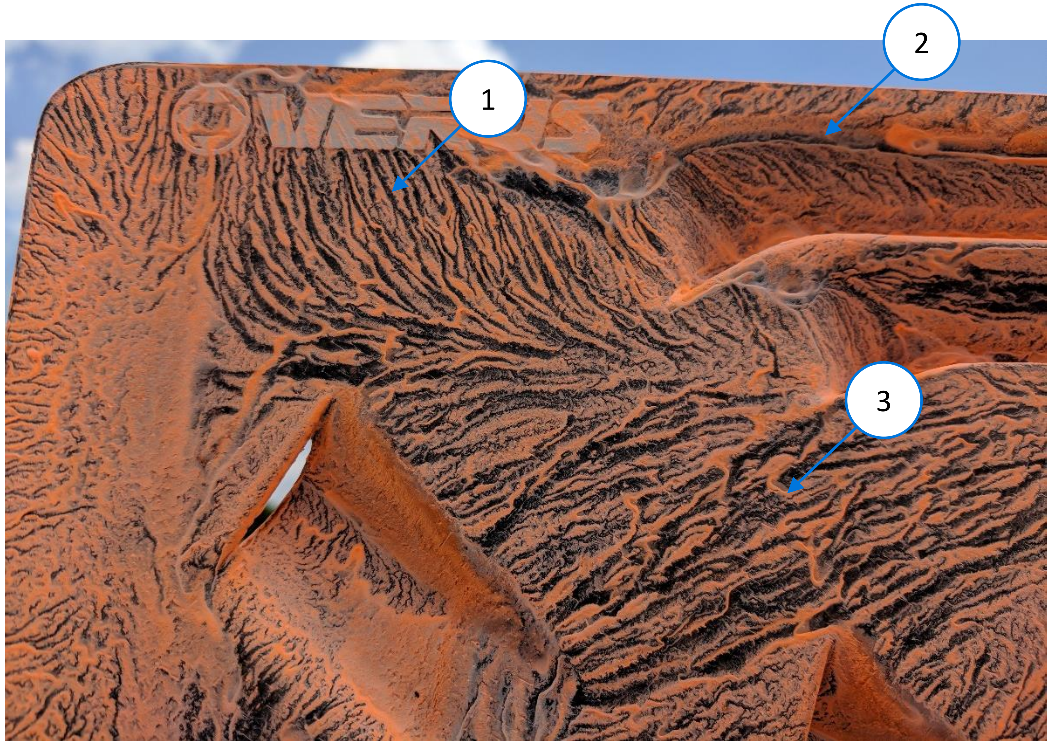


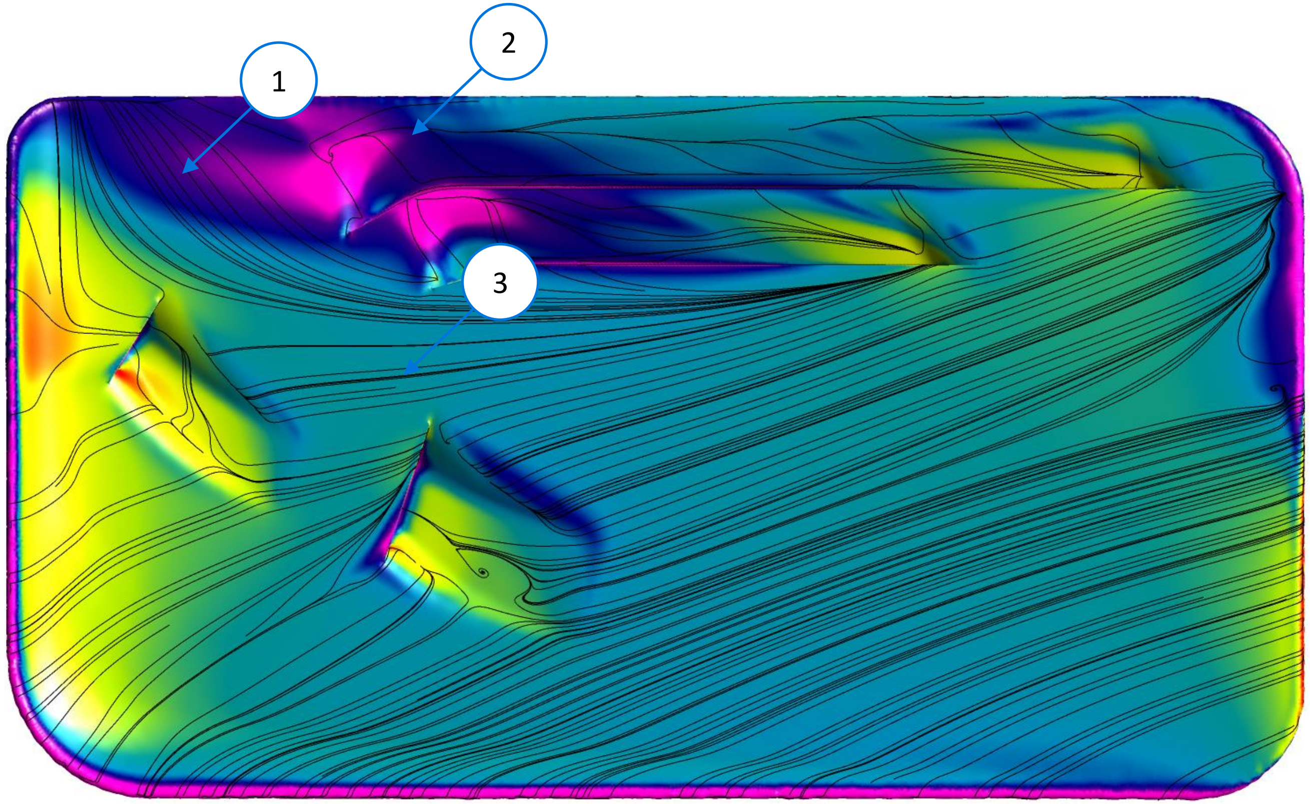




1. The airflow around the rear bottom of the endplate travels down and rear. Both CFD and tufts show this airflow and correlate well.
2. The air flow towards the front/middle bottom of the endplate travels up with the shape of the wing. Again, tufts and CFD correlate well.
3. The airflow is actually 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.

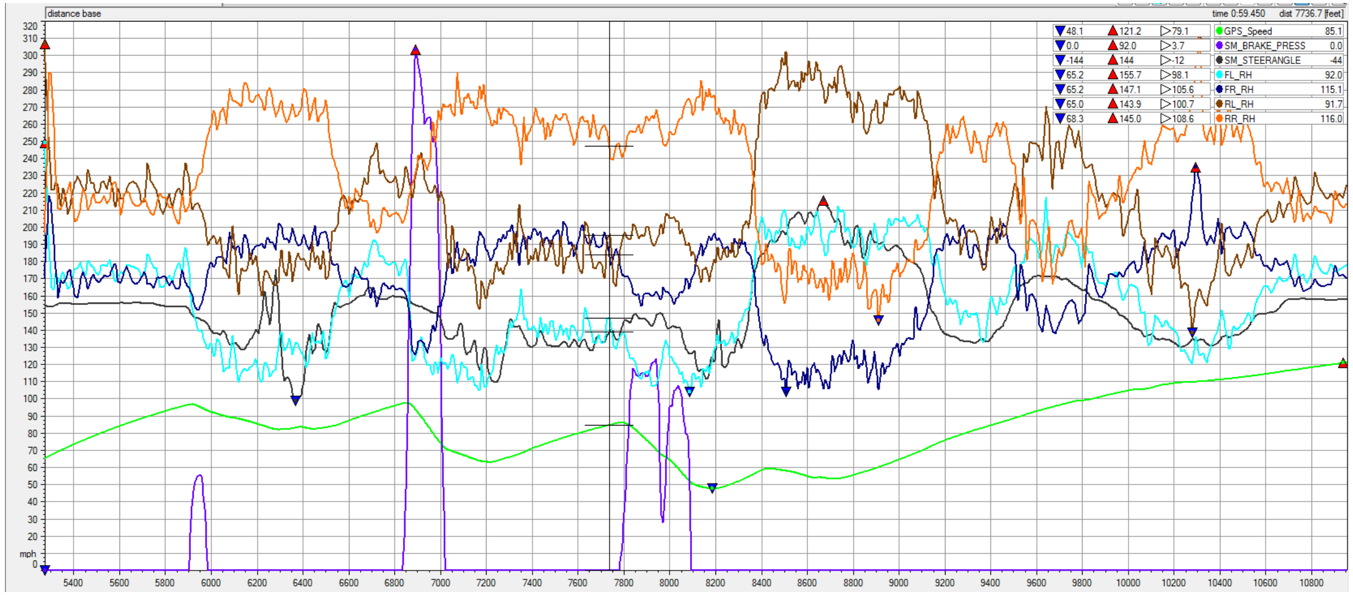
DEVELOPMENT – V1X FLOW VIZ TESTING





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.

DEVELOPMENT – V1X TRACK TESTING



The aerodynamic kit was then fully tested on the track during the summer of 2018. The car was fashioned with 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 suspension setup to go with the added downforce.

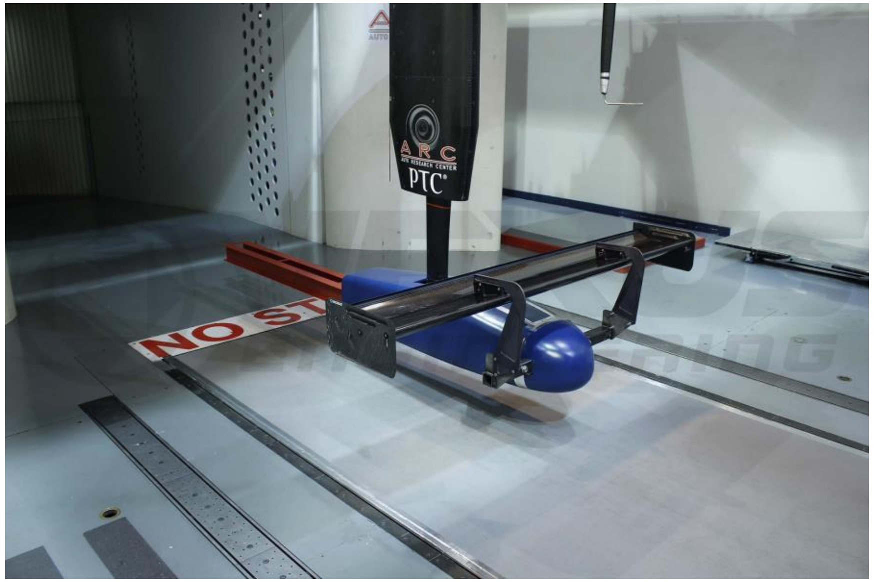
DEVELOPMENT – V1X TRACK TESTING

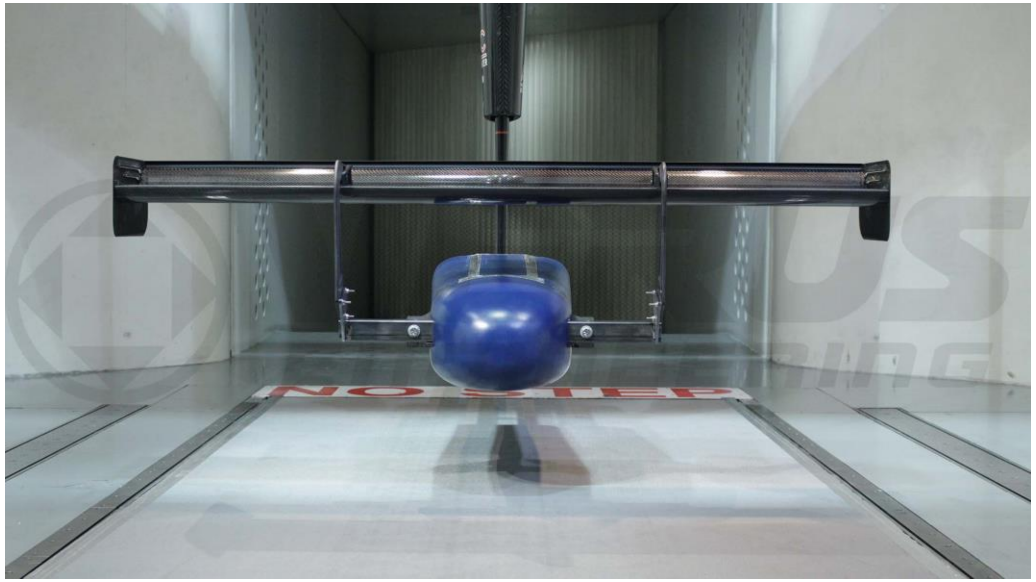
Through back-to-back testing, we saw a 2.5-second reduction at Thunderhill and 3.3 seconds at Laguna Seca on a relatively stock GT4 at only 4 degrees angle of attack with one of our customers.

VALIDATION – WIND TUNNEL

Wind tunnel at ARC testing was used in the validation of the V1X. Validating our CFD methods were key to knowing our design paths and data were correct.

The wind tunnel model tested was the 1800mm span V1X. We tested at a few different inlet velocities and wing angles. This ensured we collected enough data for proper validation.



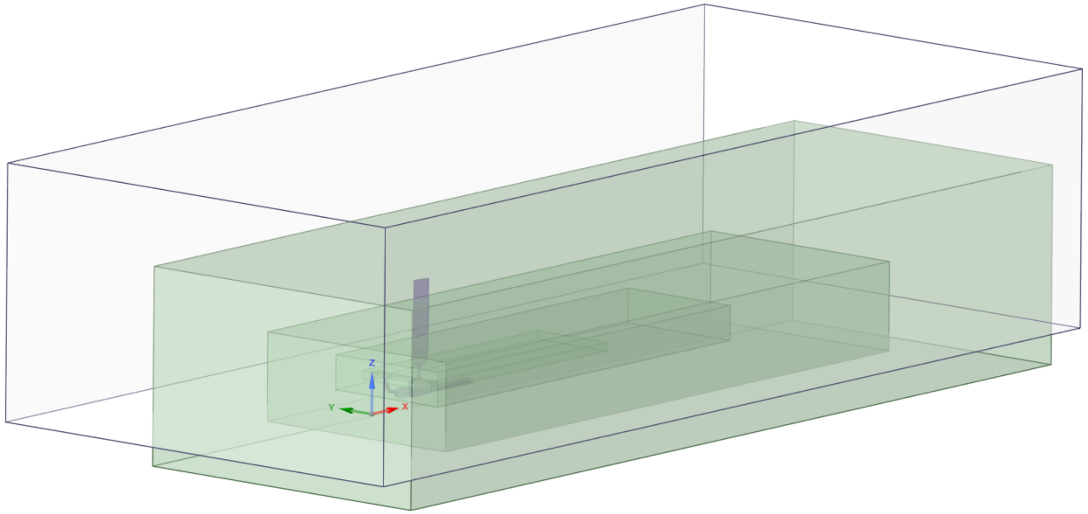


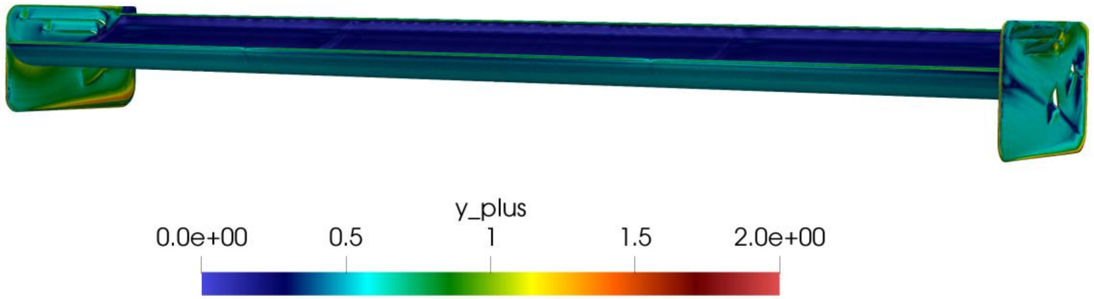
VALIDATION – WIND TUNNEL

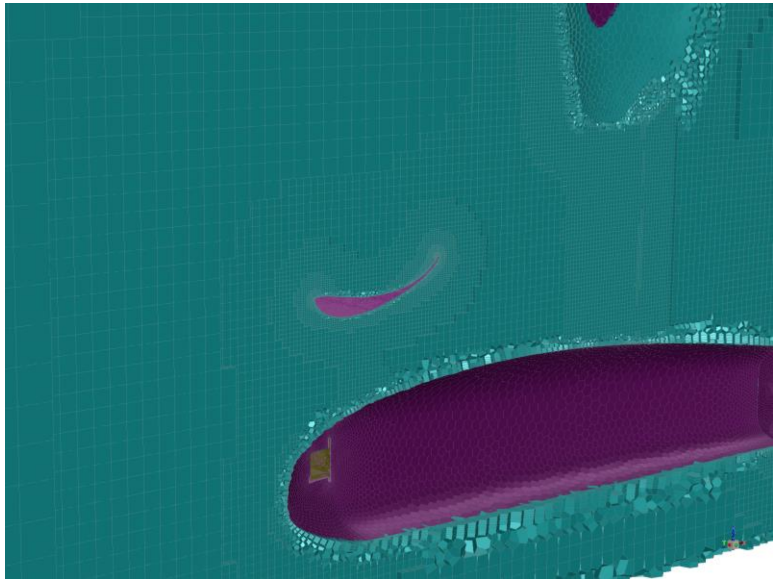
Using the recommendation of ARC, we used the model to the right to correlate the wing in the wind tunnel. The wind tunnel itself did not need to be used, only the test apparatus itself.

The mesh count was just over 40 million cells. The wing had 20 prism layers with a first cell height of 0.005mm to capture the viscous sublayer.

We are testing the wing in CFD with our main turbulence models; k-omega SST, k-epsilon realizable, and Spalart-Allmaras.

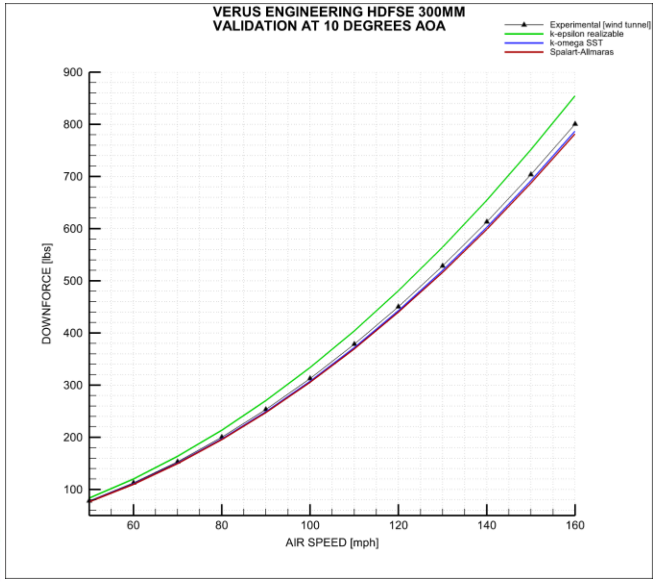


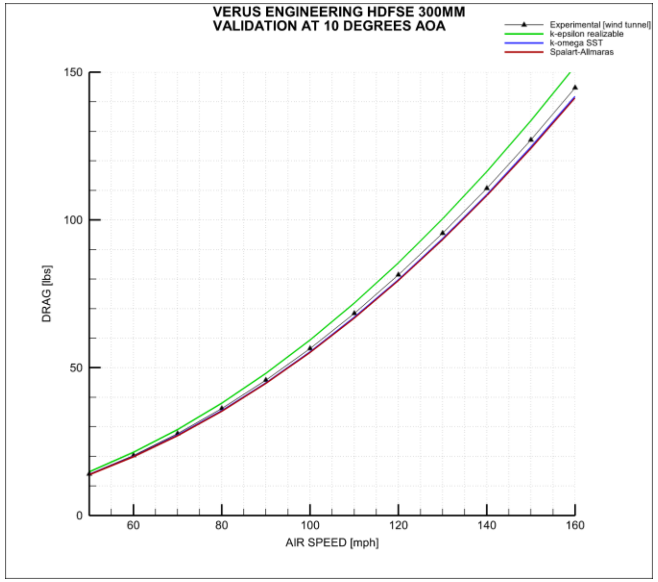




VALIDATION – WIND TUNNEL

Setup	Downforce Coefficient	Drag Coefficient	Air Speed Actual[m/s]
Experimental [wind tunnel]	2.1046	0.3803	36.5
K-omega SST	2.0693	0.3730	36.5
Spalart- Allmaras	2.0556	0.3715	36.5
K-epsilon realizable	2.2473	0.3997	36.5

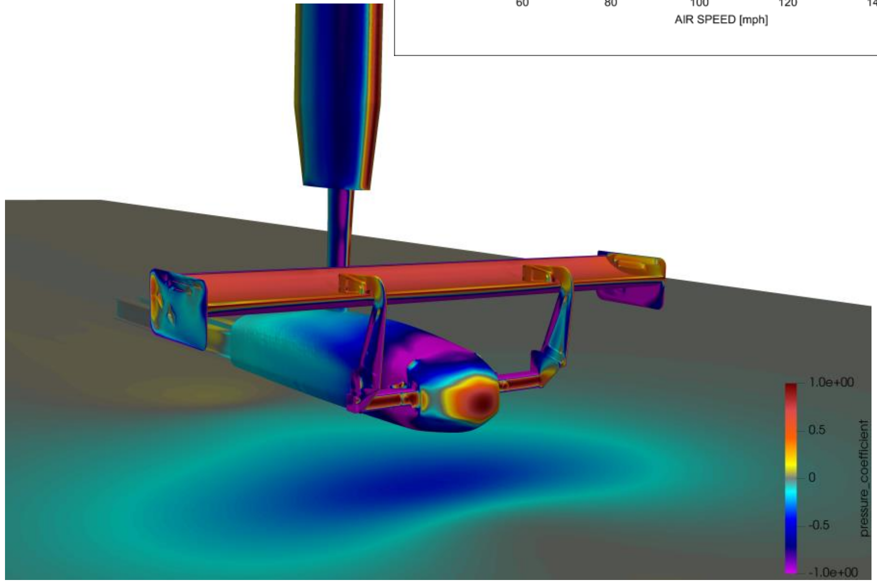


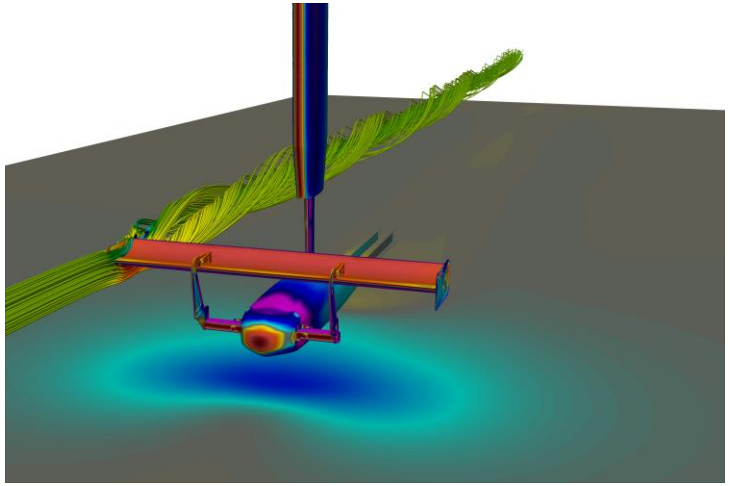


K-omega SST error:
Downforce Coefficient = -1.68%
Drag Coefficient = -1.92%

Spalart-Allmaras error:
Downforce Coefficient = -2.33%
Drag Coefficient = -2.31%

K-epsilon realizable error:
Downforce Coefficient = 6.78%
Drag Coefficient = 5.10%





SUMMARY

The Verus Engineering V1X wing increases downforce efficiently. The V1X decreased lap times by increasing performance all while keeping factory warranty. The research and development of he package was done using cutting edge technology in CFD, track testing, and wind tunnel validation.

The V1X is available in specific vehicles applications or in universal applications. The specific vehicle applications will be OEM level fit and finish. The universal applications will be a DIY install where the user will make their own uprights/brackets to the V1X with mounts. We offer CAD templates for the user to make own uprights.

THE SCIENCE

This analysis was done using ANSYS Fluent & OpenFOAM V6 which are finite volume CFD software. The solver was SIMPLE and the turbulence model was K-Omega SST using standard wall conditions unless otherwise stated. We used standard automotive arrangement when setting up boundary conditions and running a full-car. The case for full-car and wing refinement was simulated using slight yawed airflow of 0.5 degrees (except in wind tunnel validation). This yawed airflow is to ensure we are not analyzing a condition the car will almost never see which is perfectly straight airflow down the length of the car or wing.