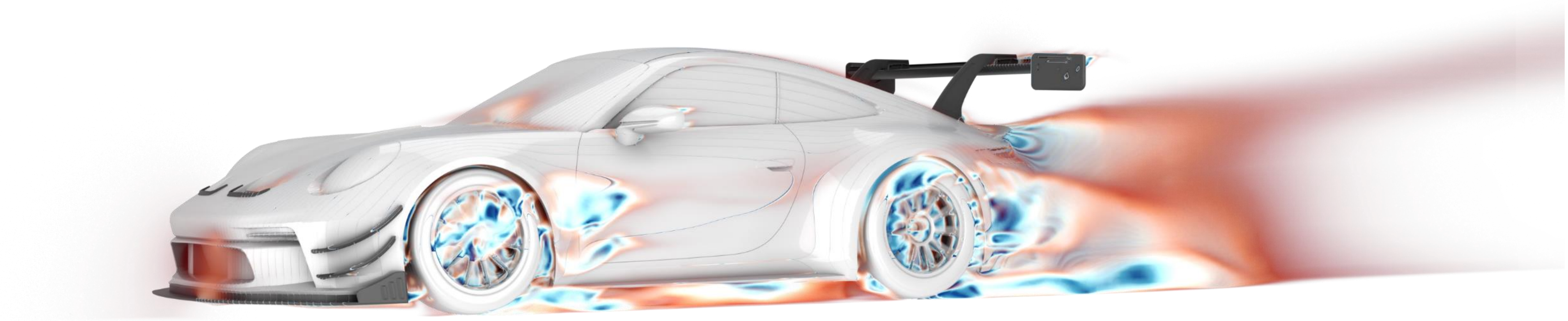


PORSCHE 992 GT3

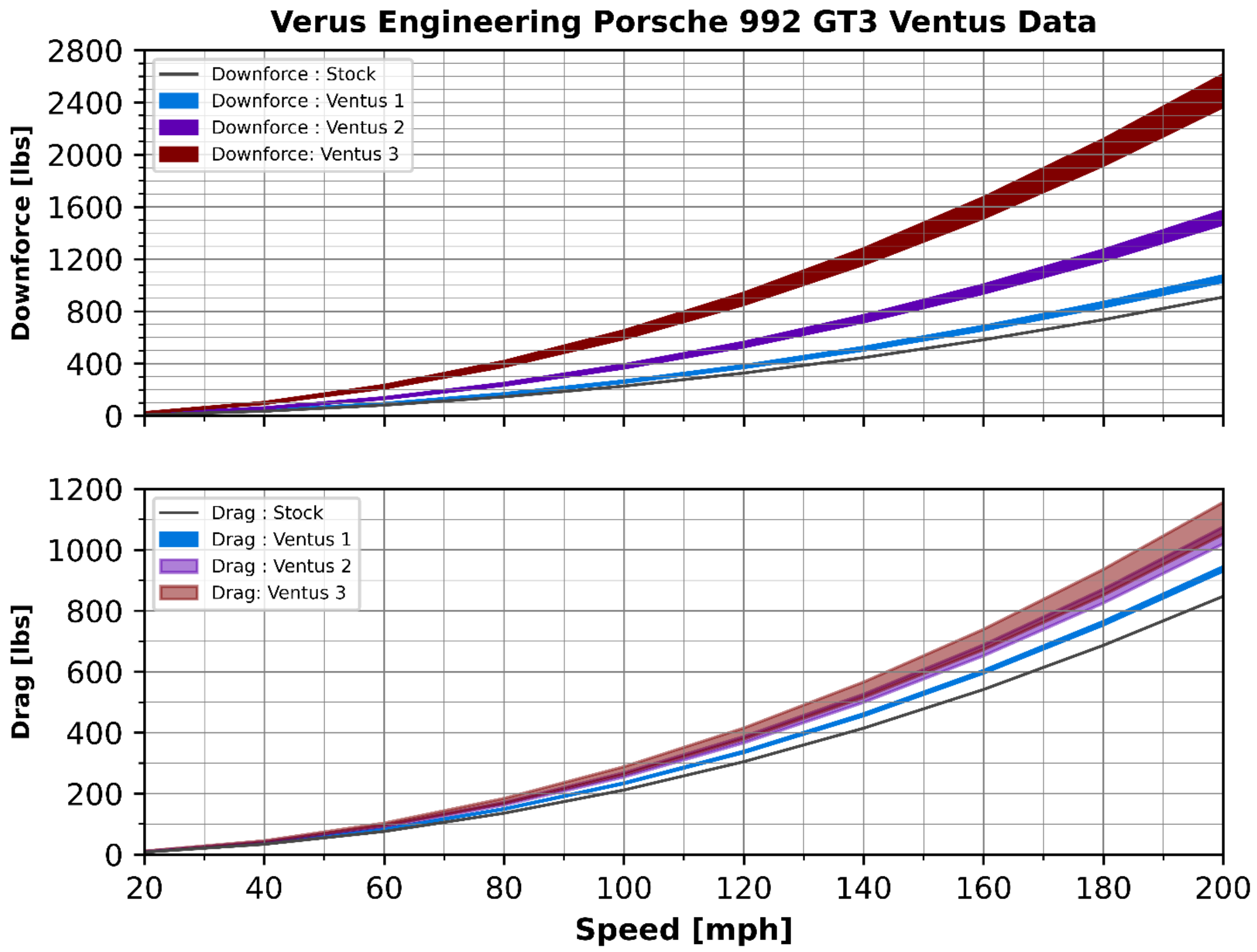
PERFORMANCE OF VERUS ENGINEERING VENTUS PACKAGES

OVERVIEW

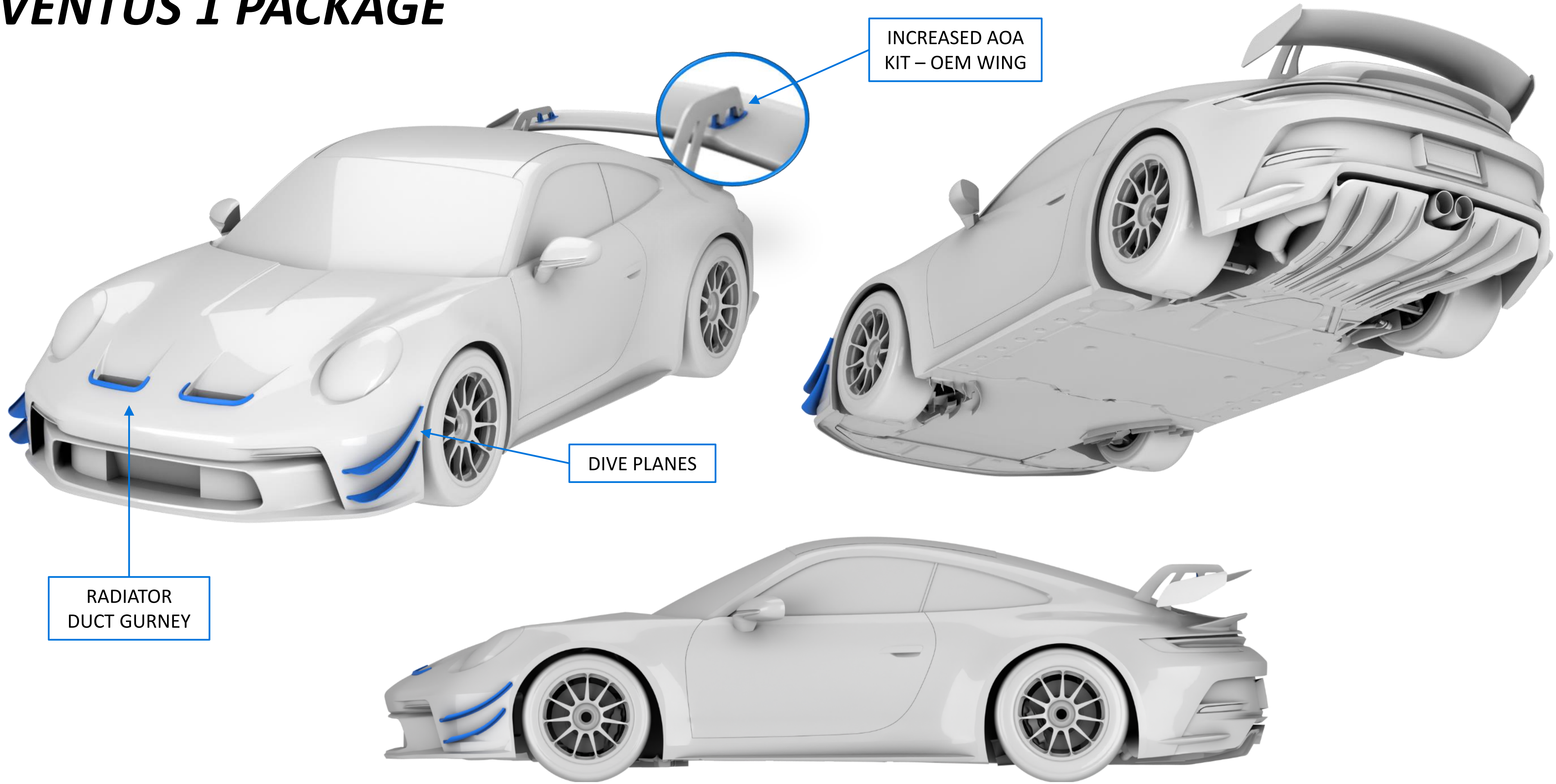
SUMMARY : AERODYNAMIC FORCES

- Aerodynamic forces change with the square of the vehicle speed, which is why we use a graph.
- The Ventus 1 package increases downforce over stock with minimal impact to drag.
- The Ventus 2 package provides a substantial increase in downforce with a small drag penalty over Ventus 1. Ventus 2 also improves the total aerodynamic efficiency (Lift/Drag) compared to OEM and Ventus 1.
- The Ventus 3 package is our highest downforce option. It's large increase in performance is thanks to the V1X wing and larger splitters featuring carbon fiber diffusers. At lower wing angles it produces less drag that the Ventus 2 package at high wing angles.
- See the following slides for a breakdown of the components that make up each Ventus package.
- Angle of Attack (AoA) adjustment allows the driver to fine tune aerodynamic balance to his or her preference.
- The Ventus kit is designed and tested to make your 992 GT3 faster around the track.

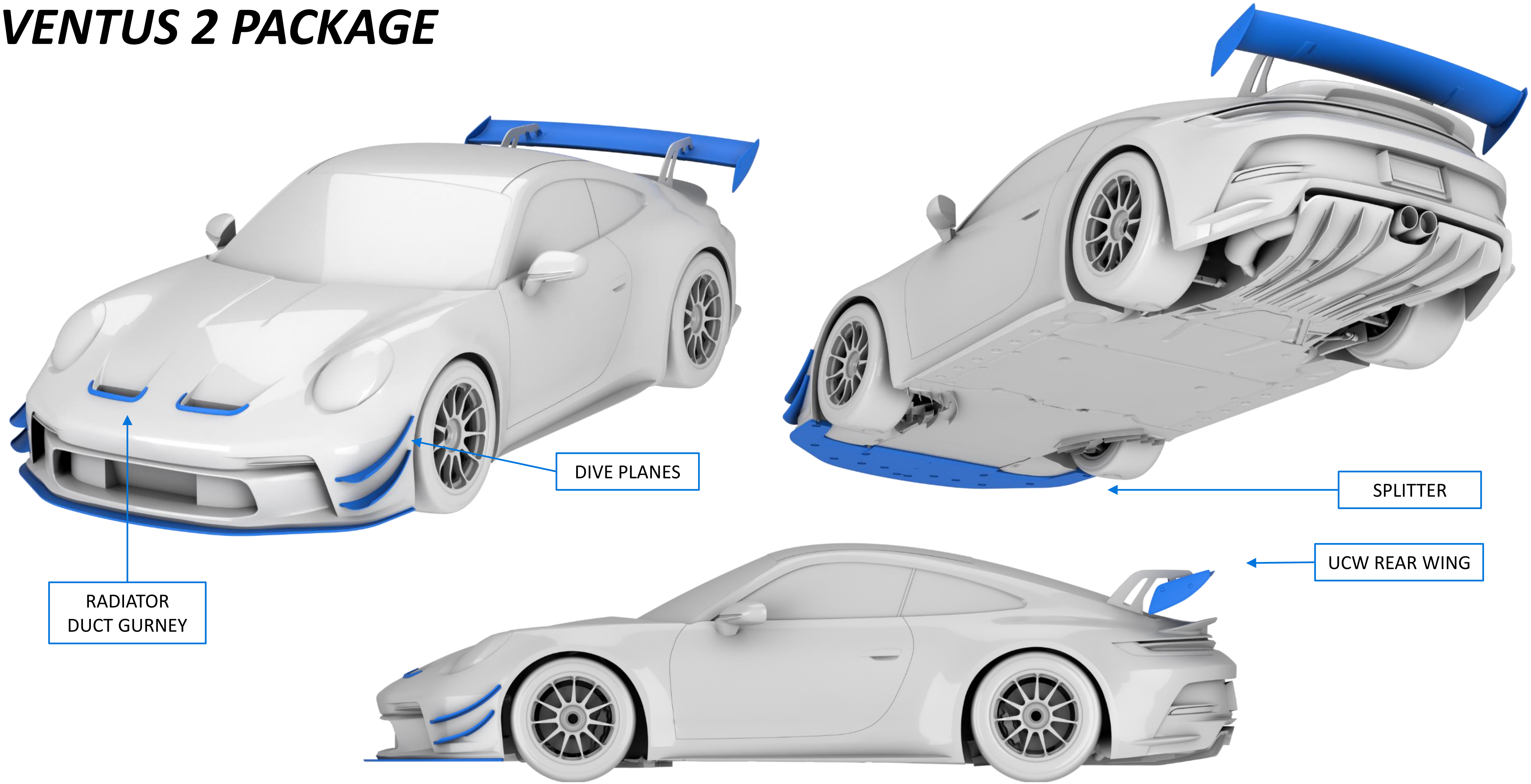
Note:	*Ventus 1 OEM Wing AoA shown above:*	*-1° to 2°*
	Ventus 2 UCW Wing AoA shown above:	*6° to 12°*
	Ventus 3 V1X Wing AoA shown above:	*2° to 12°*



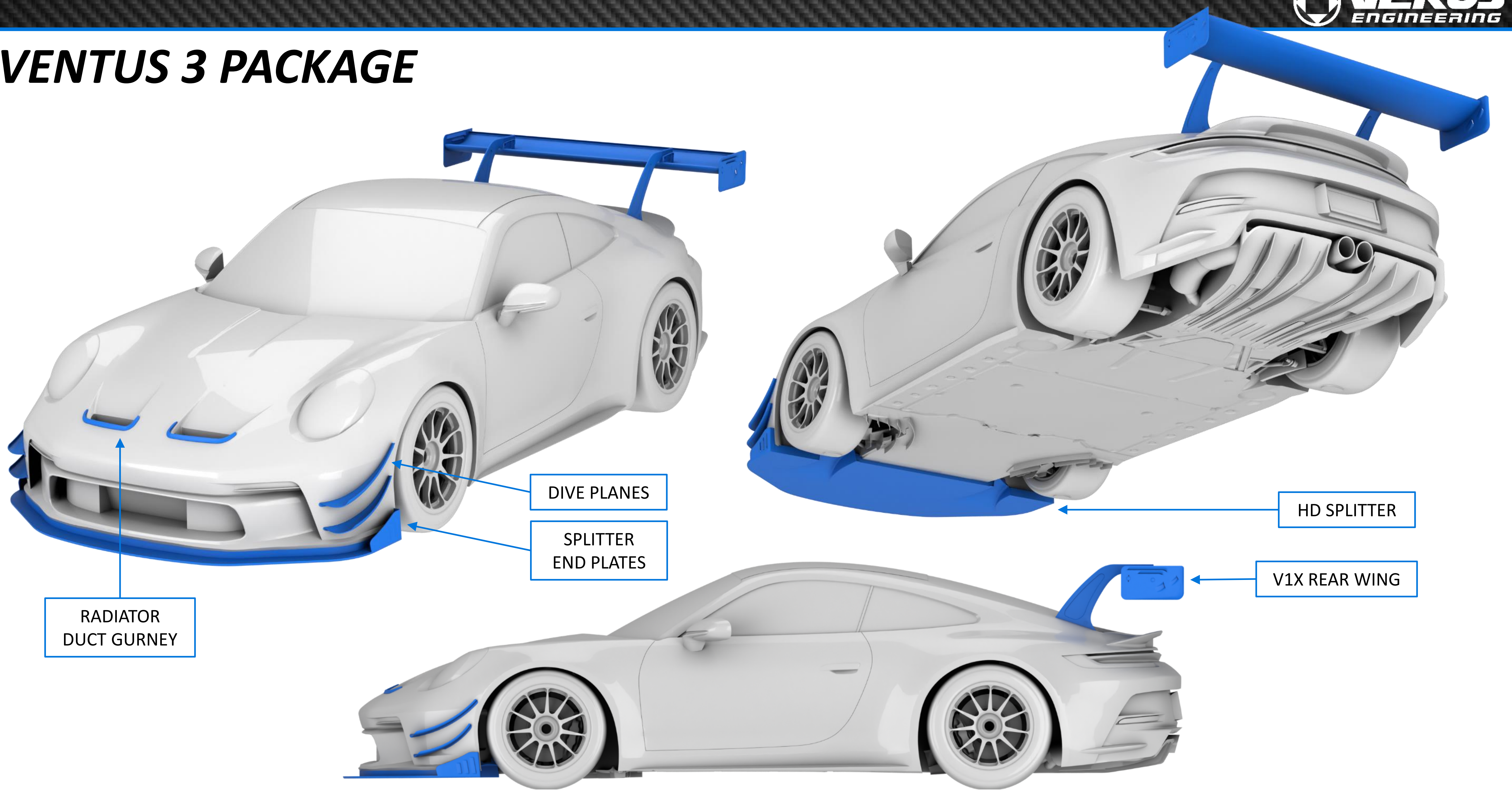
VENTUS 1 PACKAGE



VENTUS 2 PACKAGE

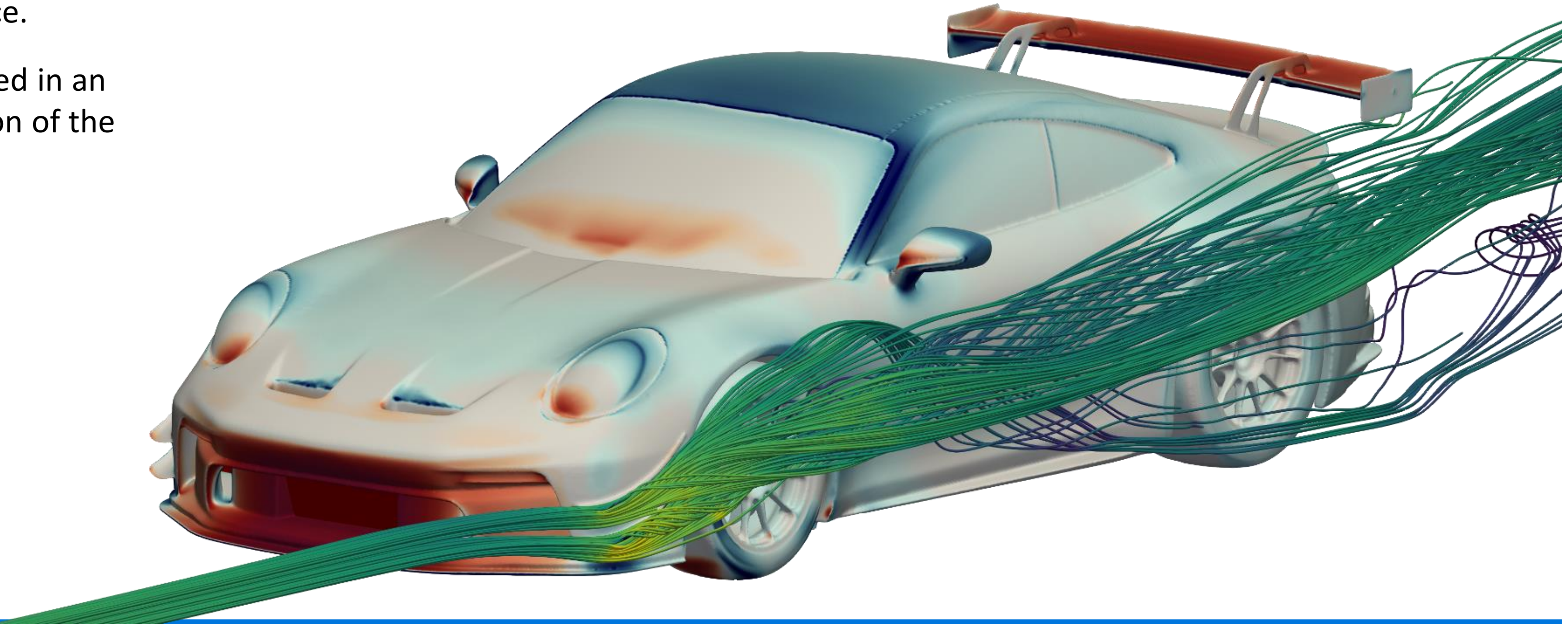


VENTUS 3 PACKAGE



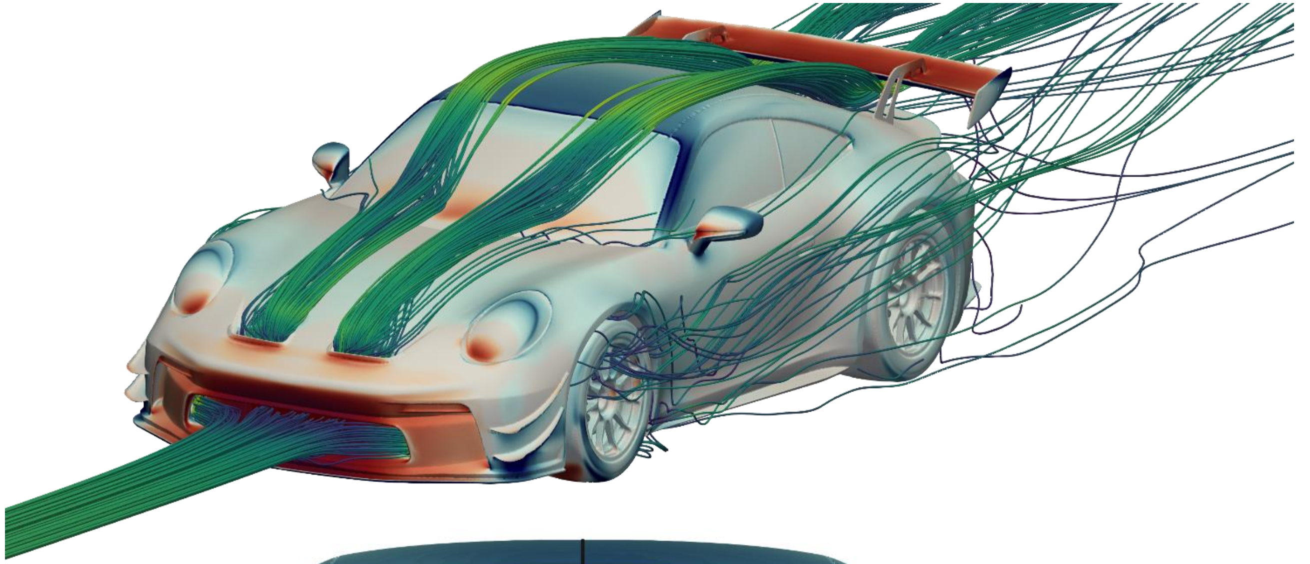
DIVE PLANES / CANARDS

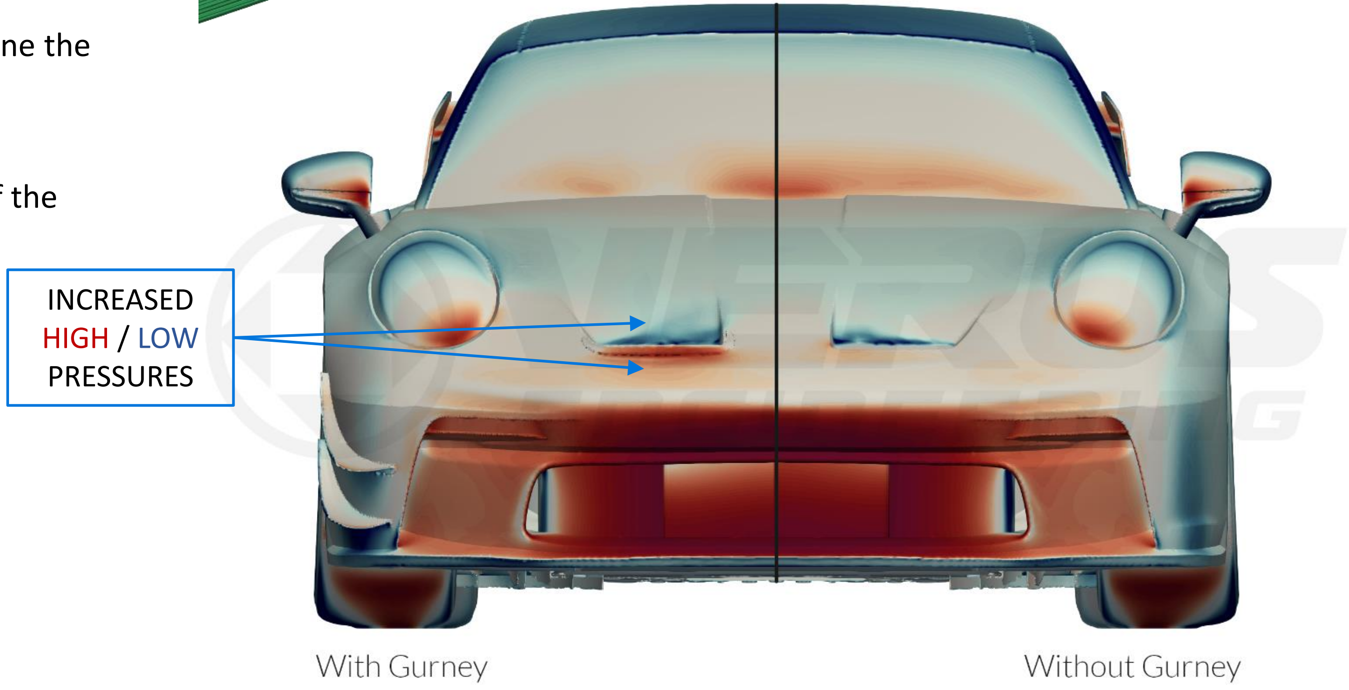
- Dive planes are great for customers looking for a slight bump in front downforce and no reduction in ground clearance.
- Verus Engineering develops dive planes to produce downforce by controlling the flow around the vehicle, not on the units themselves, improving efficacy.
- A small amount of downforce is produced on the units themselves, high pressure on top, low pressure on bottom.
- We develop the dive planes to create a beneficial vortex which helps evacuate the fenders.
- This evacuation reduces lift on the body, improving performance.
- The dive planes are produced from 2x2 twill carbon fiber finished in an automotive clear coat. Templates are supplied to ensure location of the units are correct.

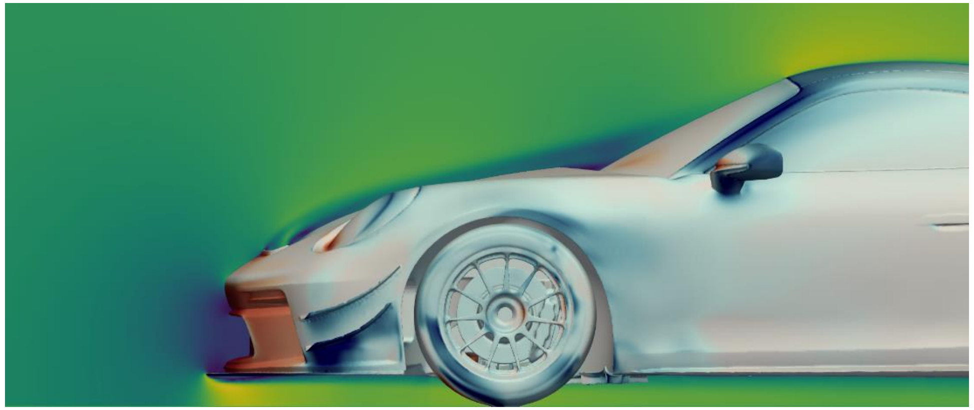


RADIATOR DUCT GURNEY

- The radiator gurneys are great for customers looking to improve front end downforce and/or improve cooling system efficiency.
- Like dive planes, they shift aero balance forward without any impact to ground clearance (like a splitter).
- These aerodynamic devices work by creating a high pressure in front of the gurney, and low pressure behind. Increased pressure in front helps push down on the front end of the car, the low pressure behind improves flow rate through the ducting and radiator.
- Radiator flow and ducting was simulated in CFD in order to determine the shape and ensure the function of the units.
- The gurneys are produced from 2x2 twill carbon fiber finished in an automotive clear coat. Templates are supplied to ensure location of the units are correct.

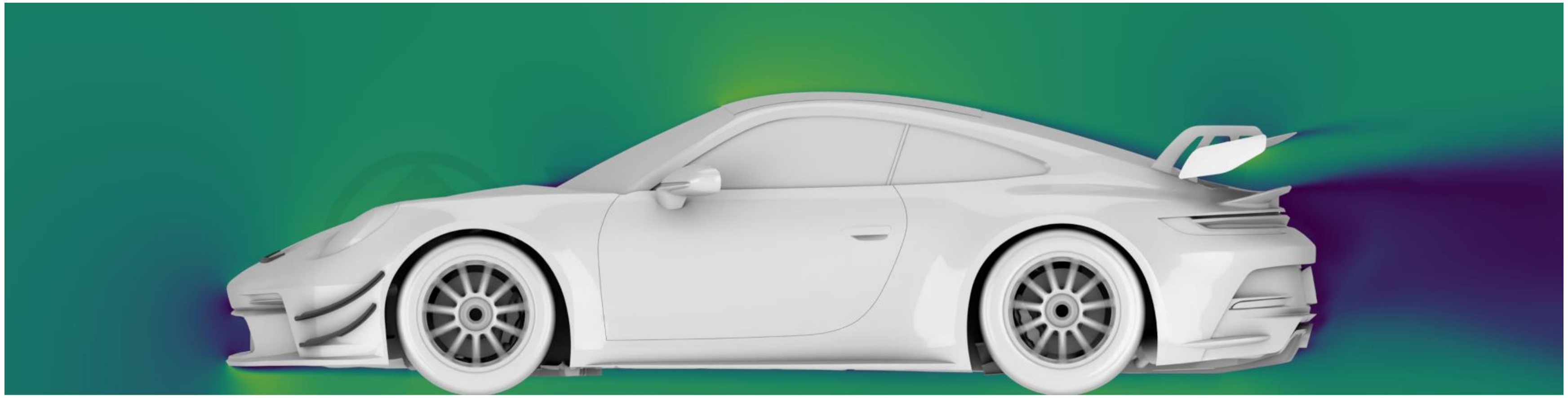






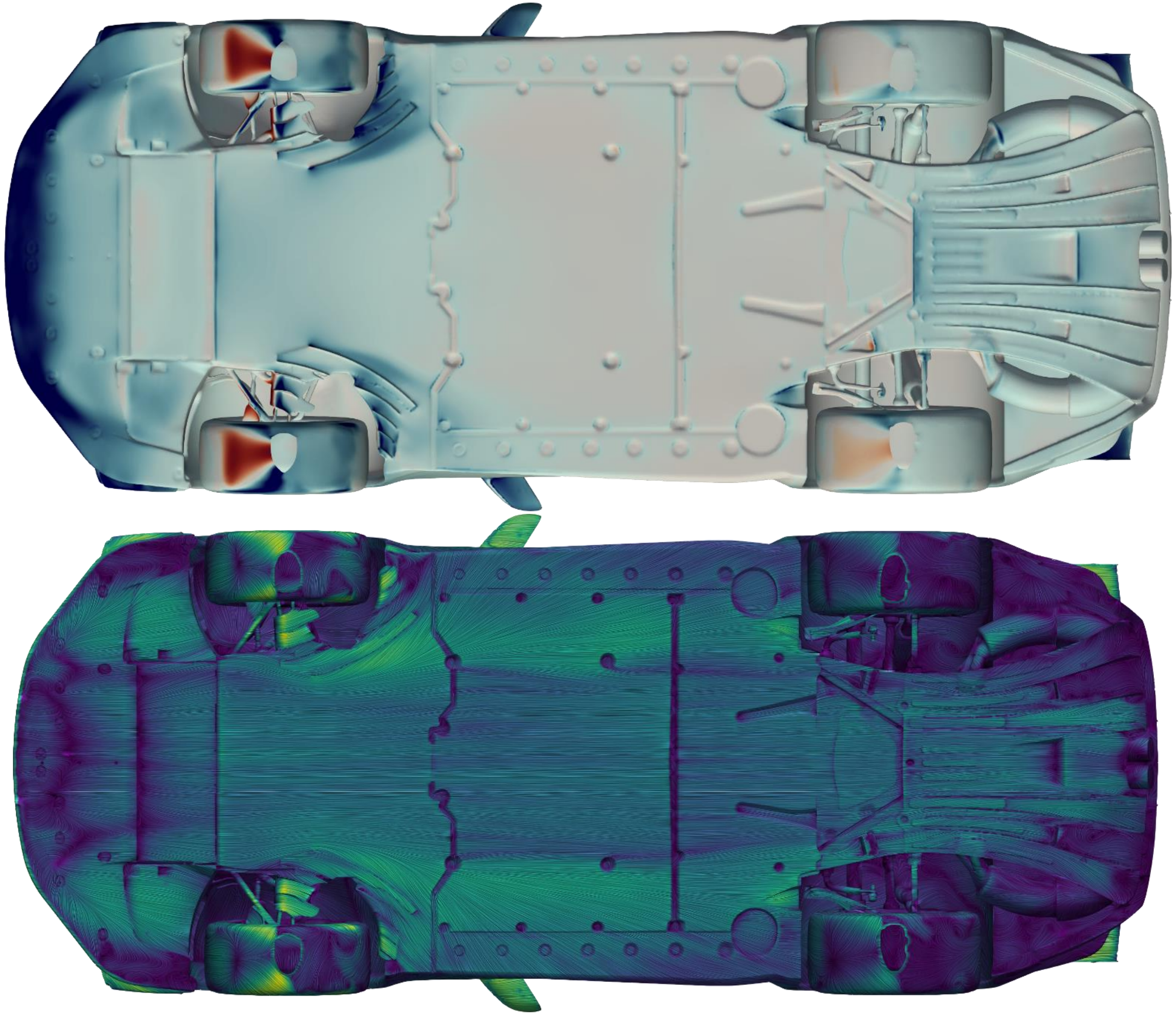
INCREASED AOA KIT – OEM WING

- This AoA kit replaces the wing mounts on the OEM wing an allow for a wider range of angle of attack adjustment.
- This gives the ability to generate more downforce from the OEM wing while retaining OEM adjustment, look, and feel.
- They bolt to the carbon wing exactly like OEM and are produced in house on our 5-axis CNC mills out of 6061 aluminum.
- CFD analysis was used to ensure that the increased angle resulted in increased performance that matched the increased front end downforce of the other components in the Ventus 1 kit.



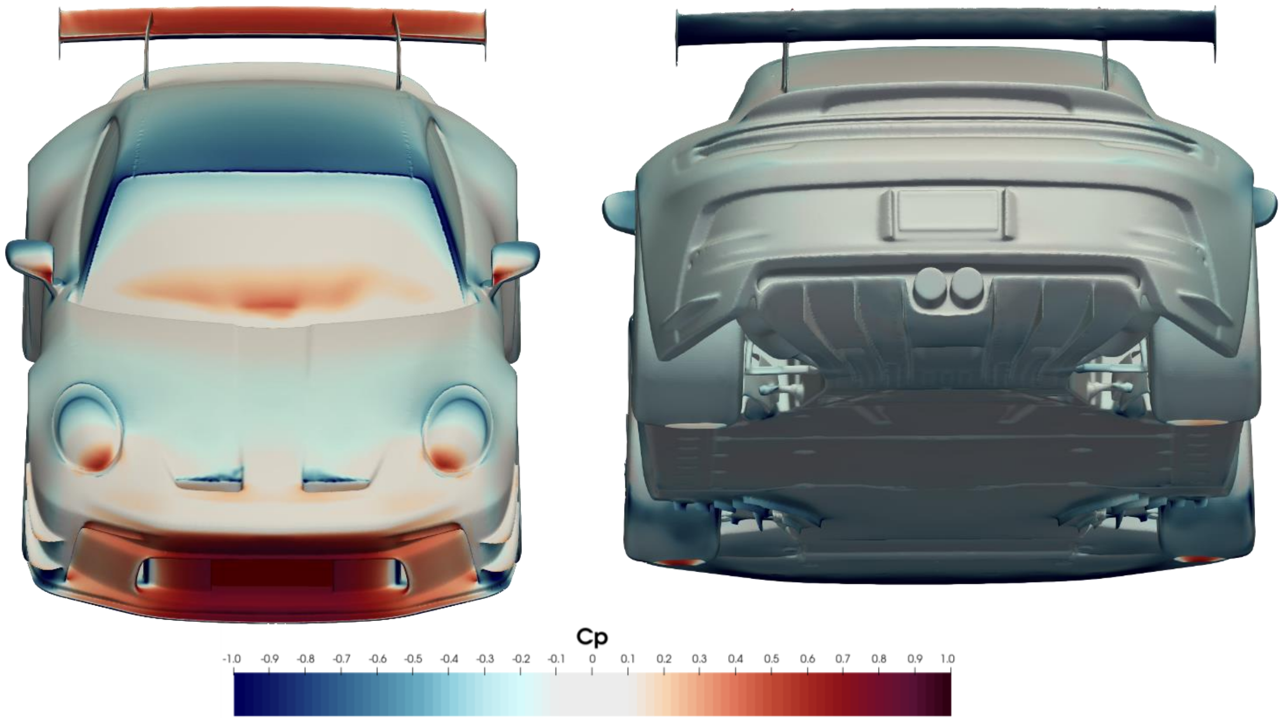
SPLITTER

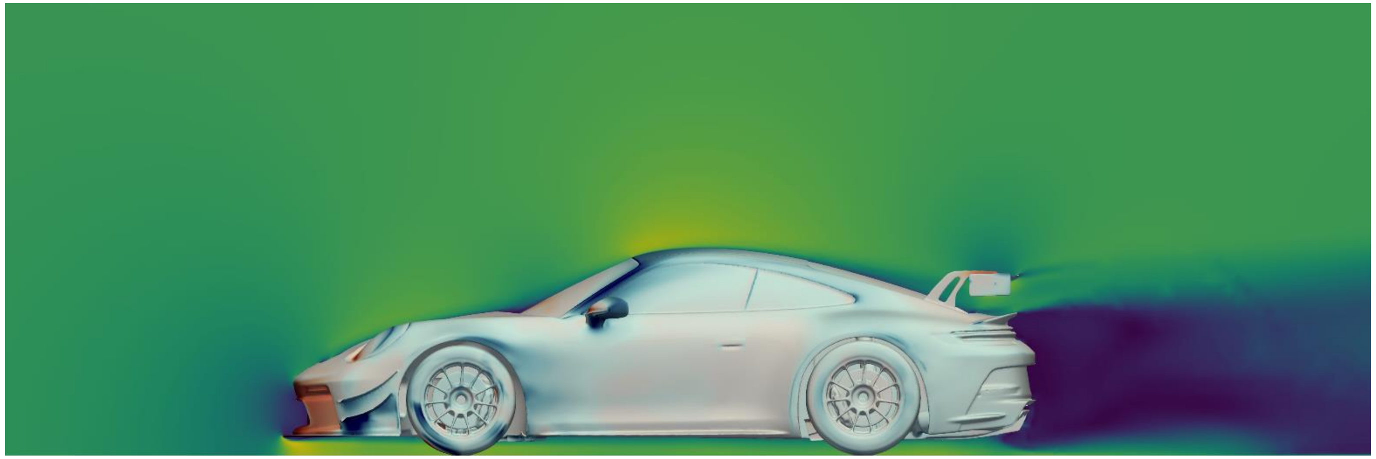
- The splitter is great for customers looking to generate significantly more front end downforce.
- The entire splitter assembly is modeled and simulated.
- The splitter has an efficiency (L/D, Lift Over Drag) of 14.5. This is a very efficient aero device.
- High pressure on the top side helps drive the splitter downward at speed
- The bottom side, like the rear wing, produces more downforce than the top side.
- The bottom is designed to feed the factory splitter diffusers for improved performance.
- Our splitter is a motorsports grade composite material. Carbon polyweave is rigid while exhibiting excellent wear characteristics. Where traditional carbon fiber components may fail due to an impact, the carbon polyweave will not.



UCW REAR WING

- The rear wing is great for customers looking for a large bump in rear downforce.
- The UCW wing profile was developed in CFD and refined in the wind tunnel.
- The airfoil produces efficient downforce on the 992 GT3.
- The bottom surface is where the majority of the downforce is generated. This low pressure pulls the car downward.
- The top surface still produces downforce, but not like the bottom surface.
- The Cp (coefficient of pressure) does not go above 0.7 on the top, but the bottom goes below -1. In other words, the bottom surface is working the wing harder. This is great as the 992 GT3 has a top mount from the factory.
- The wing bolts on like stock and is produced from 2x2 twill, pre-preg carbon fiber.

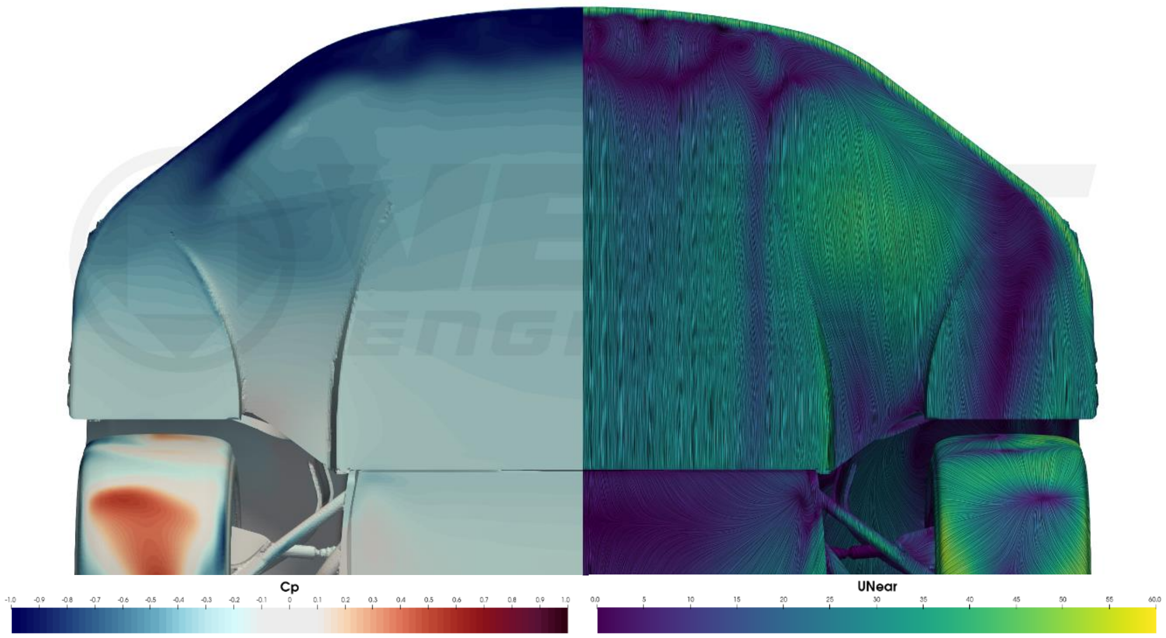


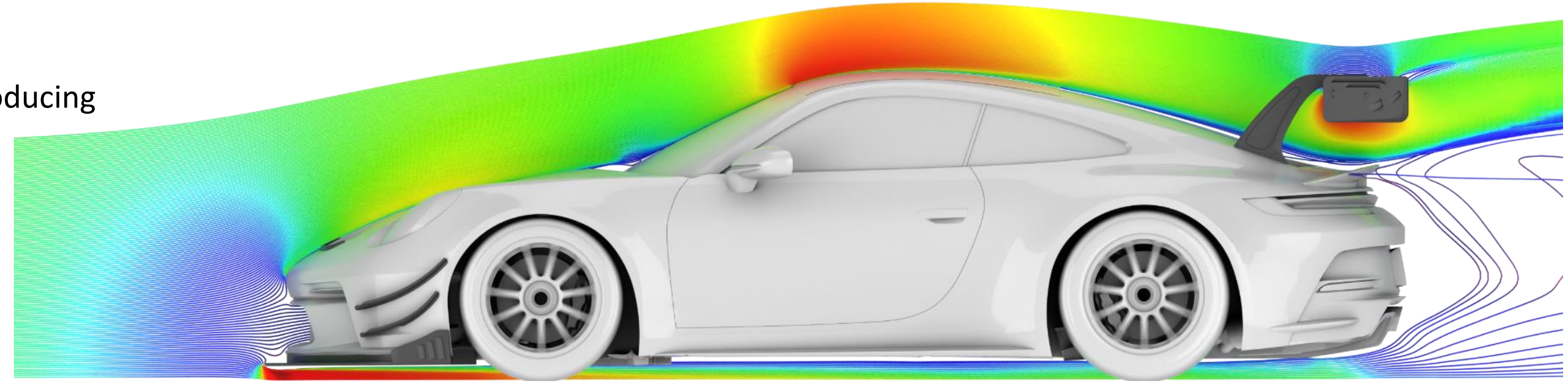


HIGH DOWNFORCE SPLITTER

- Greatly increased downforce with minimal drag penalty compared to the standard splitter.
- Improved efficiency compared to the standard splitter with L/D of 15.9 vs. 14.5.
- The entire splitter assembly is modeled and simulated.
- Designed to be paired with the V1X rear wing
- The bottom side, like the rear wing, produces more downforce than the top side.
- This splitter retains all of the features and materials of the standard splitter while adding:
    - Extended leading edge
    - Large carbon fiber diffusers (much larger than OEM)
    - Optional 3D printed carbon fiber nylon end plates
- The complete Ventus 3 package @ ~6° AoA is capable of producing more downforce than the 992 GT3RS.

(media.Porsche.com/mediakit/991-gt3-rs/en/911-gt3-rs/aerodynamic)



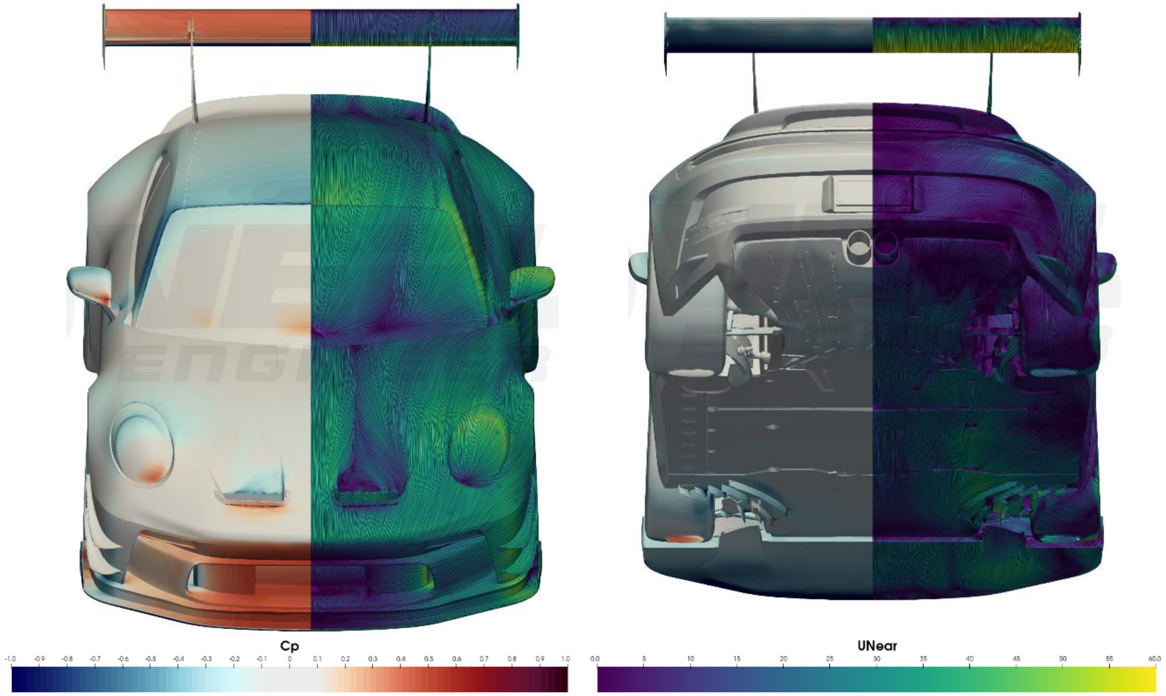


V1X REAR WING

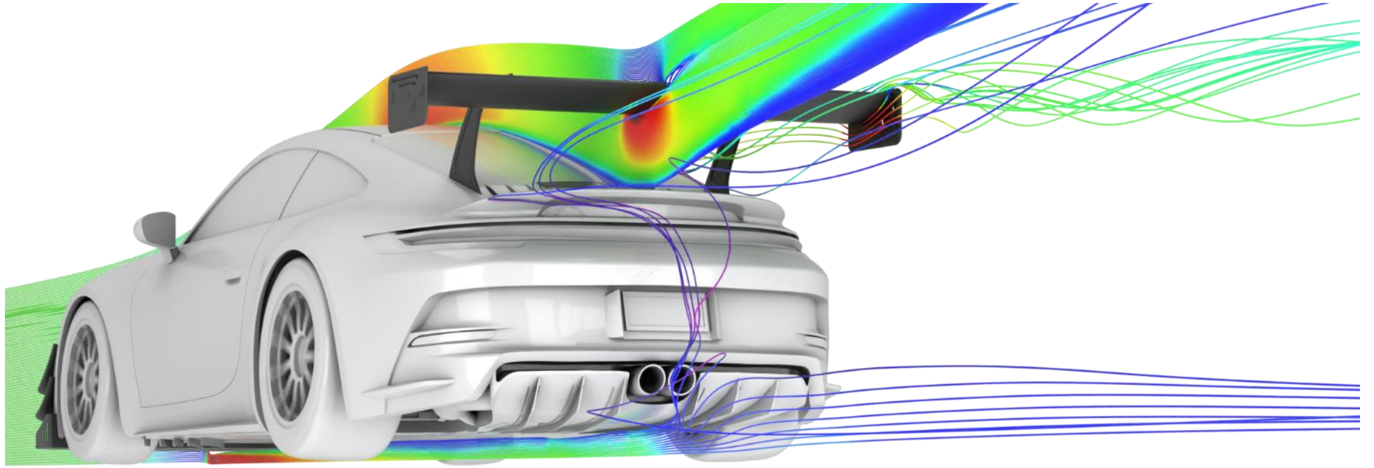
The same methodology as the UCW but with capacity for much higher downforce (see charts on the following page).

The V1X was designed with efficiency in mind:

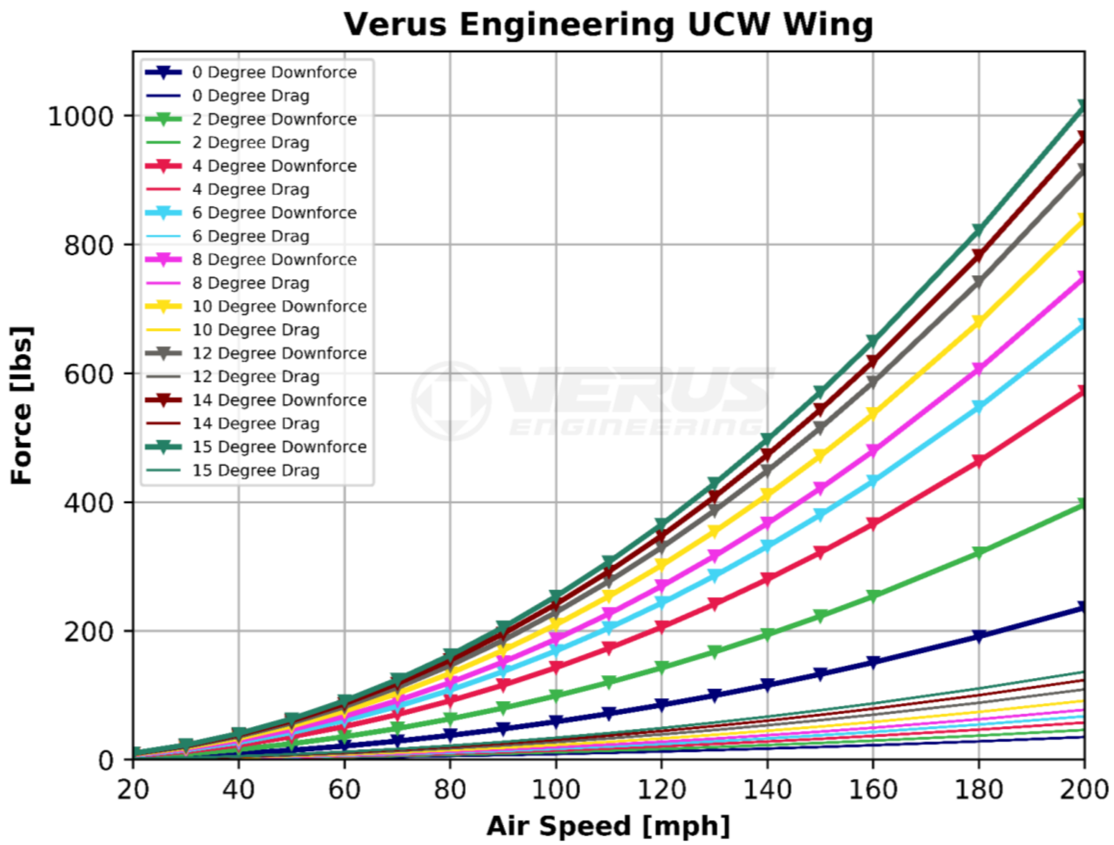
- The airfoil shape was optimized using adjoint and optimization methods in CFD and correlated in the wind tunnel.
- Slots on the endplate decrease vortex energy off the endplate. Decreasing vortex energy reduces pressure drag.
- 1700mm is the recommended wing width for the 992 GT3. However, you can custom order the width you want up to 1950mm.

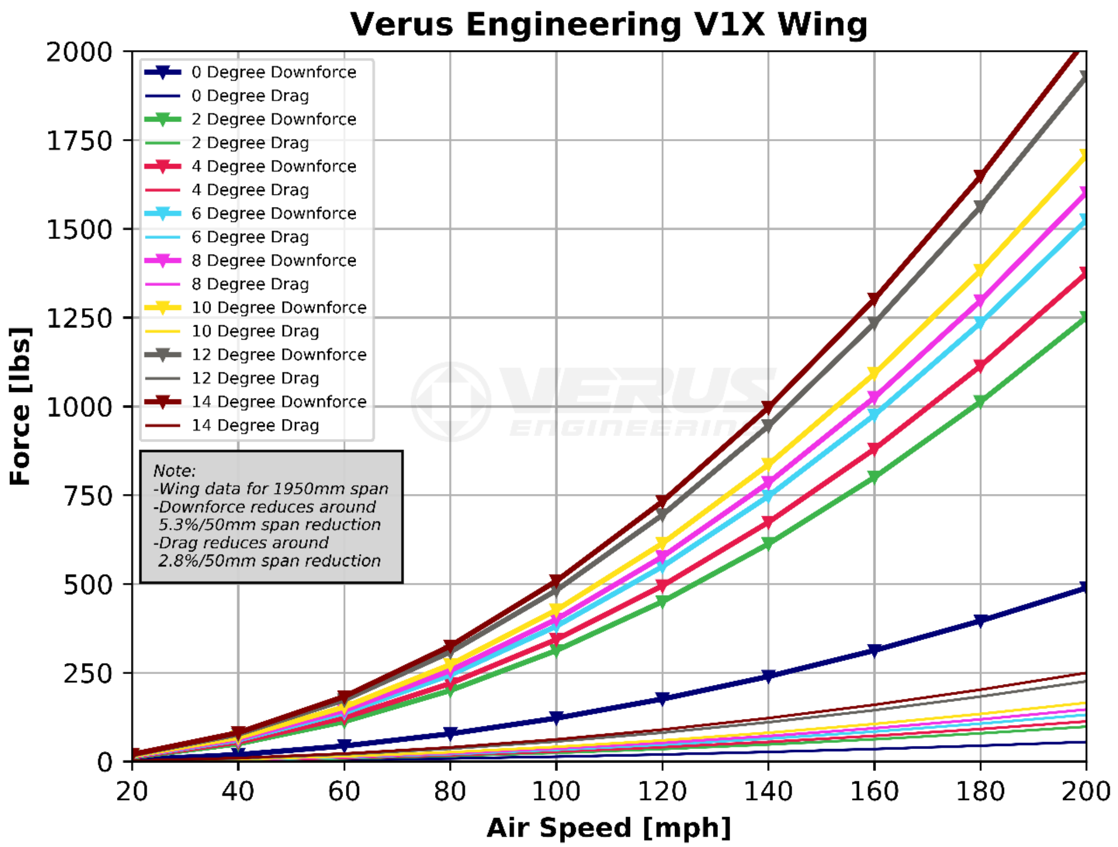


	Ventus 2 UCW @ 12°AOA	Ventus 3 V1X @ 6° AOA	Percent Difference
Chord (mm)	250	300	+ 20%
Total Downforce (lbs) @ 120 mph	544	903	+ 63.0%
Total Drag (lbs) @ 120 mph	387	394	+ 1.8%
Balance (% Front/Rear)	41.6 / 58.4	47.6 / 52.4	+ 14%



SUMMARY : UCW & V1X REAR WINGS



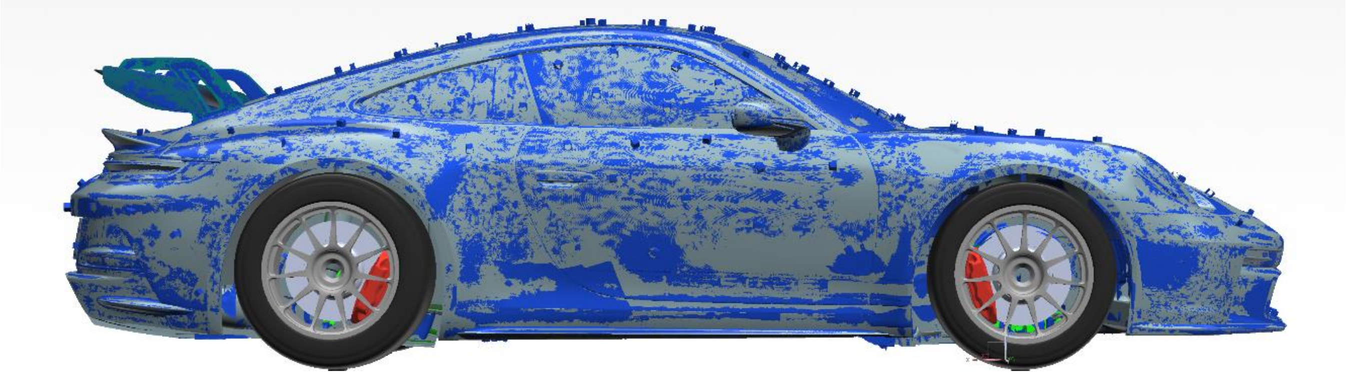


SUMMARY : GENERAL

- The Ventus kits are designed to decrease lap times utilizing well developed and functional aerodynamic components.
- The products feature an OEM like fit and finish with zero permanent modifications to the vehicles.
- The components increase vehicle performance.
- No engine modifications means you retain the factory drivetrain warranty!
- The R&D was done using cutting edge technology in CFD, wind tunnel testing, track testing with a professional driver, and proven designs from past work.
- Individual components can be installed without the full package, though to ensure a safe balance, we recommend the packages.

QUALITY OF CAD MODEL

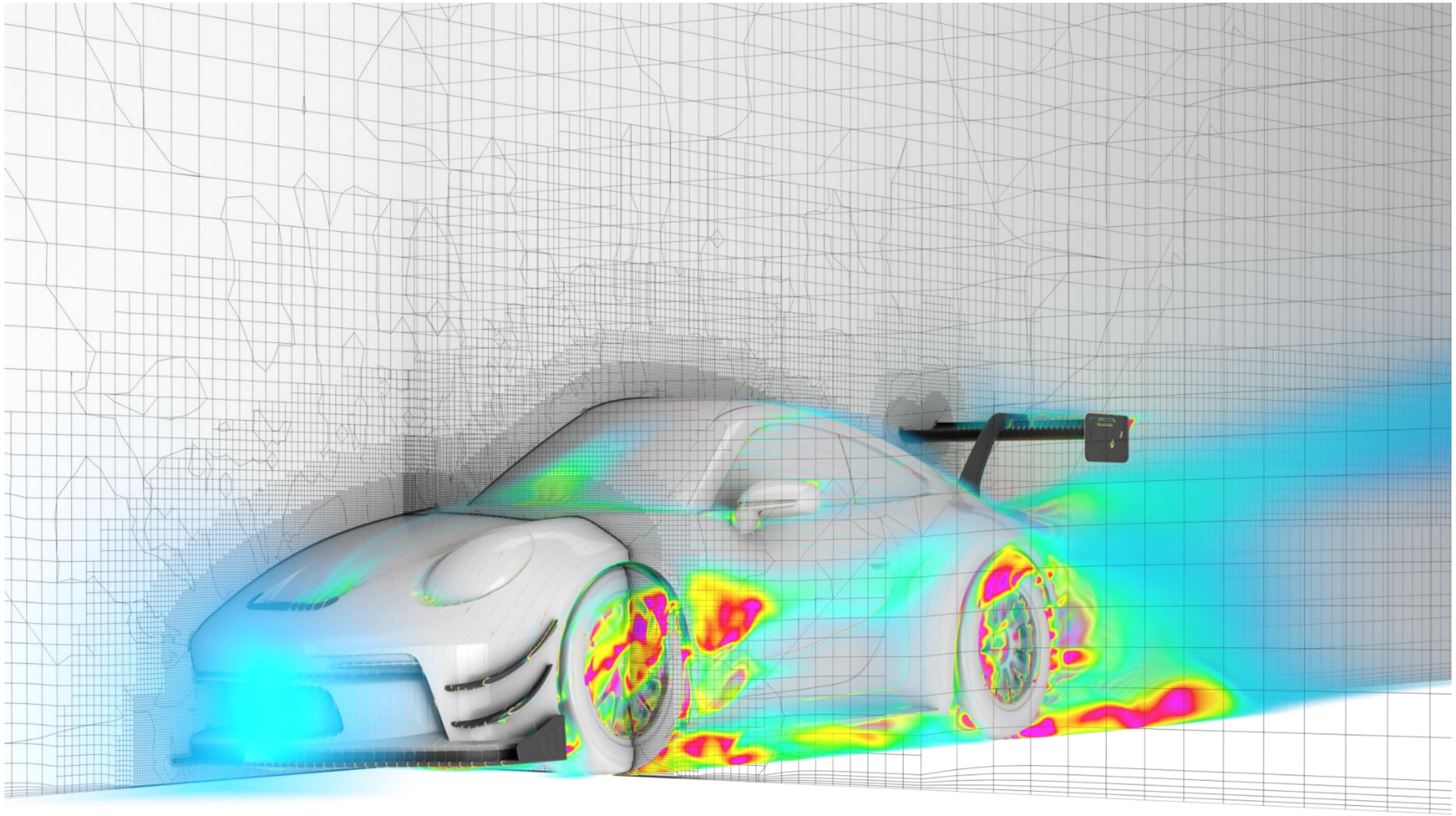
- The CAD model is a crucial aspect of accuracy.
- Bad inputs result in bad outputs.
- The CFD simulation is only as good as the geometry and setup of the CFD analysis.
- The 992 GT3 was scanned in house and a 3D CAD model was created from this scan.
- The image to the right shows the overlay of the CAD model (gray) and the scan (blue).
- The surfaces are less than 1mm off from the actual scan model in the “worst” locations, with most of the car being less than this.
- Through ducts and radiator ducting were modeled for improved analysis accuracy.



THE SCIENCE

- The development was done using OpenFOAM v2106 which is a finite volume CFD software. The solver was SIMPLE and the turbulence model was K-Omega SST using standard wall conditions. We use standard automotive arrangement when setting up boundary conditions and running a full-car. Most of the cases simulated used a slight yawed airflow of 0.5 degrees. 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. Other ride heights and yaw rates were also used to simulate cornering.

- The use of porous flow was used for all the cooling stacks on the car. The darcy-forchheimer values used were based on past work of similar radiators/heat exchangers. All three coolers in the front were used for the porous flow.



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).