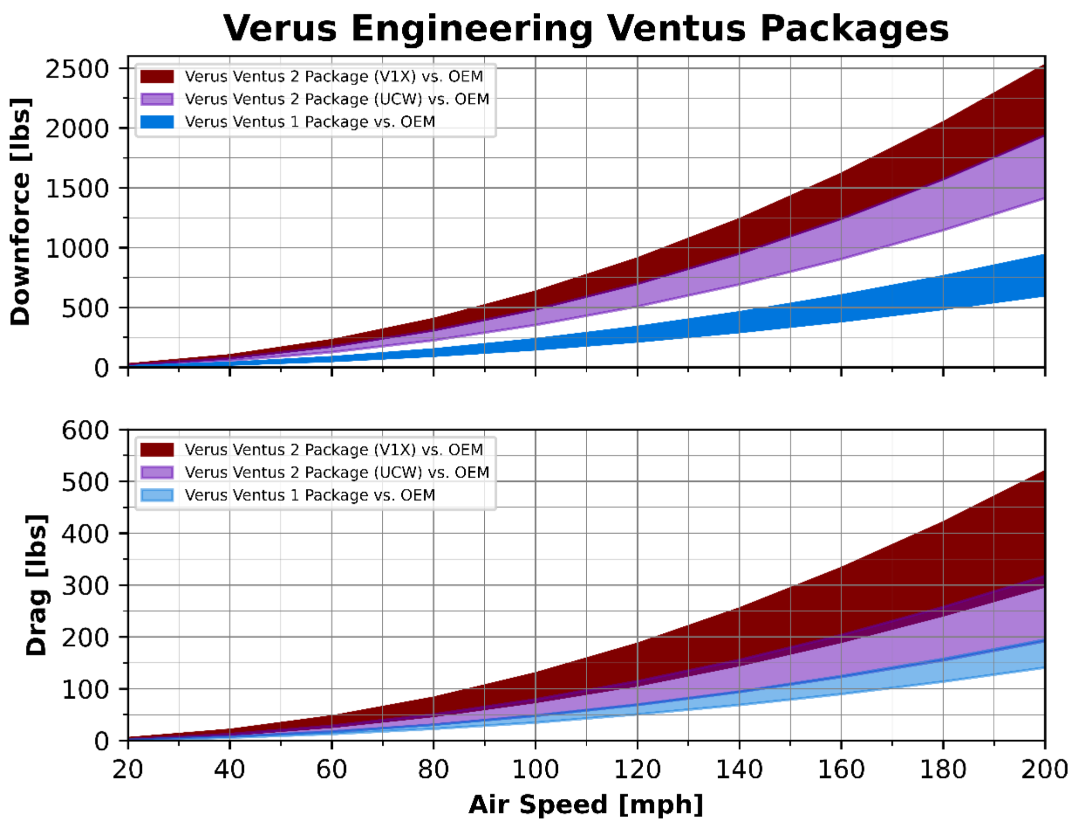
BMW G82 M4 PLATFORM

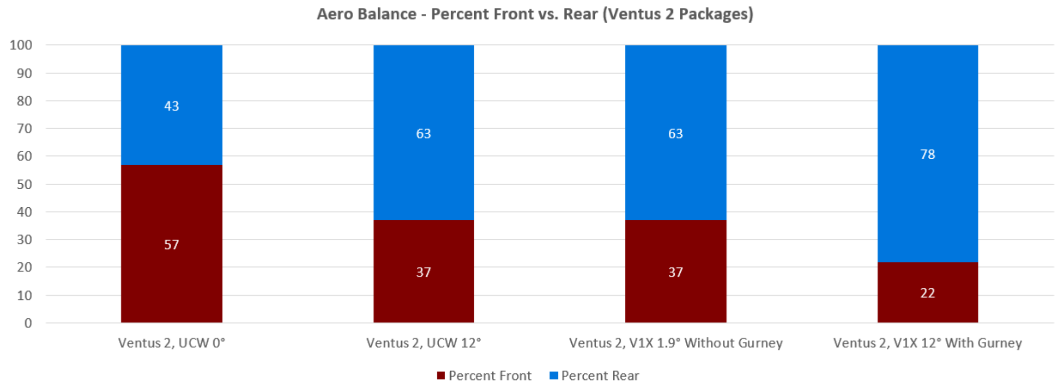
PERFORMANCE OF VERUS ENGINEERING VENTUS PACKAGES

OVERVIEW

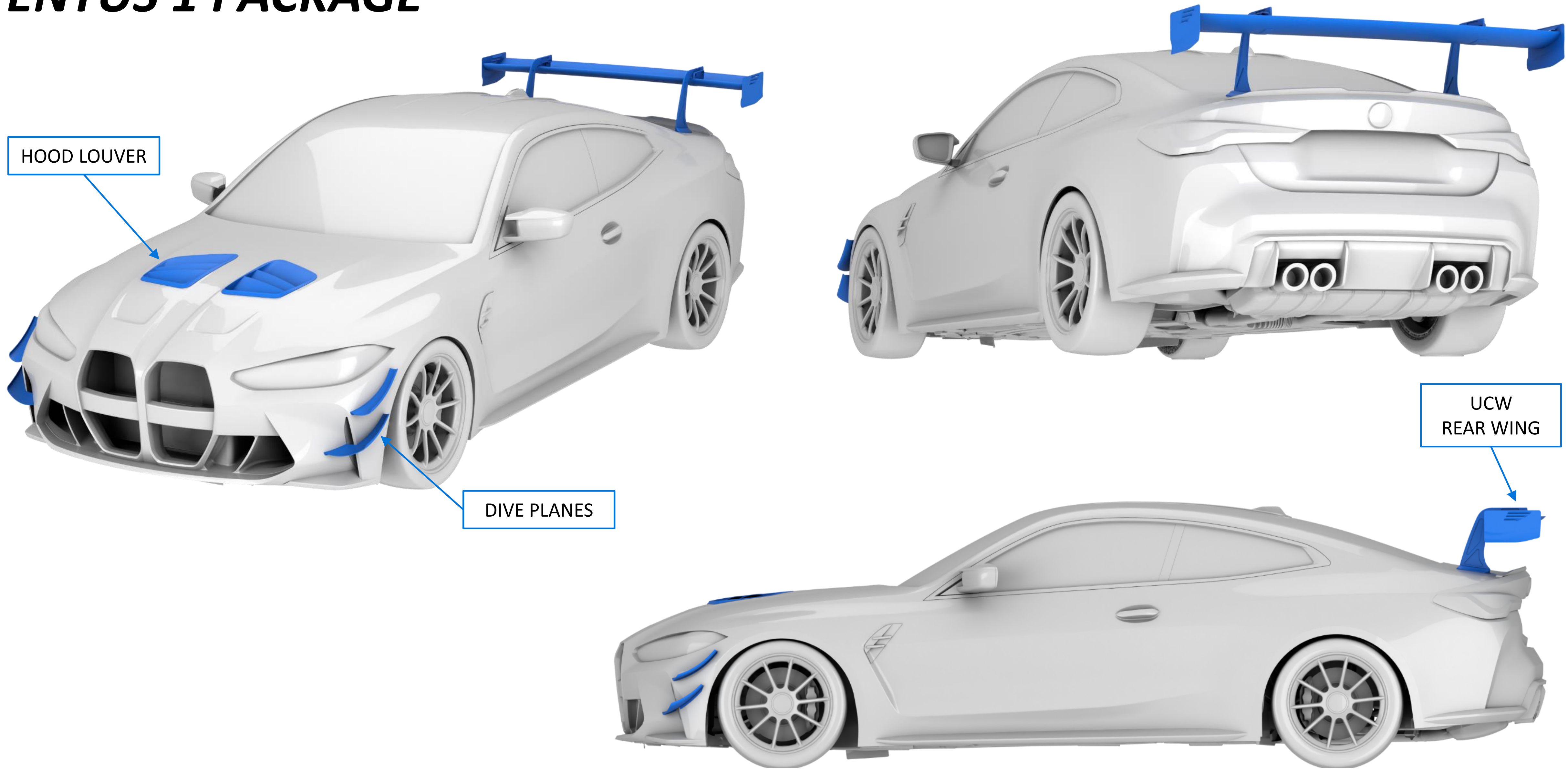
SUMMARY : AERODYNAMIC FORCES

- Aerodynamic forces change with the square of the vehicle speed, which is why we use a graph.
- The Ventus 1 & 2 packages significantly increase downforce over stock with a comparatively minimal impact to drag and are a great choice for track enthusiasts and competitive racers alike.
- The Ventus 1 package uses the Verus Engineering Dive Planes, UCW Rear Wing, and we recommend the use of the Carbon Hood Louver to increase downforce and improve aero balance.
- The Ventus 2 package uses the Verus Engineering Dive Planes, UCW or V1X Rear Wings, Front Splitter (with End Plates), Side Splitters, and Hood Louver.
- Angle of Attack (AoA) adjustment allows the driver to fine tune aerodynamic balance to his or her preference.
- The thick diverging lines for Ventus 1 and 2 show how performance varies depending on setup.
    - Ventus 1 is shown from 0° AoA (no Hood Louver) to 5° AoA (with Hood Louver)
    - Ventus 2 is shown from 0° AoA to 12° AoA with the UCW
    - Ventus 2 is shown from 2° AoA to 12° AoA with the V1X
    - Note that the V1X at 2° produces the same downforce as the UCW at 12° with 1.5% less drag and the same aero balance.

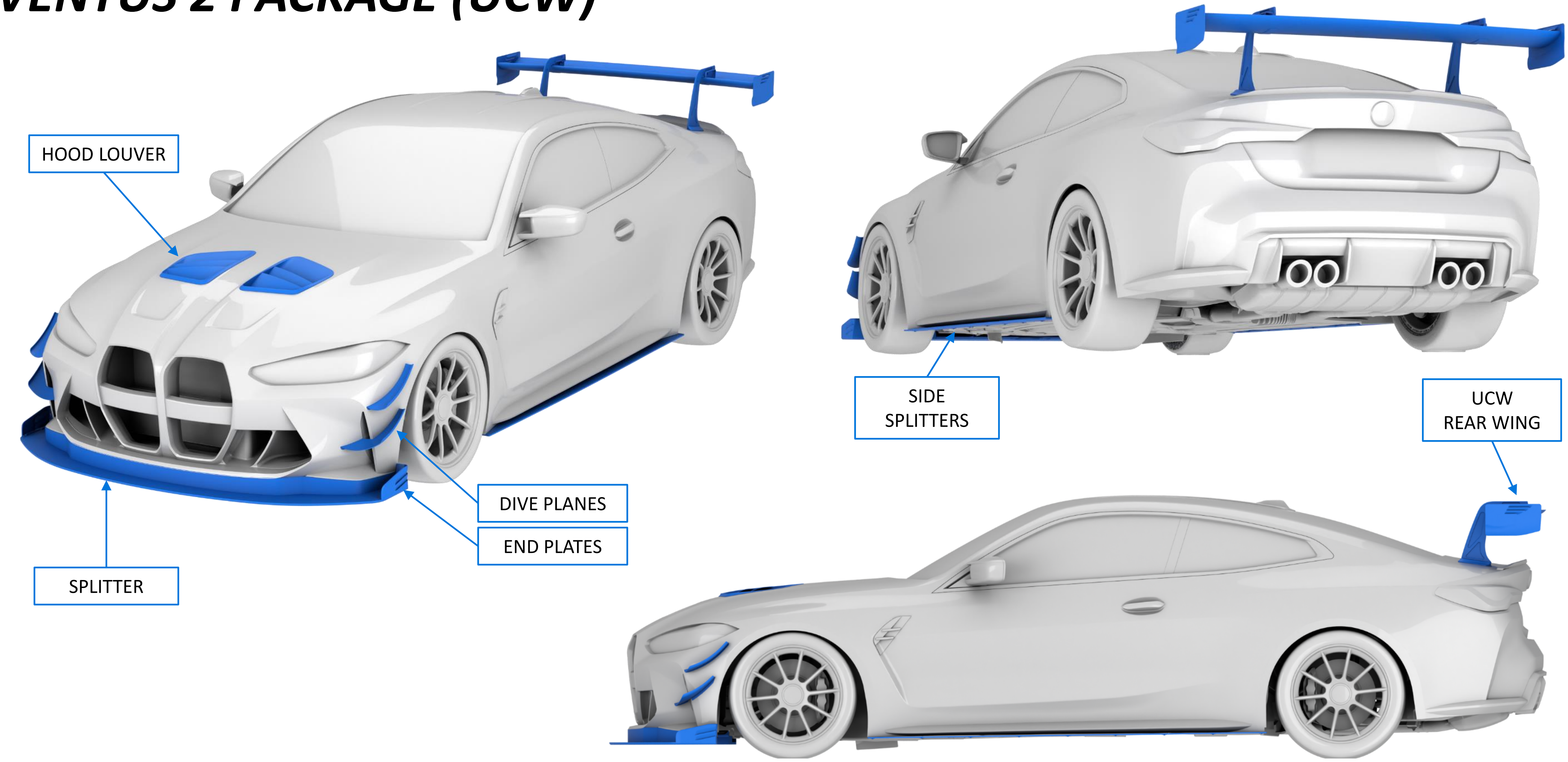




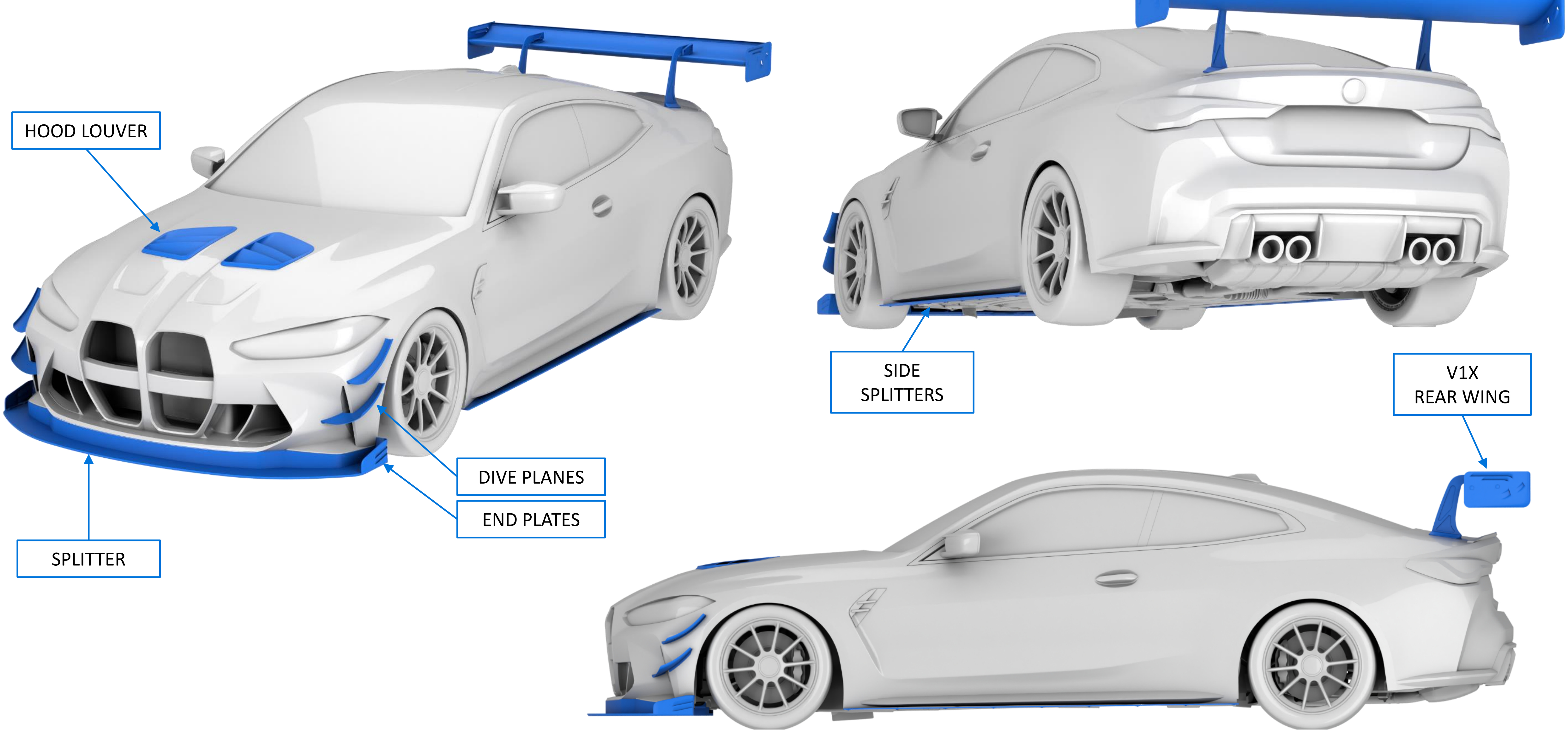
VENTUS 1 PACKAGE



VENTUS 2 PACKAGE (UCW)

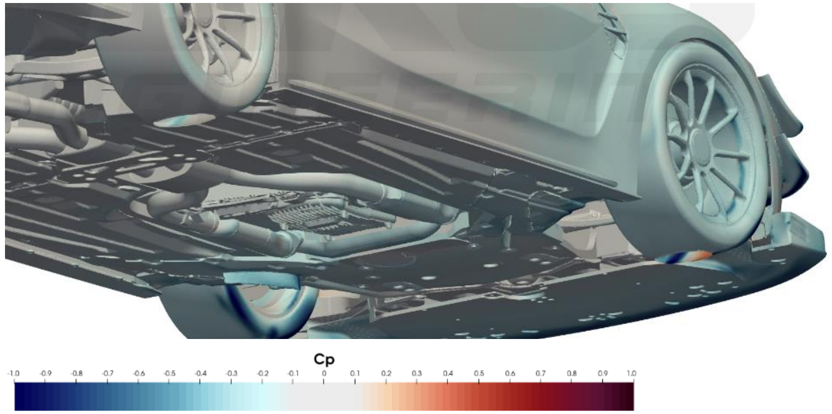


VENTUS 2 PACKAGE (V1X)



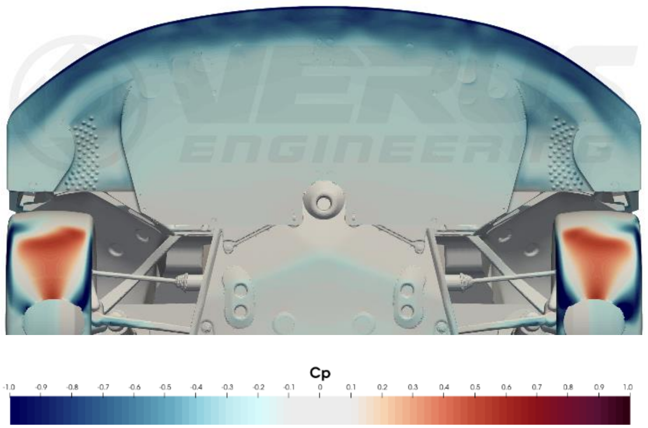
DIVE PLANE / CANARDS

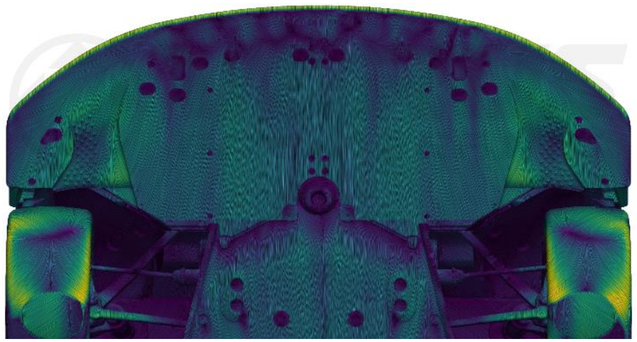
- Dive planes are great for customers looking for a slight bump in front downforce and no reduction in ground clearance.
- Verus Engineering develops dive planes to produce downforce by controlling the flow around the vehicle, not on the units themselves, improving efficacy.
- A small amount of downforce 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.

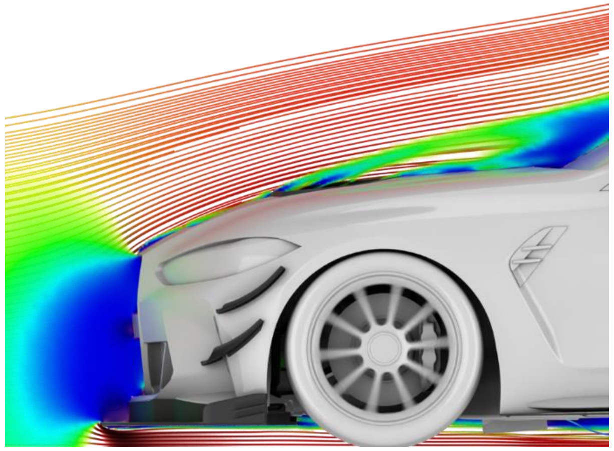


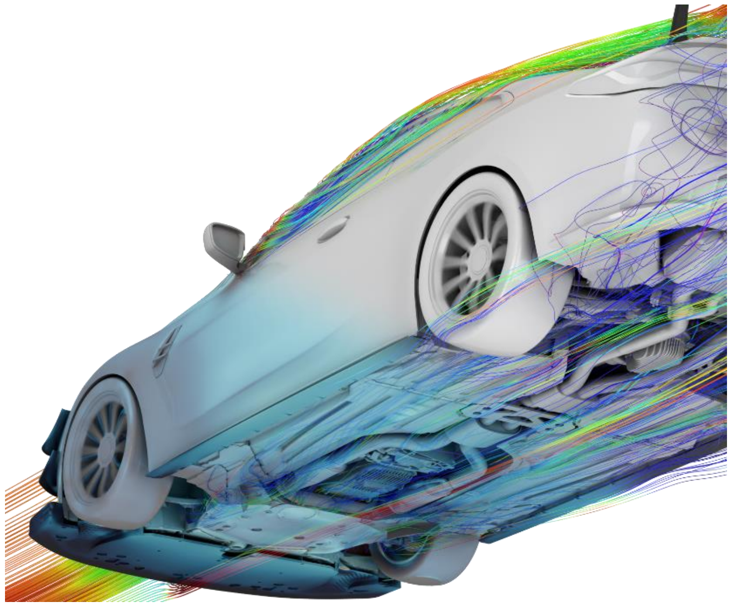
SPLITTER

- The splitter is great for customers looking to generate significantly more front end downforce.
- The entire splitter assembly is modeled and simulated.
- Front splitters are very efficient aero devices.
- 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 Verus Engineering splitter includes a rearward facing duct to maintain flow through the downward facing oil cooler eliminate the impact on splitter performance. Unlike our G87 M2 splitter, this duct exits on the top side of the splitter. We recommend monitoring oil temperature during sustained high load driving, especially in hot climates.
- 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.



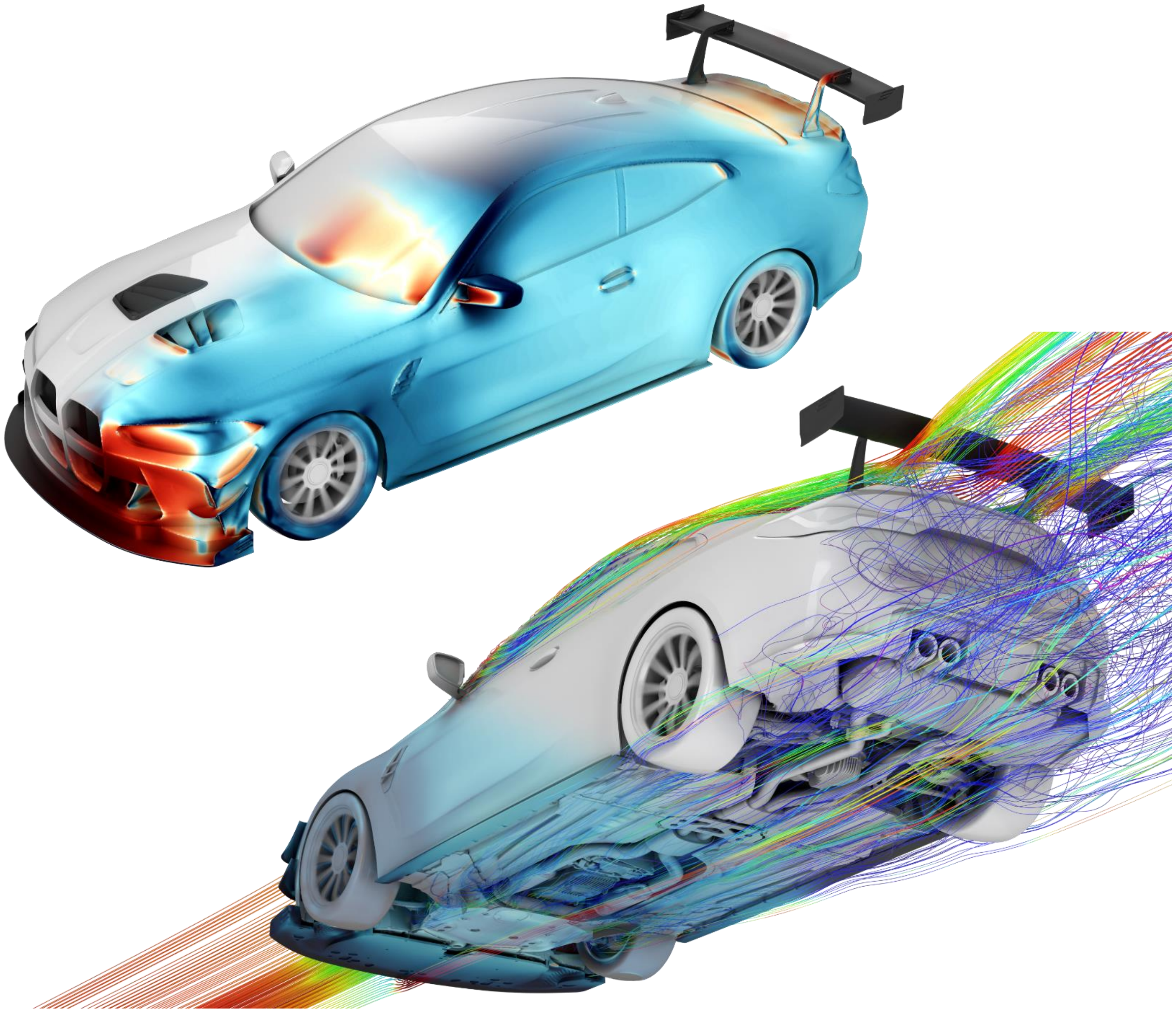






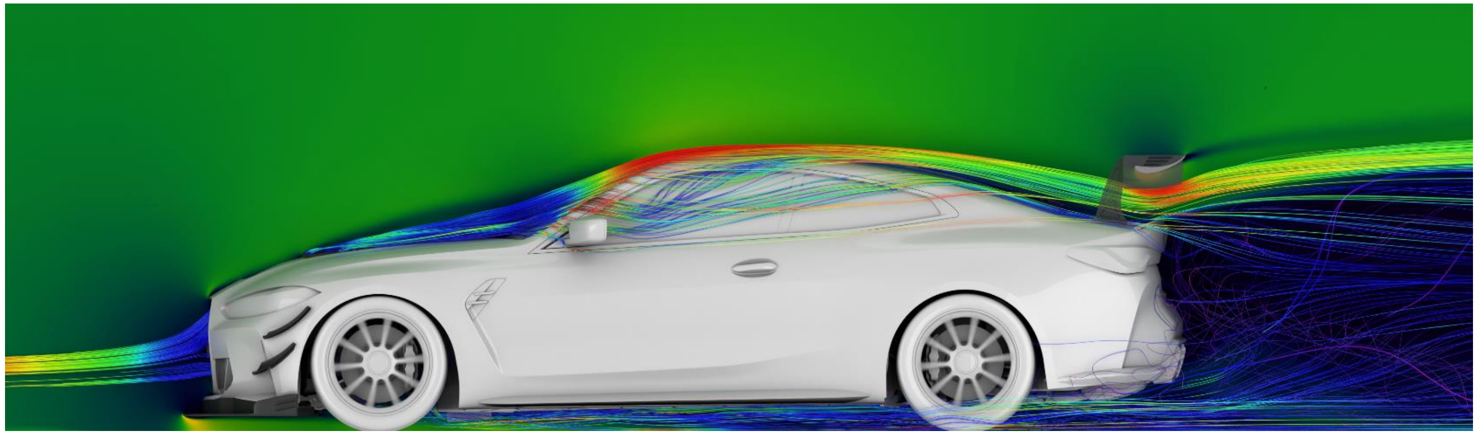
SIDE SPLITTERS

- Side splitters reduce the amount of high pressure air from the top side of the vehicle making it under the vehicle.
- We focused on designing the units to clean up underbody airflow during turning or high yaw conditions.
- The increase in downforce is centrally located on the vehicle and the aero balance is minimally affected.
- Our side splitters are made with 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.
- The side splitters bolt to the vehicle using supplied hardware installed in the factory side skirt locations.



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 substantial downforce on the G82 M4.
- 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 trunk mounts are machined from 6061 aluminum and have a lower surface matched to the contour of the OEM trunk lid. They sandwich the trunk lid with the hinge mounts using stainless steel standoffs to prevent trunk deformation. This makes for one of the most rigid UCW wing kits we've ever produced.
- The UCW is produced from 2x2 twill carbon fiber finished in an automotive clear coat.



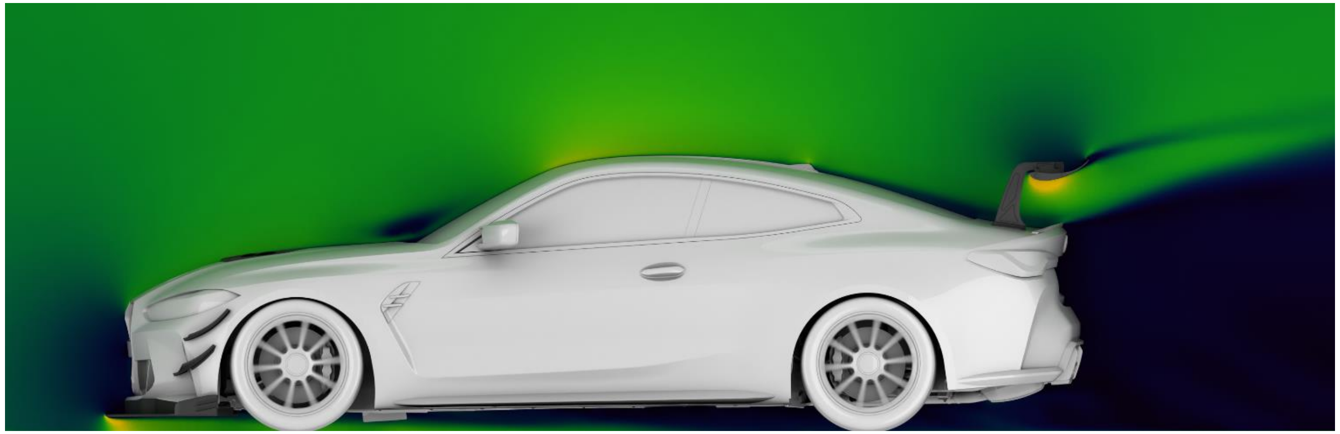
V1X REAR WING

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

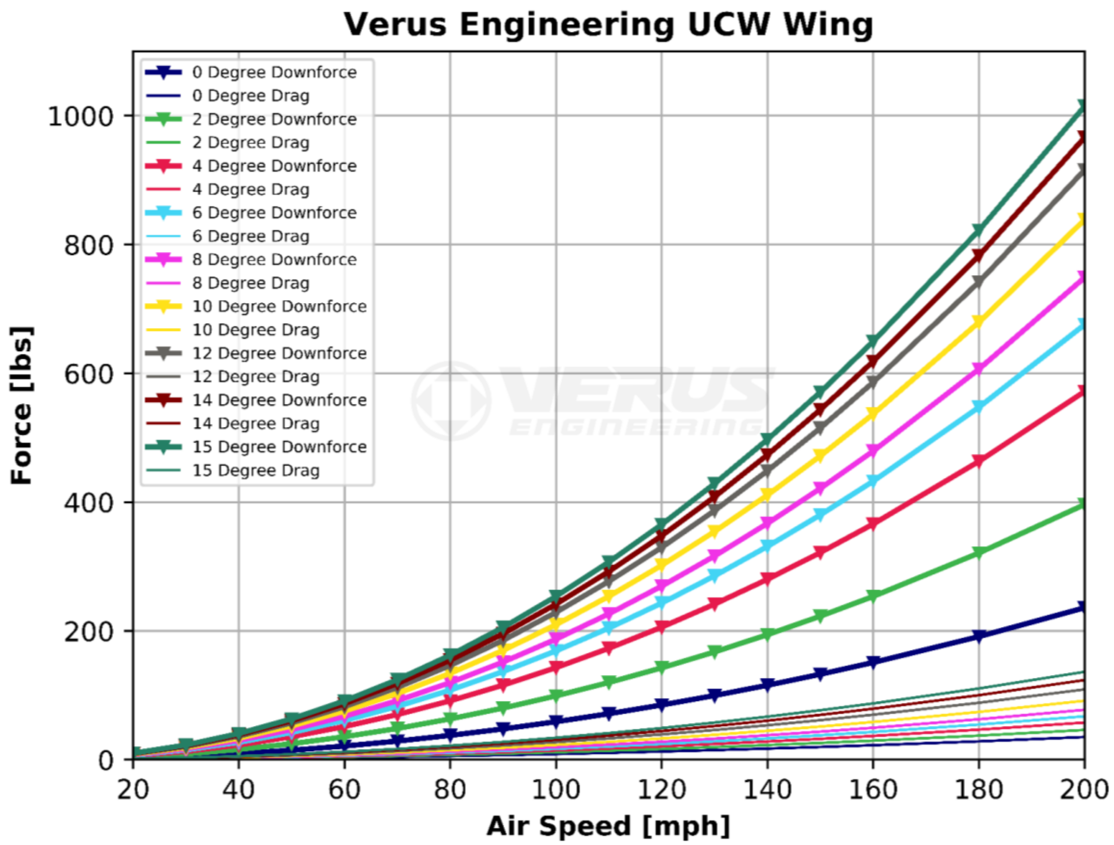
The V1X was designed with efficiency in mind:

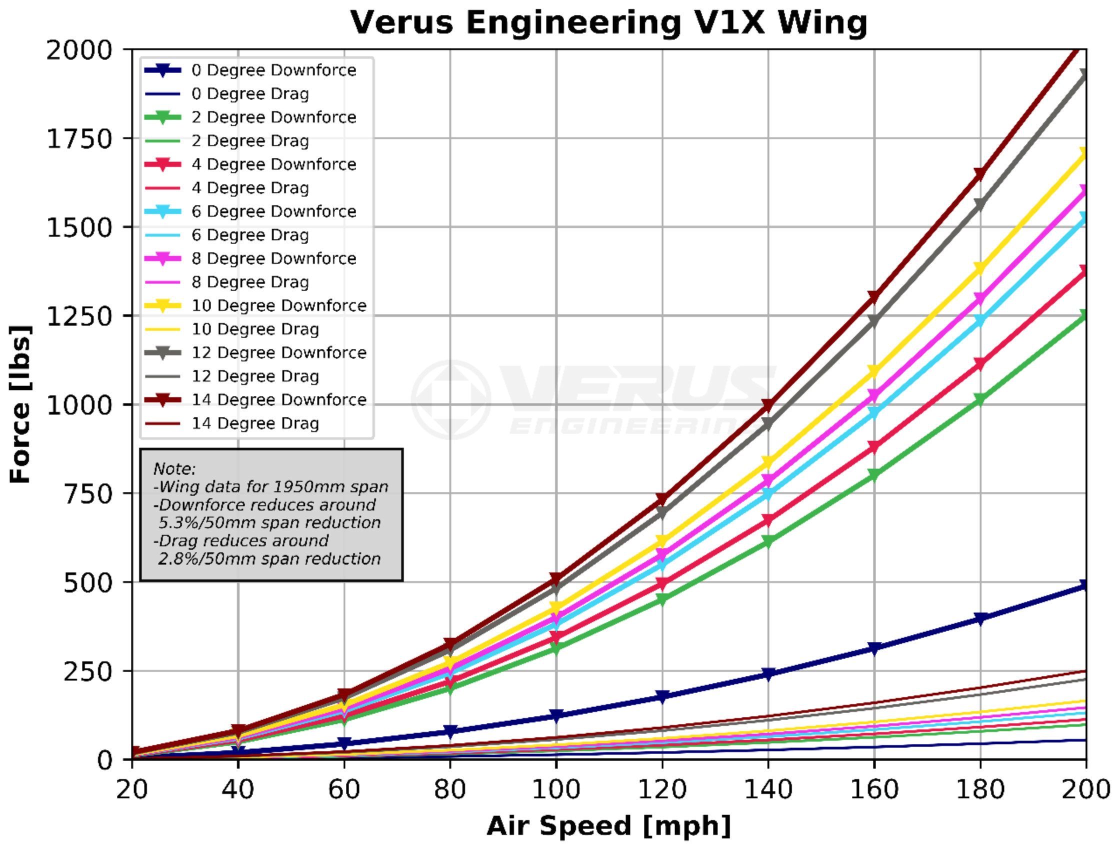
- The airfoil shape was optimized using adjoint and optimization methods in CFD and correlated in the wind tunnel.
- Slots on the endplate decrease vortex energy off the endplate. Decreasing vortex energy reduces pressure drag.
- Swan Neck mount provides the V1X with cleaner air and more bottom surface area to make more efficient downforce.
- 1750mm is the default wing width for the M4. However, you can custom order the width you want up to 1950mm.

	Ventus 2 UCW @ 12°AOA	Ventus 2 V1X @ 2° AOA	Percent Difference
Chord (mm)	250	300	+ 20%
Downforce (lbs) @ 120 mph	668	669	+ 0.1%
Drag (lbs) @ 120 mph	482	475	- 1.5%
Balance (% Front/Rear)	36.8 / 63.2	37.0 / 63	- 0.5%



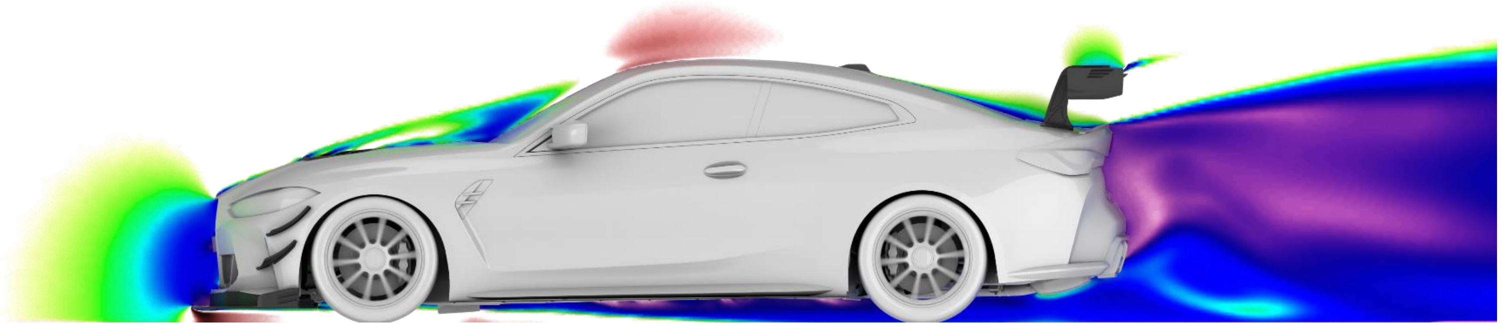
SUMMARY : UCW & V1X REAR WINGS

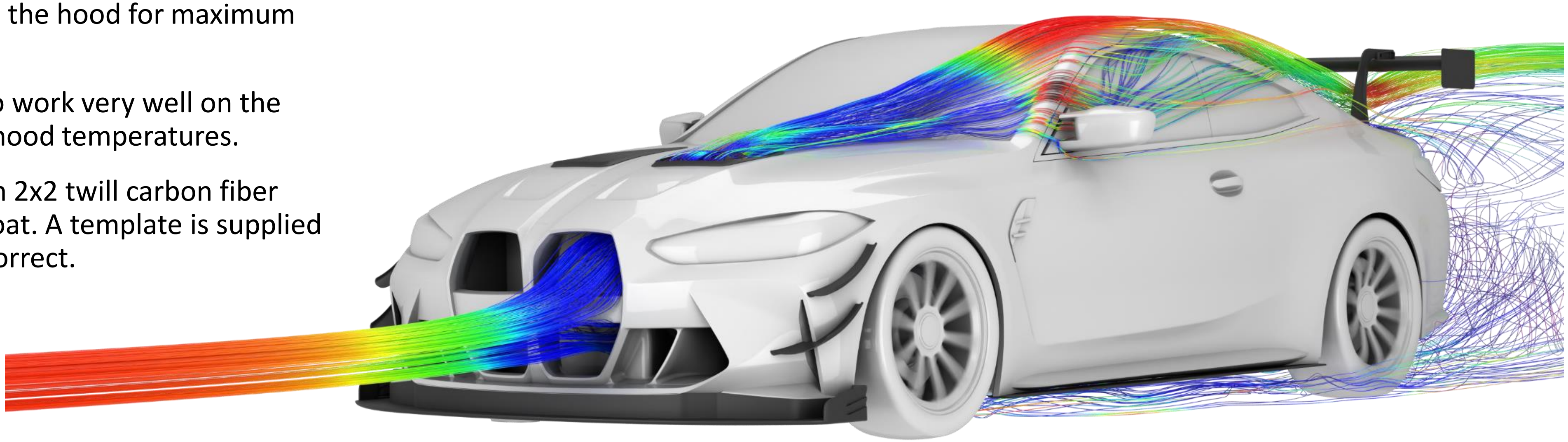




HOOD VENT / LOUVER

- Reduces engine bay heat and pressure.
- The louver improves cooling stack efficiency and under hood component longevity.
- Adds a bump in the front end downforce by alleviating air pressure in the engine bay which significantly improves aero balance (35% Front to 45% Front with the UCW at 5° AoA)
- Developed using 3D scan data to have an OEM type fit and finish to the hood's contour.
- Placed in an area that removed ***minimal*** under hood structure and low pressure above the hood for maximum evacuation.
- Track testing shows the louvers to work very well on the car, dramatically reducing under hood temperatures.
- The hood louver is produced from 2x2 twill carbon fiber finished in an automotive clear coat. A template is supplied to ensure location of the unit is correct.



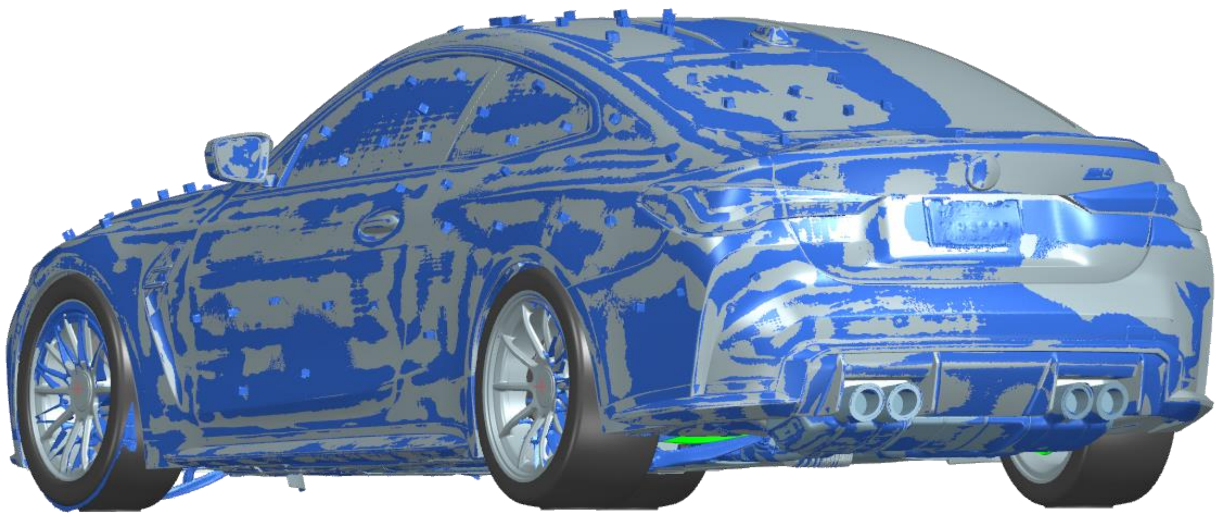


SUMMARY

- The Verus Engineering Ventus Packages for the BMW G82 M4 platform are designed to decrease lap times utilizing well developed and functional aerodynamic components.
- These packages are designed to fit like OEM and increase the factory performance all while keeping the factory warranty.
- The components increase vehicle performance.
- The R&D of the packages was done using cutting edge technology in CFD, knowledge gained through wind tunnel testing, track testing with professional driver, and proven designs from past work.
- The individual components can be installed without the full package, though to ensure a safe balance, we recommend the packages.

QUALITY OF CAD MODEL

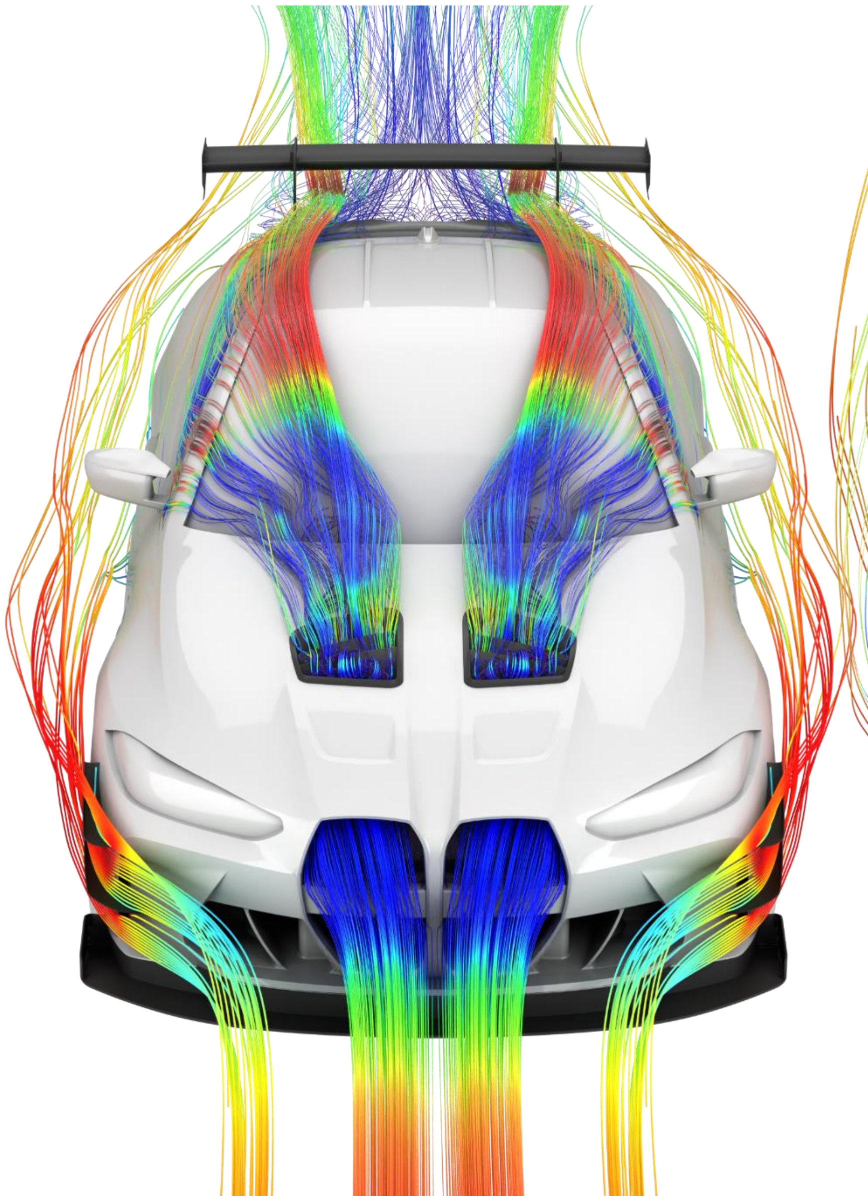
- The CAD model is a crucial aspect of accuracy.
- Bad inputs result in bad outputs.
- The CFD simulation is only as good as the geometry and setup of the CFD analysis.
- The M4 was scanned in house and a 3D CAD model was created from this scan.
- The image to the right shows the overlay of the CAD model (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.

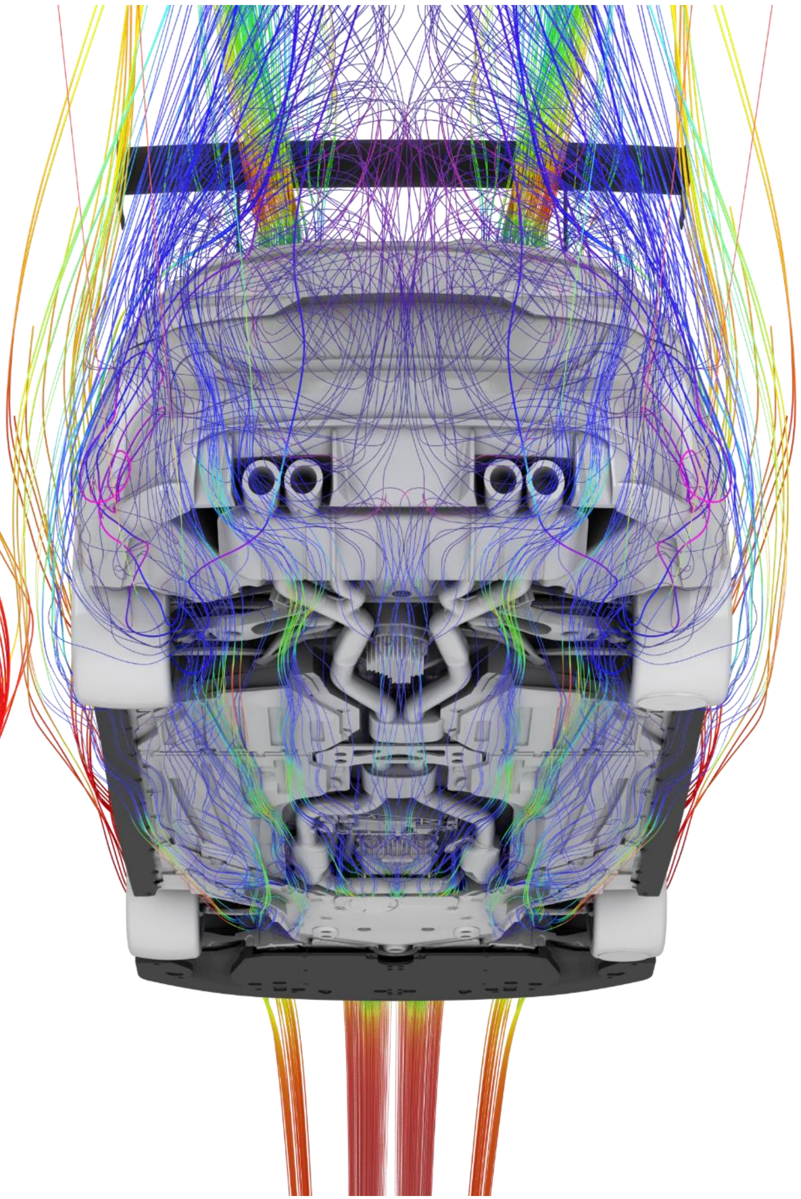


THE SCIENCE

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 five 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).