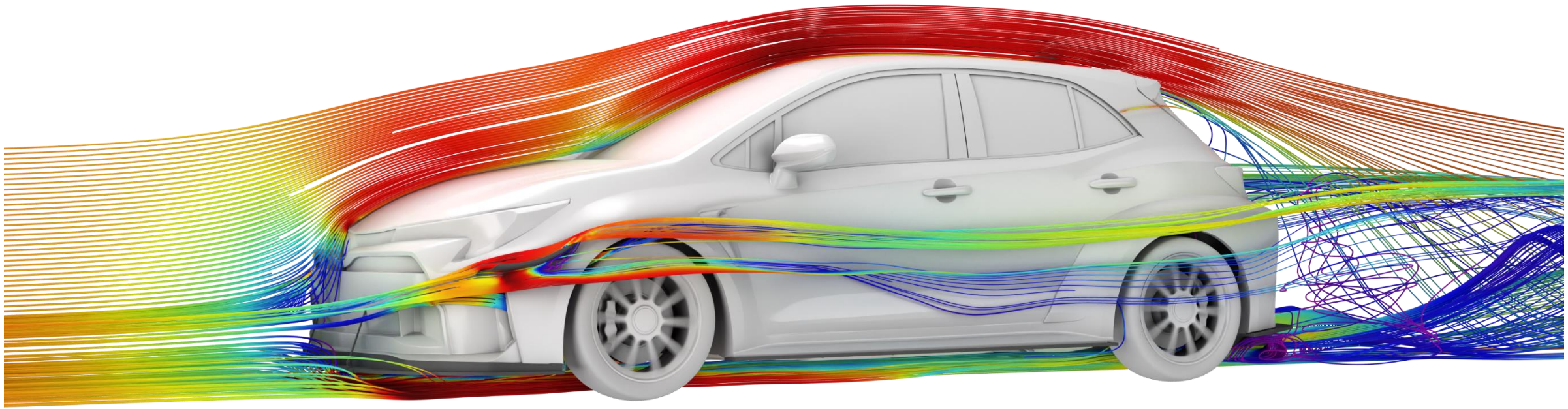


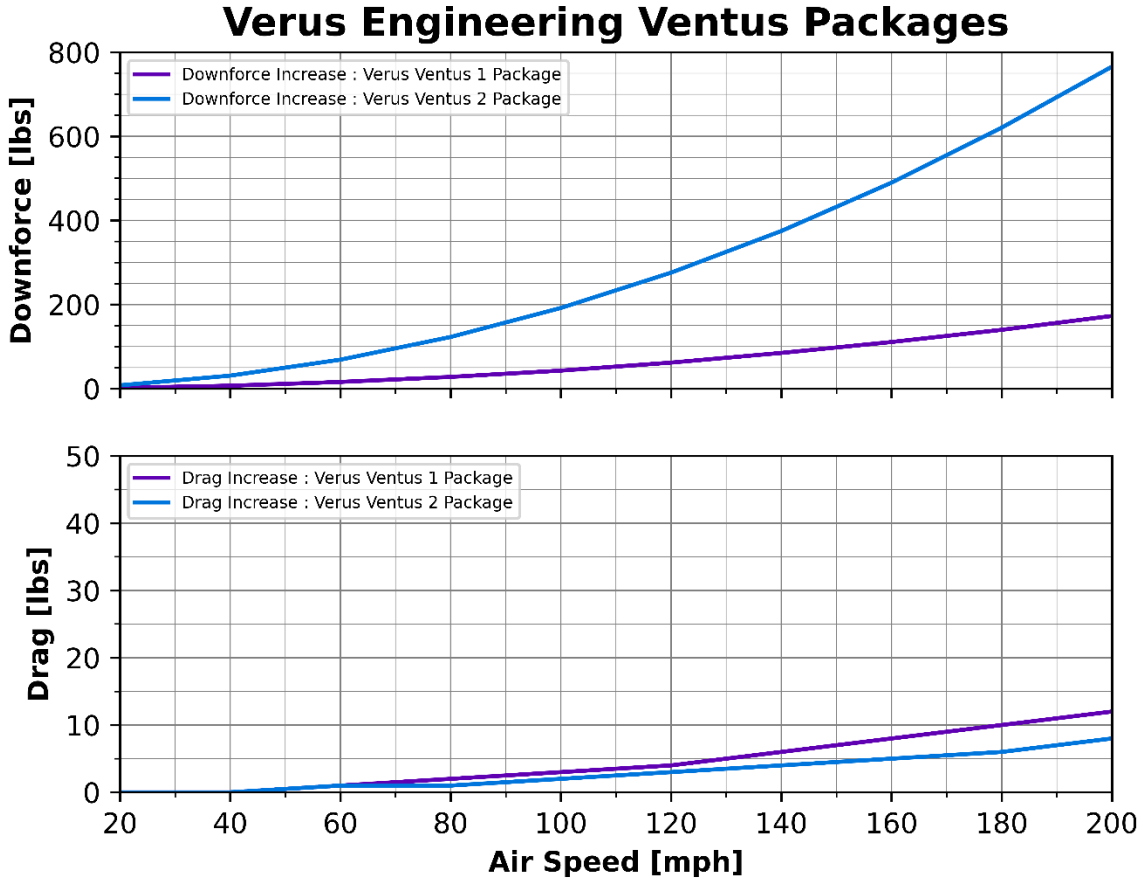
TOYOTA GR COROLLA PLATFORM

PERFORMANCE OF VERUS ENGINEERING VENTUS PACKAGES

OVERVIEW

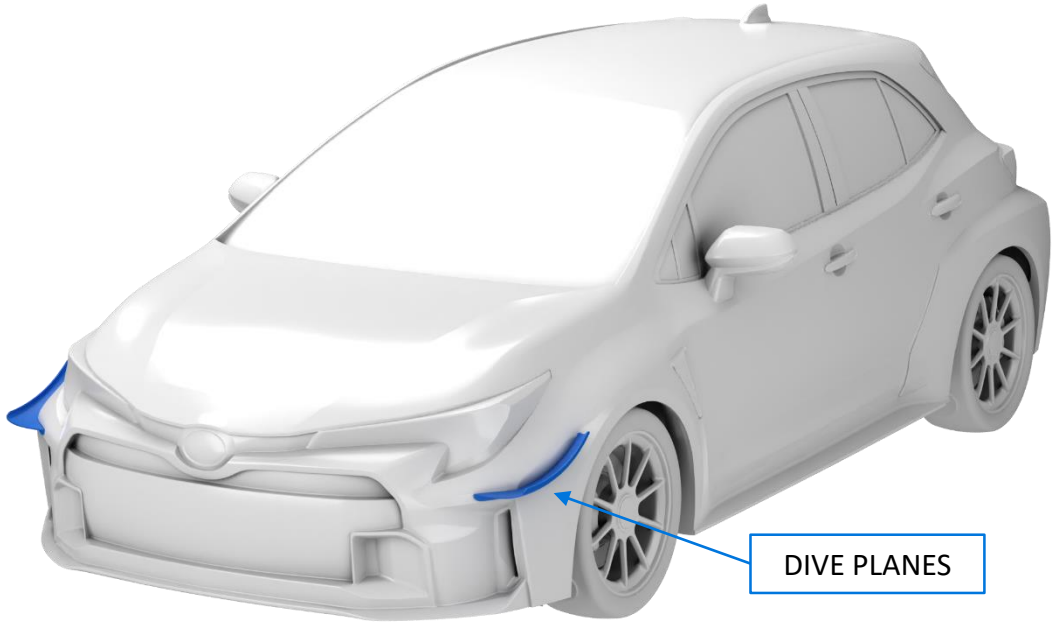
SUMMARY : AERODYNAMIC FORCES

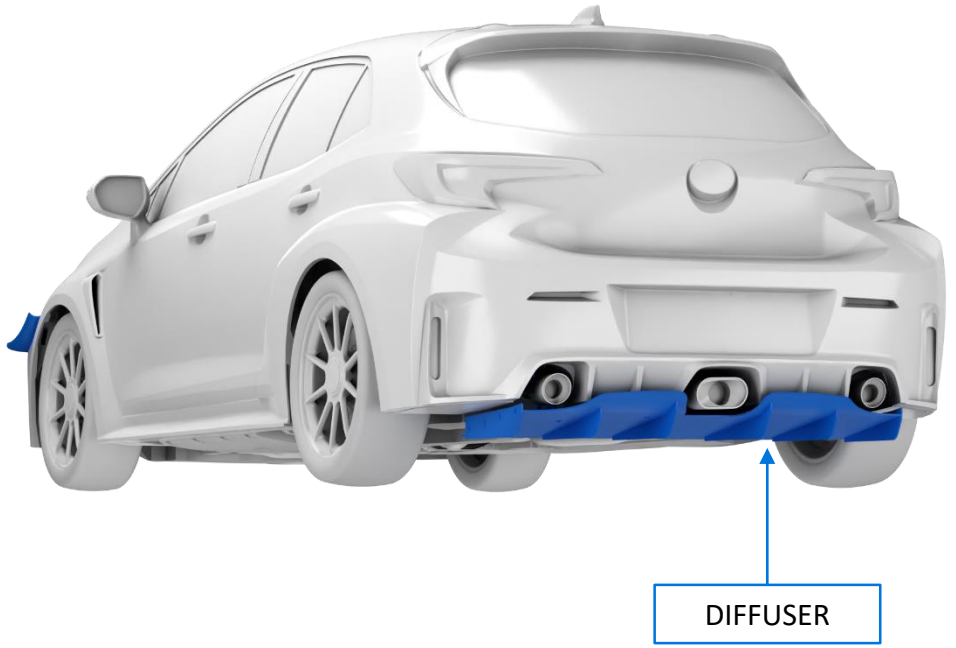
- Aerodynamic forces change with the square of the vehicle speed, which is why we use a graph.
- The Ventus 1 & 2 packages increase downforce over stock with minimal impact to drag.
- The Ventus 1 package uses the Verus Engineering Dive Planes and Rear Diffuser.
- The Ventus 2 package uses the Verus Engineering Dive Planes, Rear Diffuser, Front Splitter, Side Splitters and Rear Spats.



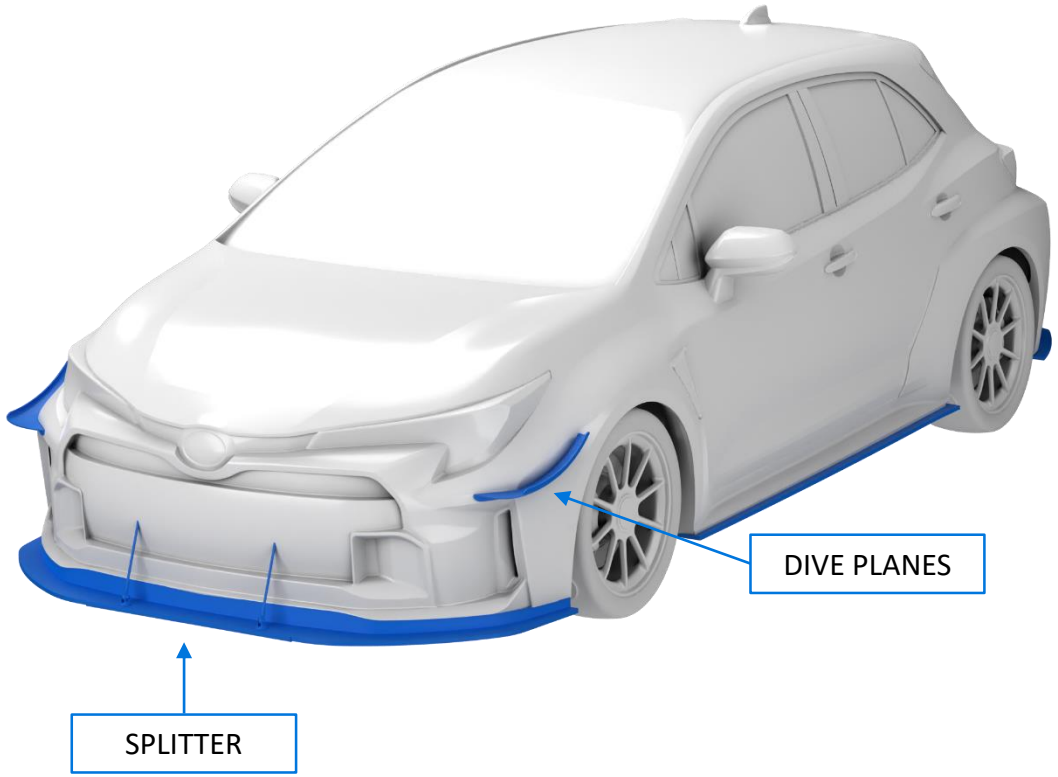
Note: The force values represent the change from the factory GR Corolla

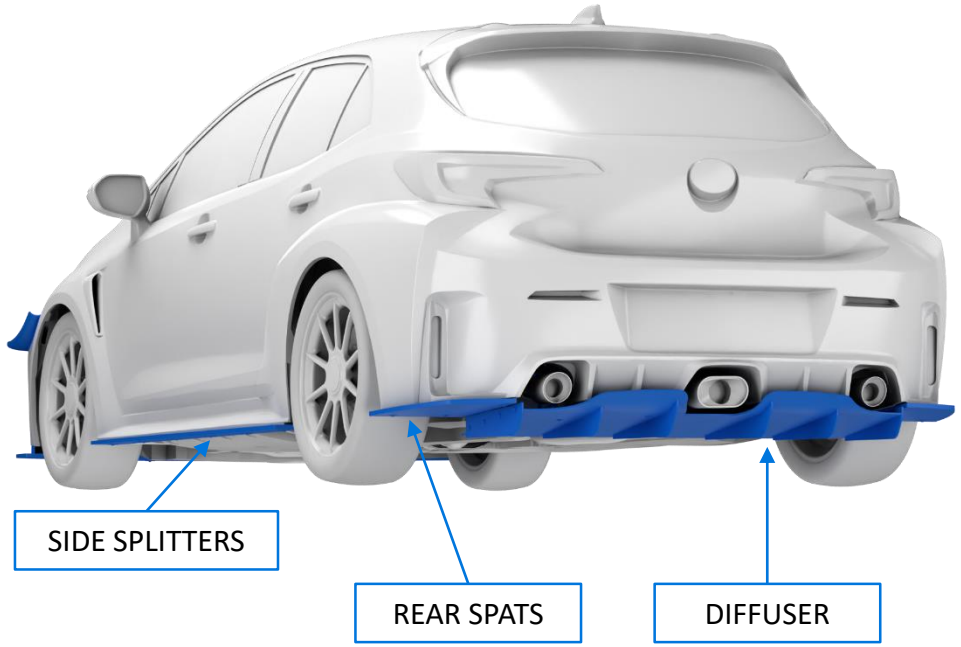
VENTUS 1 PACKAGE





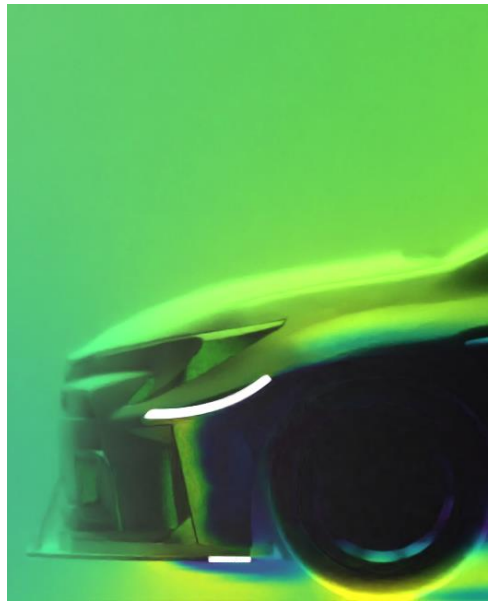
VENTUS 2 PACKAGE

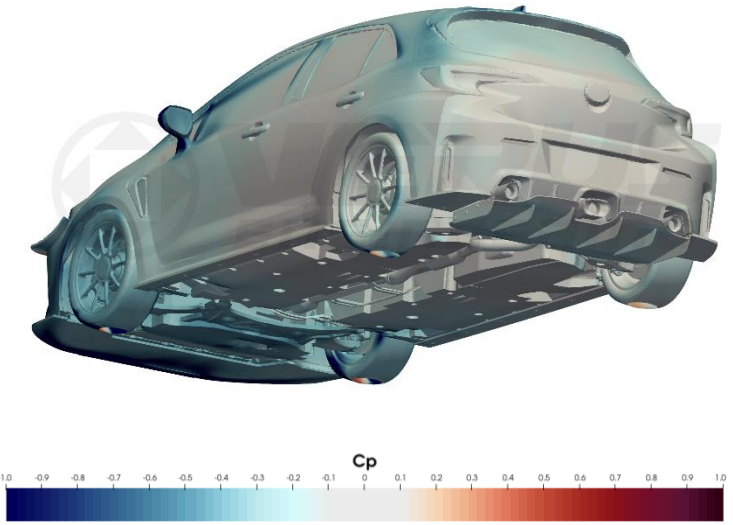


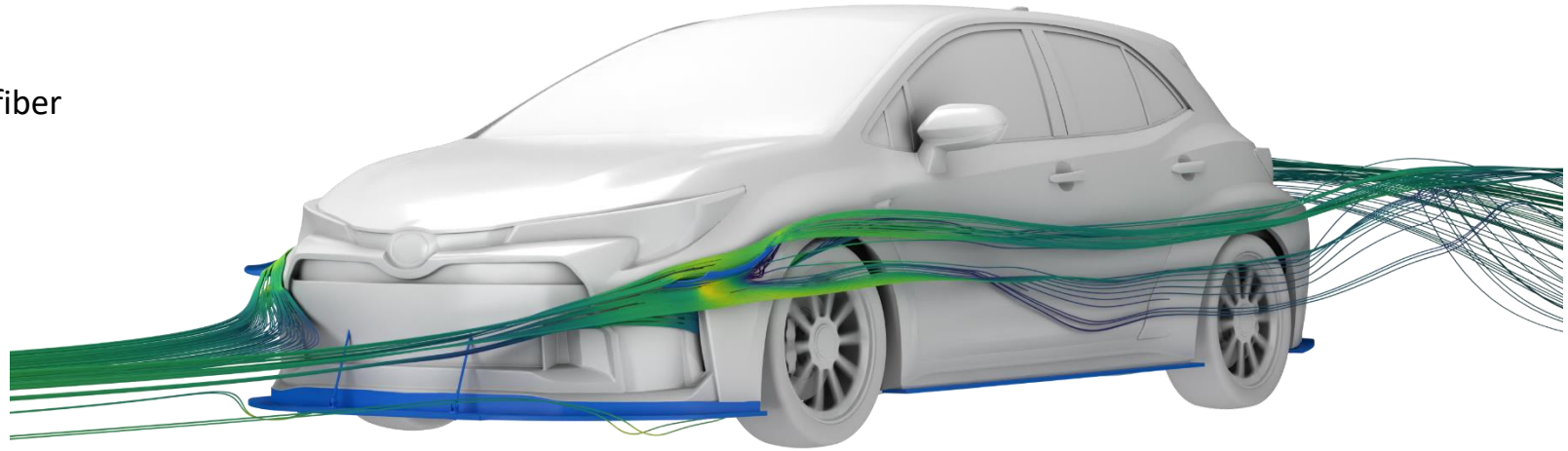


DIVE PLANE / CANARDS

- 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.

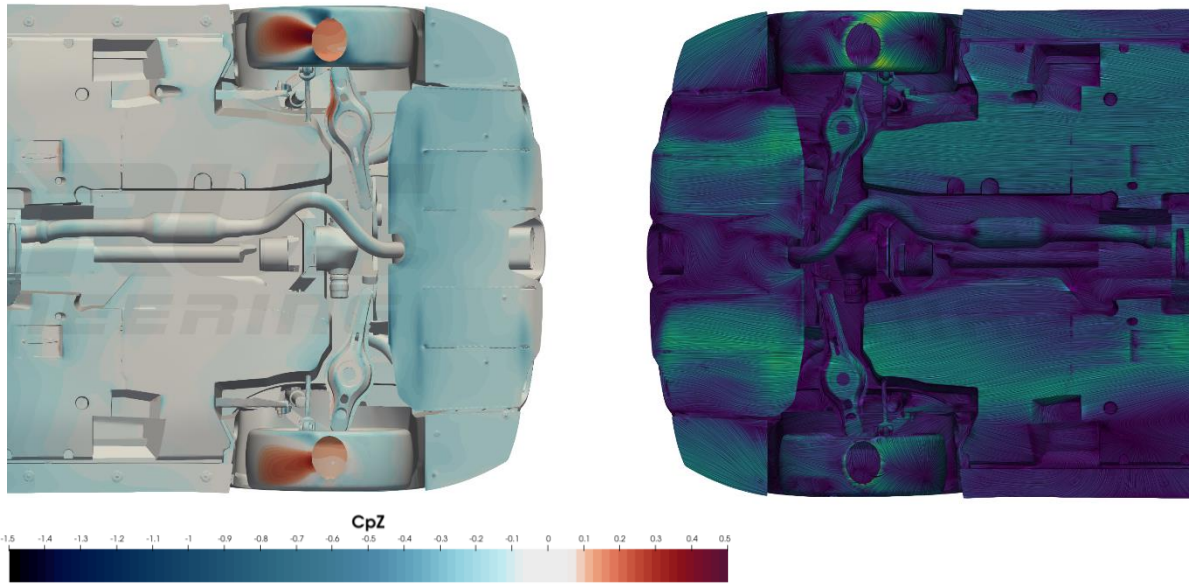


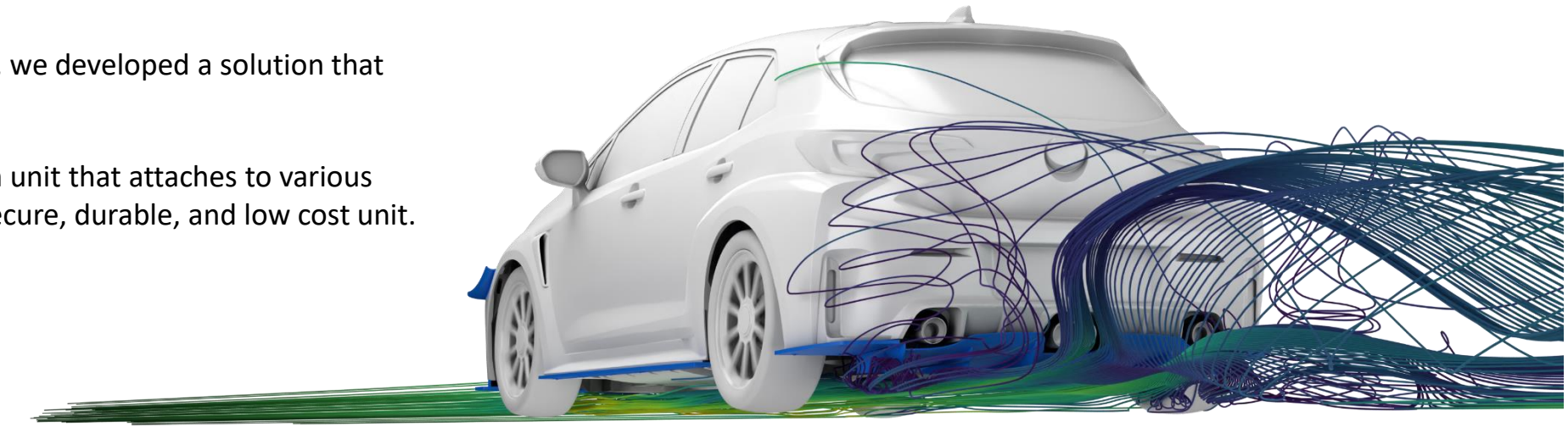




DIFFUSER

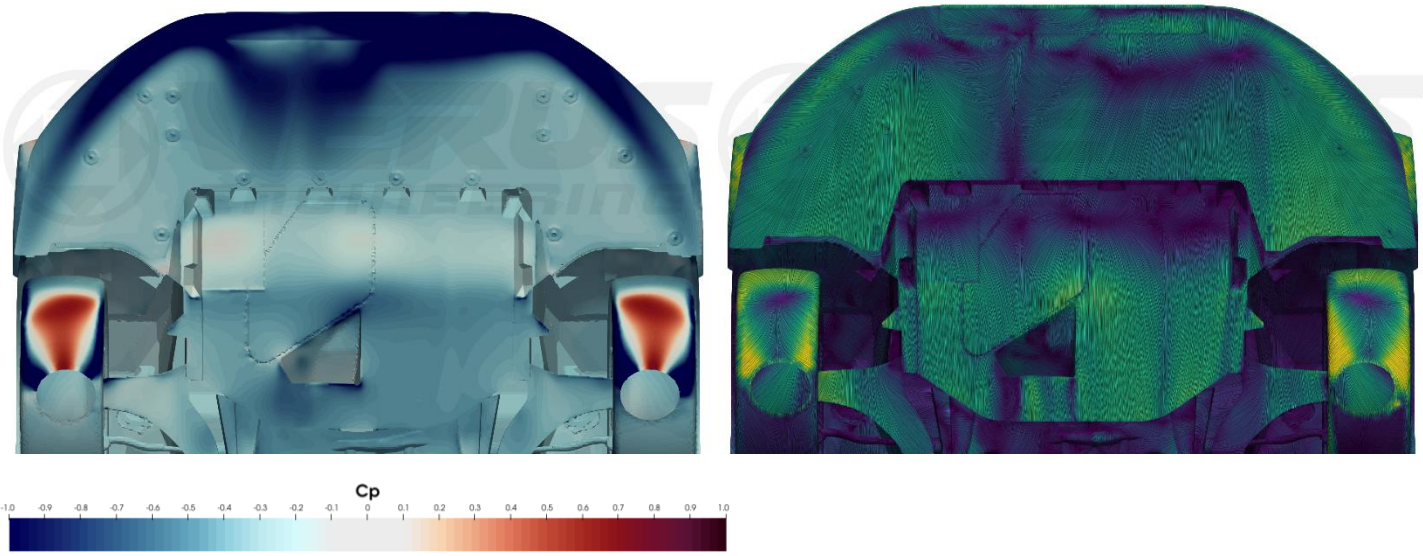
- The rear diffuser is a key component in creating efficient downforce.
- A diffuser is perfect for a street car as it will add stability (downforce) *and* reduce overall drag, when designed properly.
- The diffuser functions by creating low pressure on the bottom surface and reduces drag by filling in the void behind the vehicle.
- A large portion of drag on road vehicles is pressure drag, which is the low pressure region behind the car.
- This low pressure wants to pull the car rearward and is also known as the wake region.
- Using CFD and good design practices, we developed a solution that creates downforce and reduces drag.
- The rear diffuser is a sheet aluminum unit that attaches to various chassis and bumper locations for a secure, durable, and low cost unit.

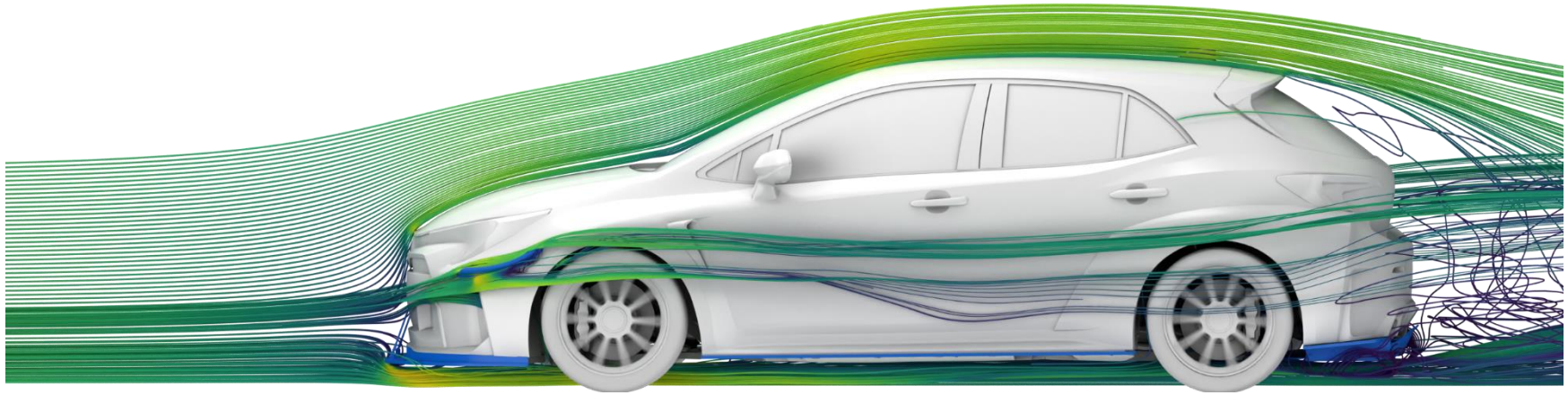




FRONT SPLITTER

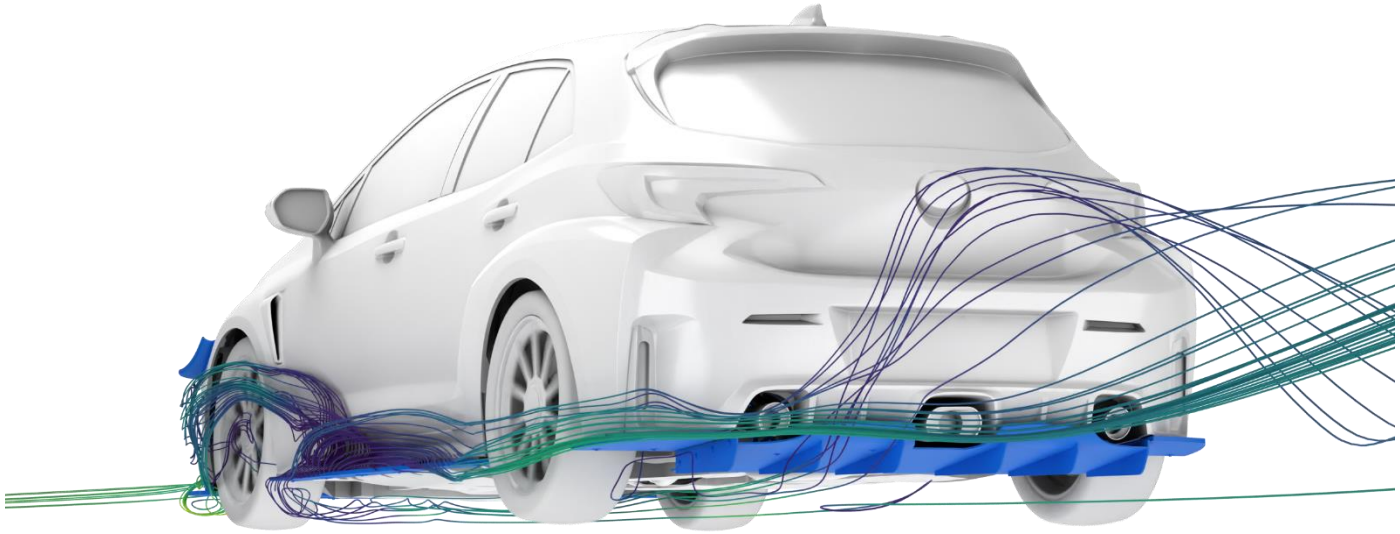
- The splitter is great for customers looking to generate significantly more front end downforce.
- The entire splitter assembly is modeled and simulated.
- Front splitters are very efficient aero devices.
- High pressure on the top side helps drive the splitter downward at speed.
- The bottom side, like the rear wing, produces more downforce than the top side.
- The splitter is produced from a hard plastic, which is light, rigid, and cost effective.

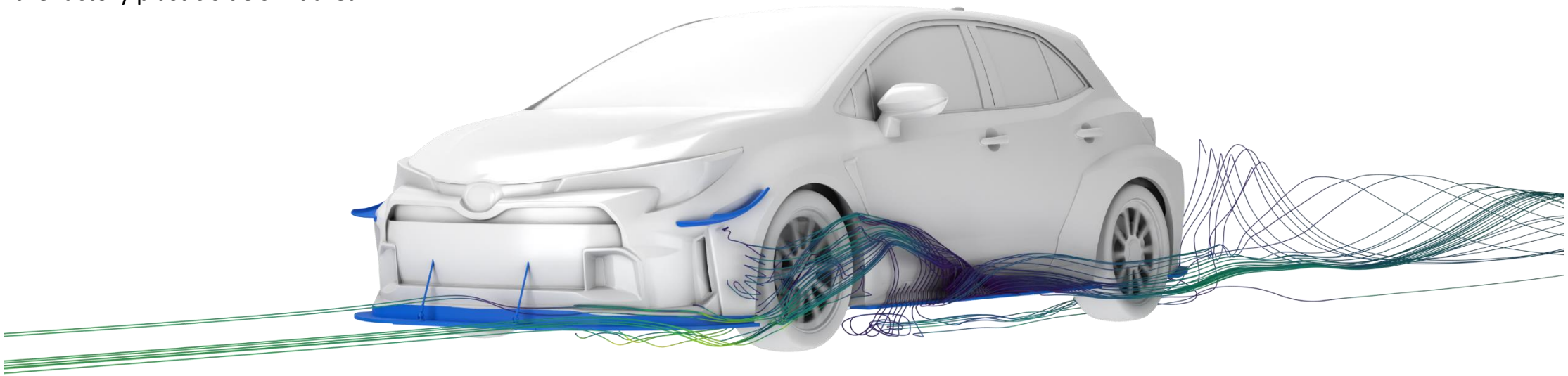




SIDE SPLITTERS

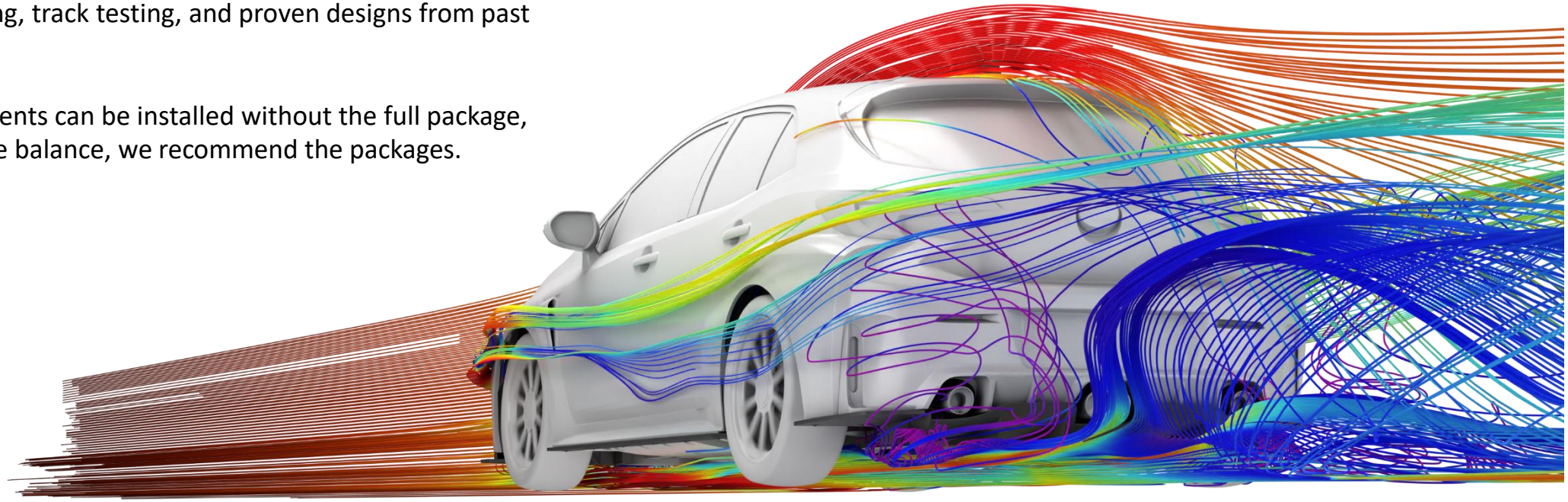
- Side splitters reduce the amount of high pressure air from the top side of the vehicle making it under the vehicle.
- We focused on designing the units to clean up underbody airflow during turning or high yaw conditions.
- The increase in downforce is centrally located on the vehicle and the aero balance is minimally affected.
- The side splitters and rear spats are produced from rigid plastic and bolt to the vehicle through rivet nuts that are installed in the factory plastic side skirt area.





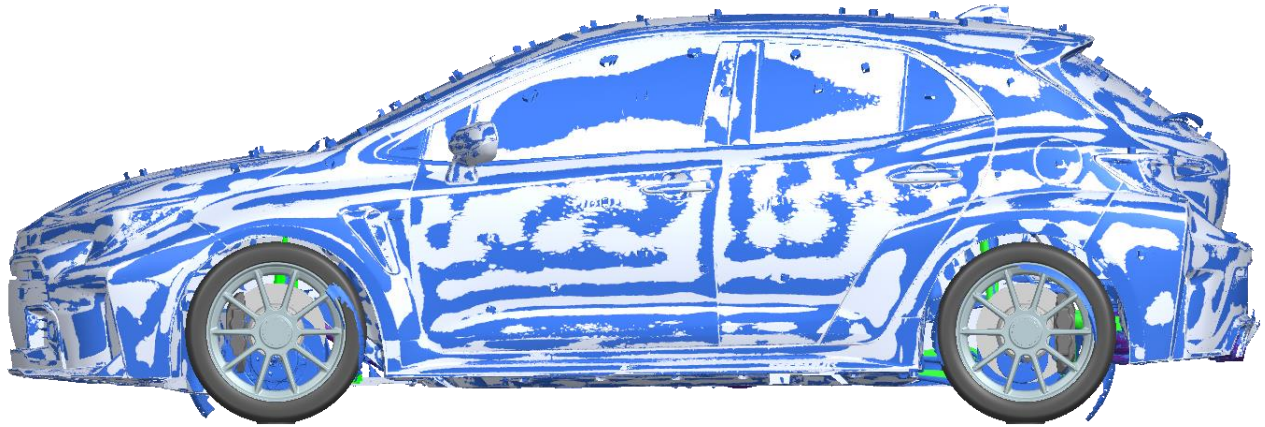
SUMMARY

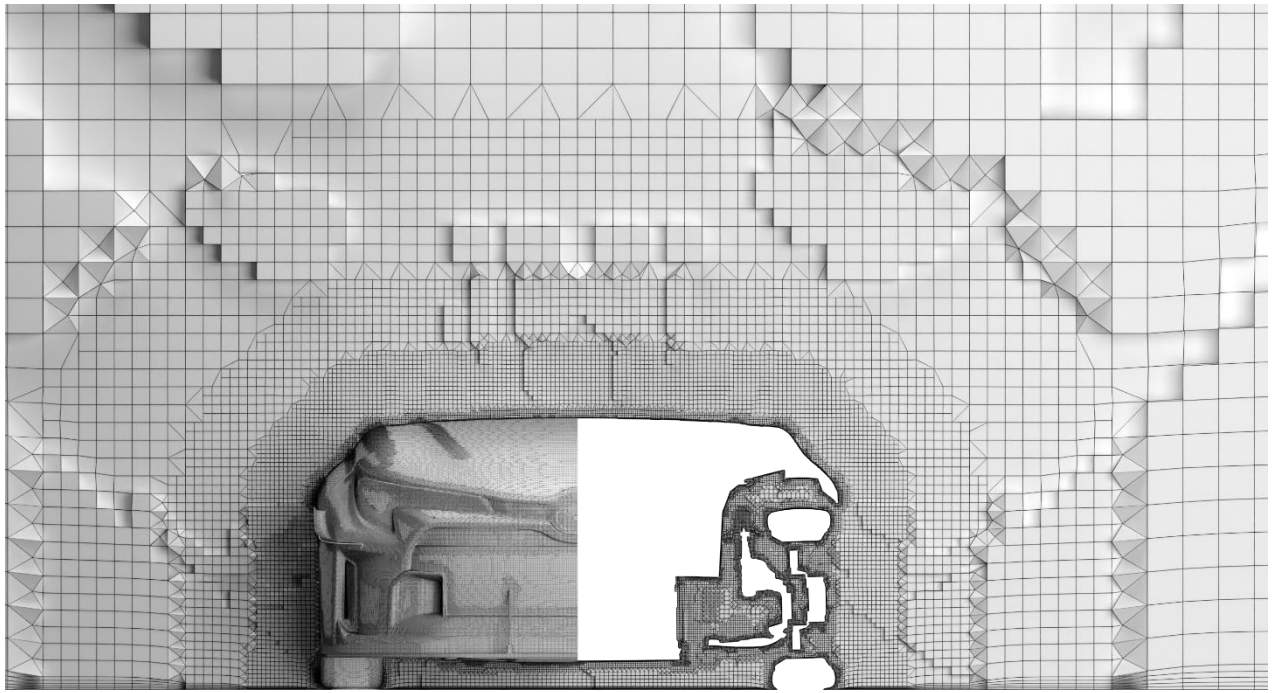
- The Verus Engineering Ventus Packages for the Toyota GR Corolla platform are designed to decrease lap times utilizing well developed and functional aerodynamic components.
- These packages are designed to fit like OEM and increase the factory performance **all while keeping the factory warranty.**
- The components increase vehicle performance.
- The R&D of the packages was done using cutting edge technology in CFD, wind tunnel testing, track testing, 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

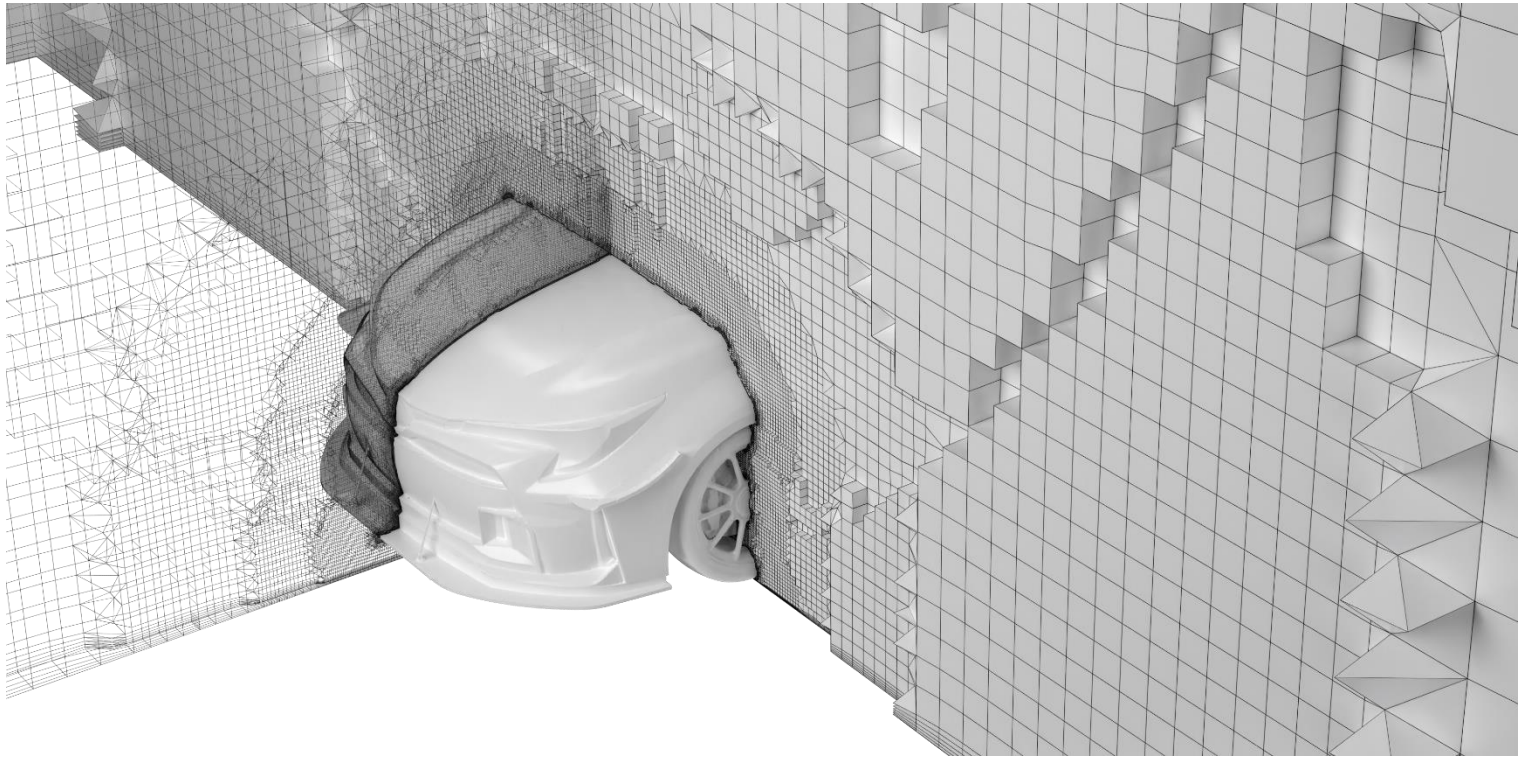
- The CAD model is a crucial aspect of accuracy.
- Bad inputs result in bad outputs.
- The CFD simulation is only as good as the geometry and setup of the CFD analysis.
- The GR Corolla was scanned in house and a 3D CAD model was created from this scan.
- The image to the right shows the overlay of the 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 from the front bumper to the wheel well were modeled for improved analysis accuracy.

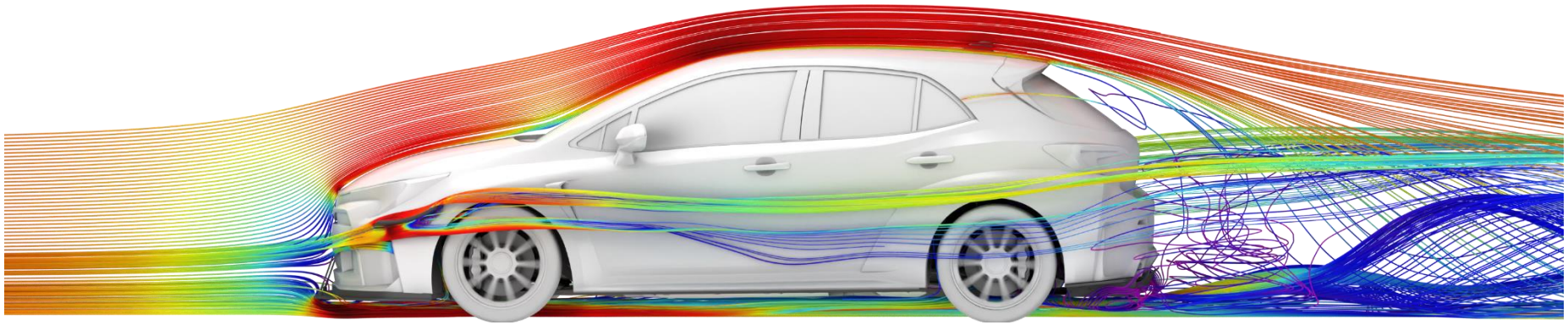




THE SCIENCE

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.





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).