MAZDA MIATA ND

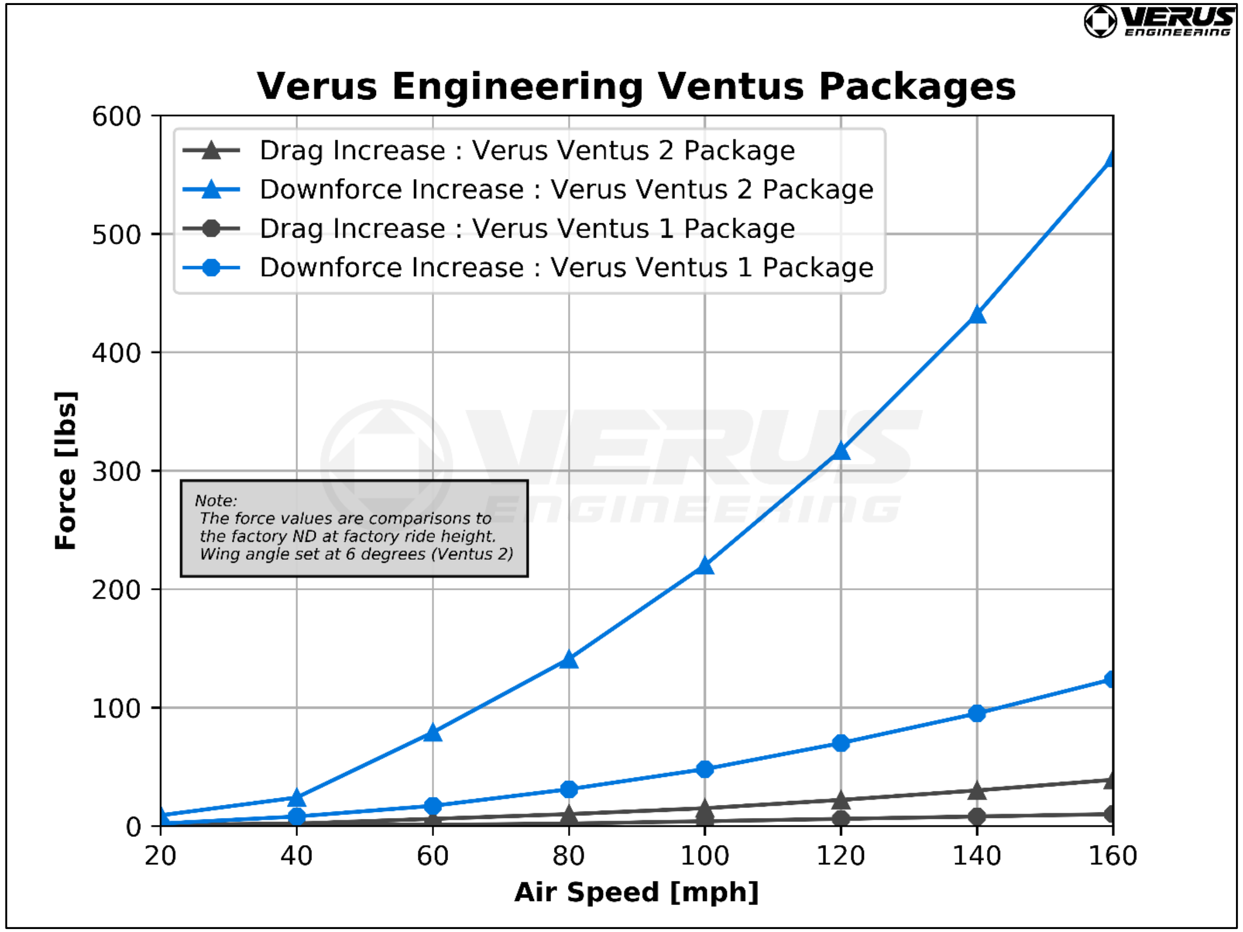
PERFORMANCE OF VERUS ENGINEERING VENTUS PACKAGES

OVERVIEW

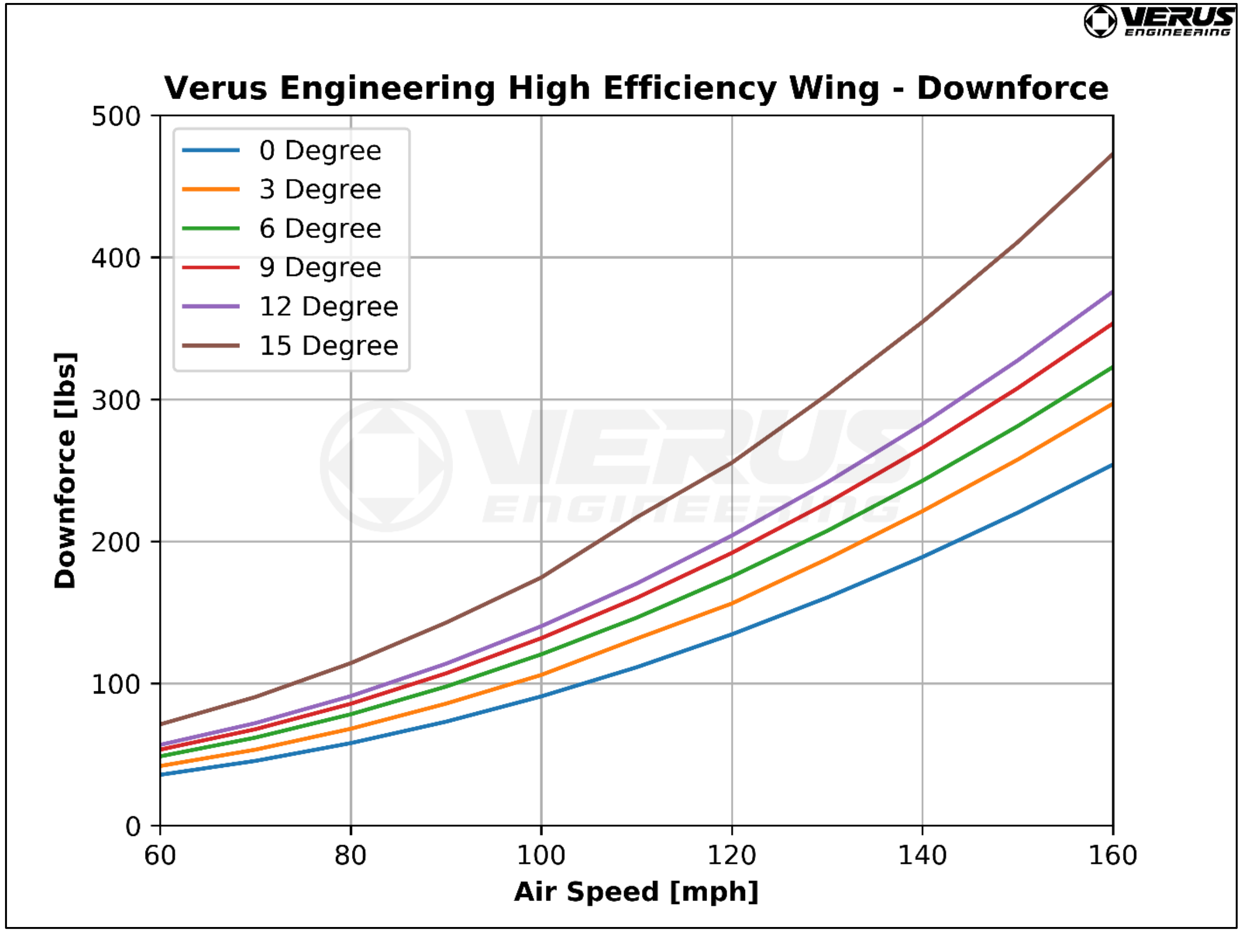
SUMMARY : AERODYNAMIC FORCES

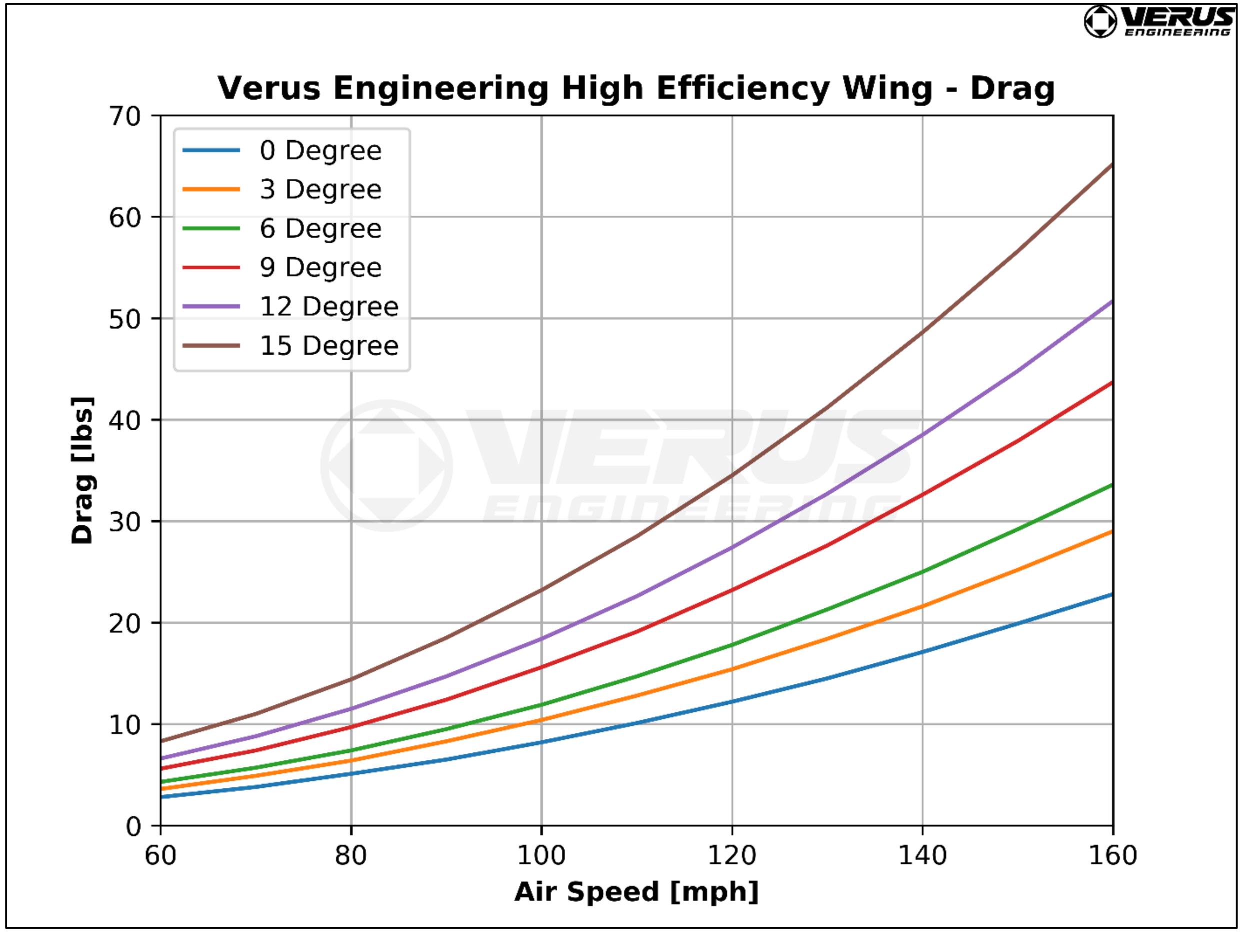
Aerodynamic forces change with the square of vehicle speed. When developing an aerodynamic package, Verus Engineering focuses on maximizing efficiency while increasing downforce significantly. In other words, we look at creating downforce while keeping drag increases minimal or negligible.

Efficient downforce will decrease lap times and improve vehicle performance. The benefit of an entire package is keeping a factory like aerodynamic balance while increasing vehicle downforce.



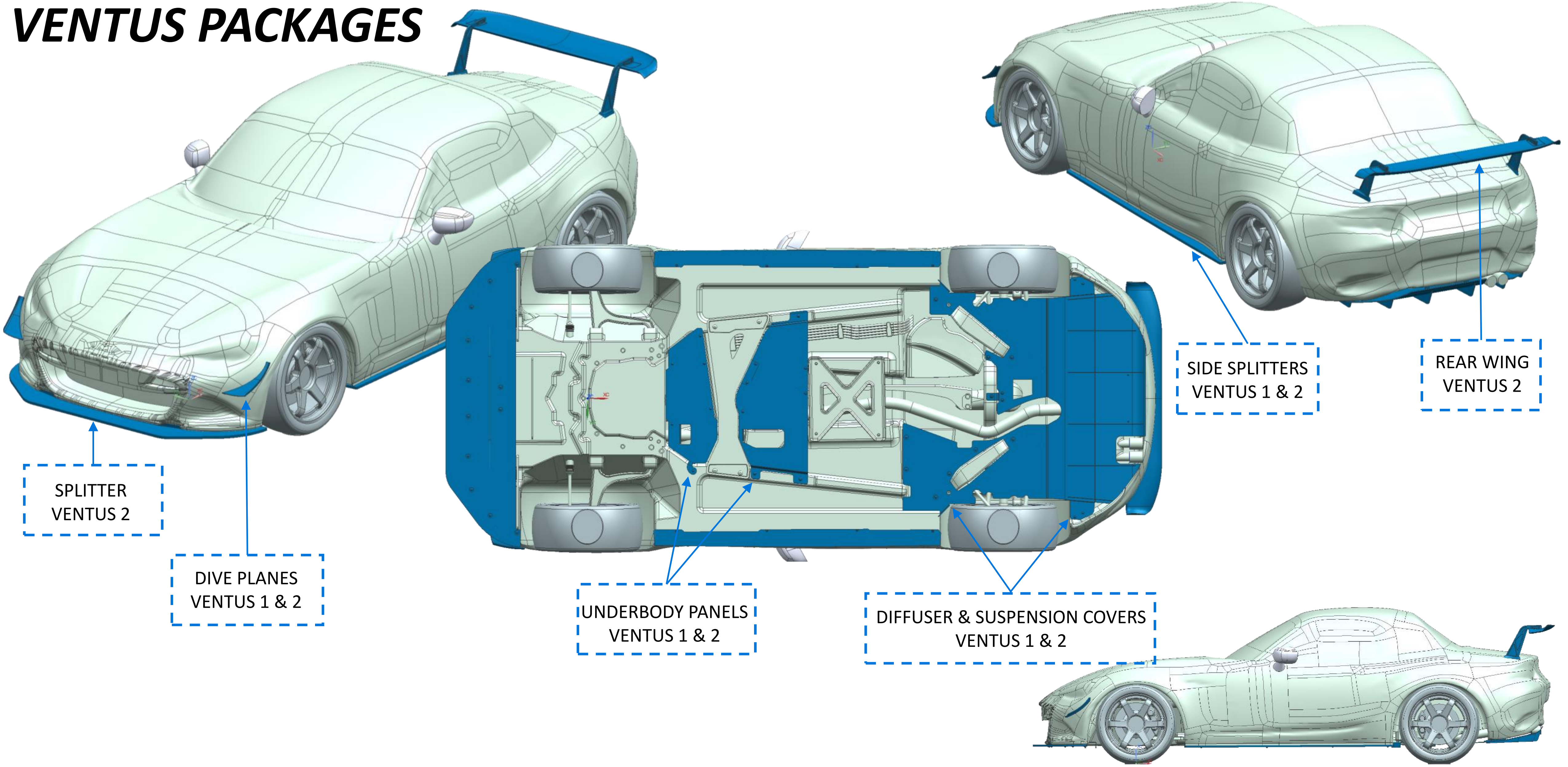
SUMMARY : AERODYNAMIC FORCES





Freestream downforce data on the Verus Engineering High Efficiency Wing which is on the Ventus 2 Package. The data on the car on the previous page is from 6 degrees angle of attack. How the downforce and drag can change based on wing angle change can be calculated using these graphs.

VENTUS PACKAGES



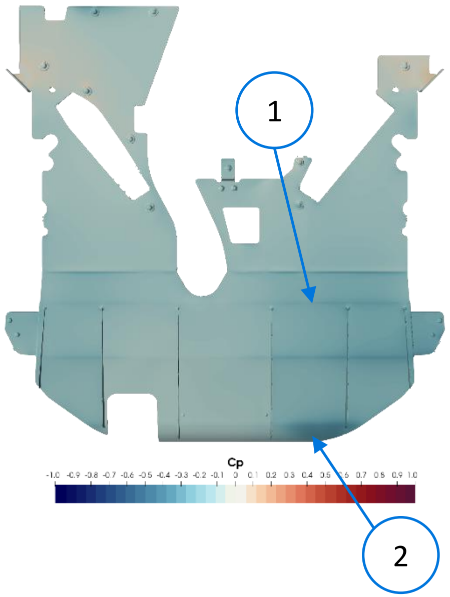
DEFINITIONS

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).

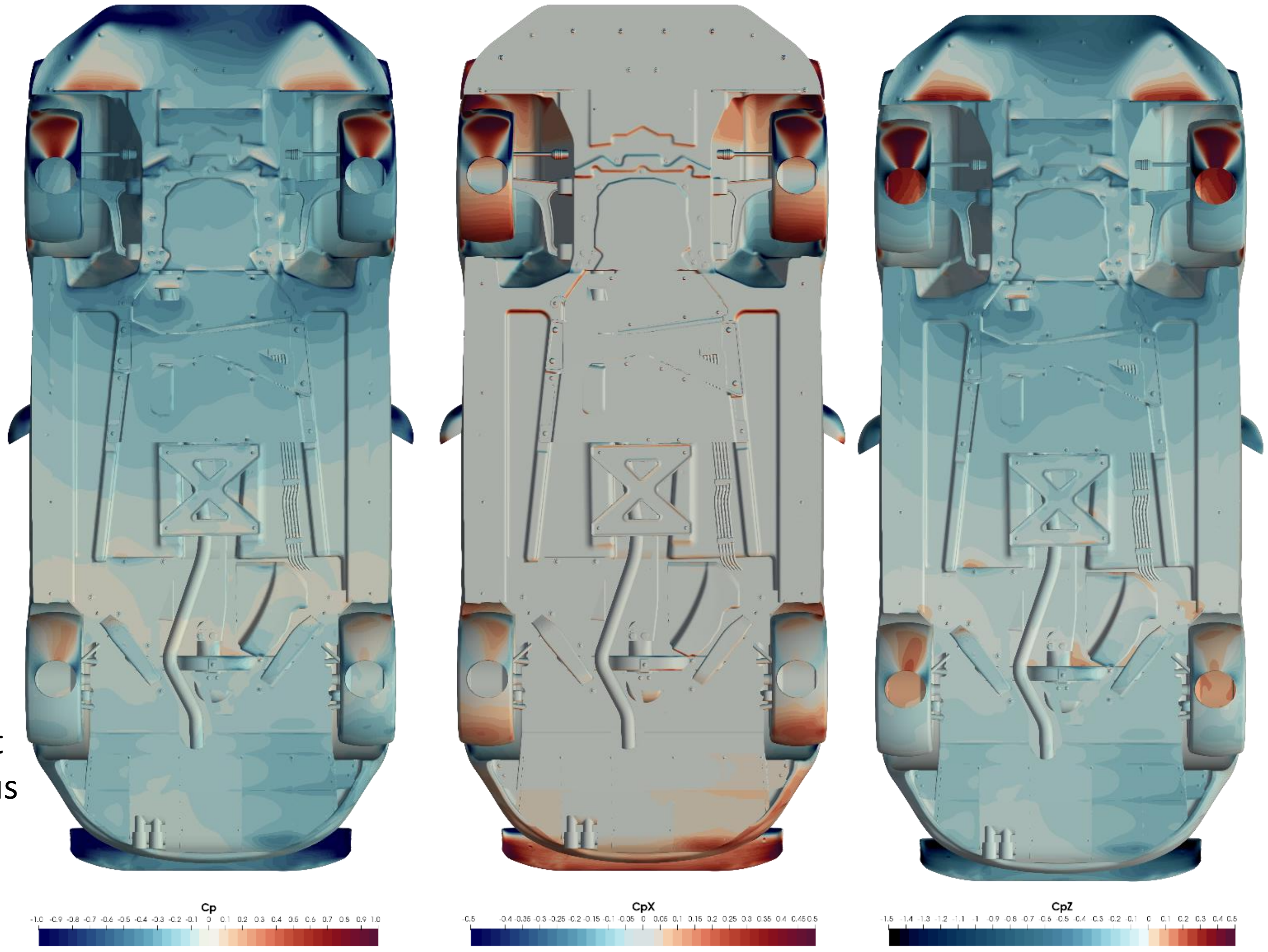
DIFFUSER & SUSPENSION COVER DETAILS

The Verus Engineering Rear Diffuser is a key component in creating efficient downforce. Adding a rear diffuser is perfect for a street car since it will add downforce and reduce overall car drag when designed properly. Downforce can be viewed via the low pressure on the surface of the diffuser (Cp & CpZ plots).

Drag is a little trickier to understand. Looking at the surface of the diffuser, it looks like the diffuser adds drag. This can be seen clearly in the CpX plot. This is specifically called induced drag. On the following page, we will go into further detail on how the diffuser aids in drag reduction.

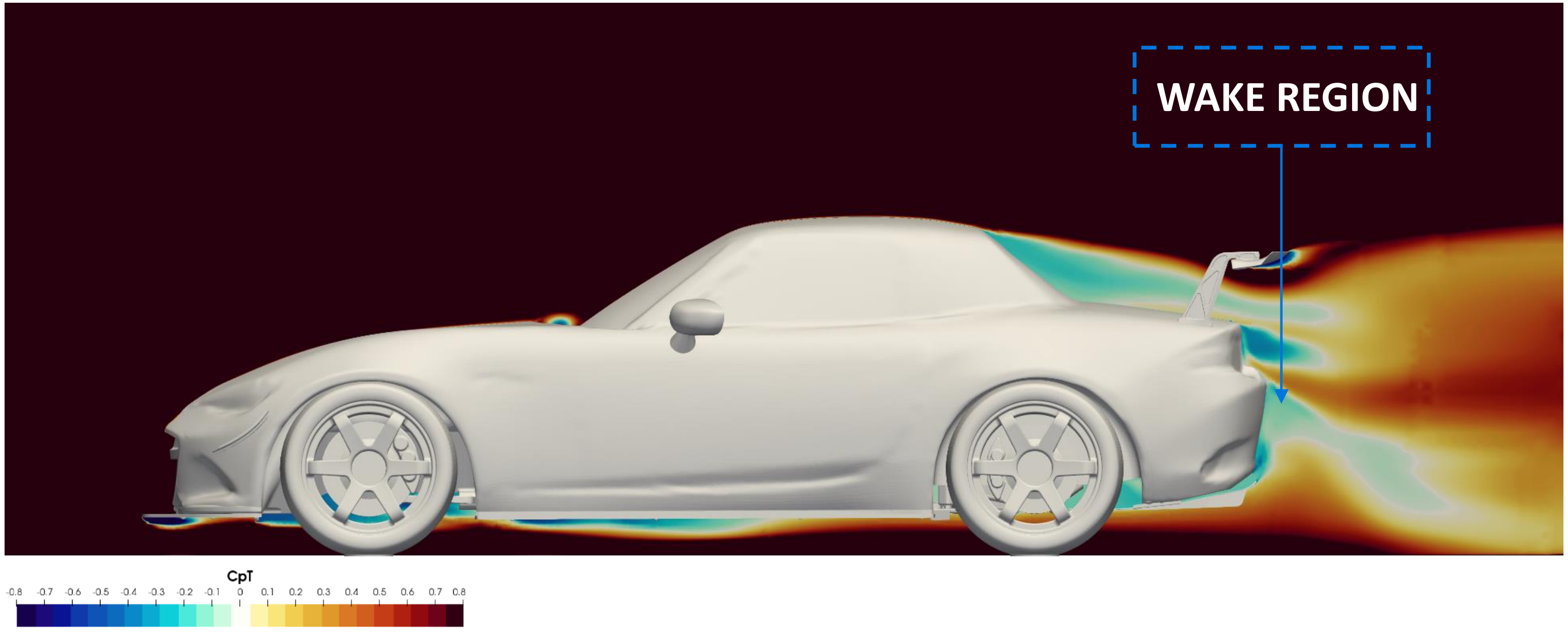


1. Main Diffuser Throat
2. Second Diffuser Throat Synonymous with Verus Rear Diffusers



DIFFUSER & SUSPENSION COVER DETAILS

A large portion of the drag on a normal road vehicle, like the ND Miata, is from pressure drag. Pressure drag is caused by the low pressure region behind the vehicle which wants to pull the car rearward. This low pressure region behind the vehicle is called the wake region. Knowing this information and with proper R&D we can increase downforce and reduce drag from the rear diffuser. The Verus Engineering Diffuser specifically targets the wake region and helps fill this region with air from under the vehicle. Filling this wake region reduces overall drag on the car.

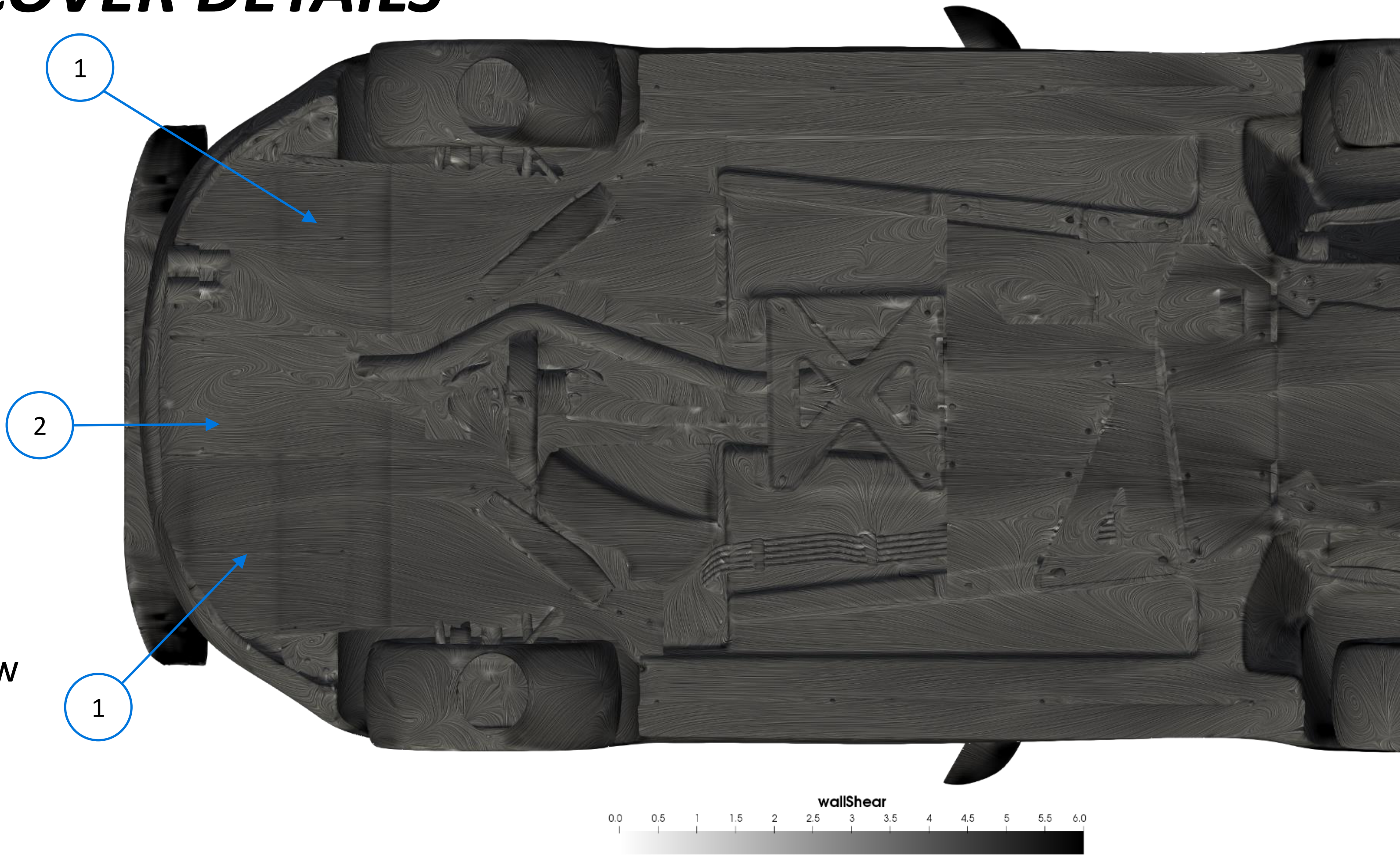


The CpT Plot shown above is used to visualize the wake region behind the car. The blue zone behind the vehicle is the wake and minimizing this as much as possible will reduce drag.

DIFFUSER & SUSPENSION COVER DETAILS

The photo to the right shows an LIC Plot of Wall Shear to examine how the air flow is acting on the surface. This is an excellent plotting tool for developing better parts and correlating to real world results.

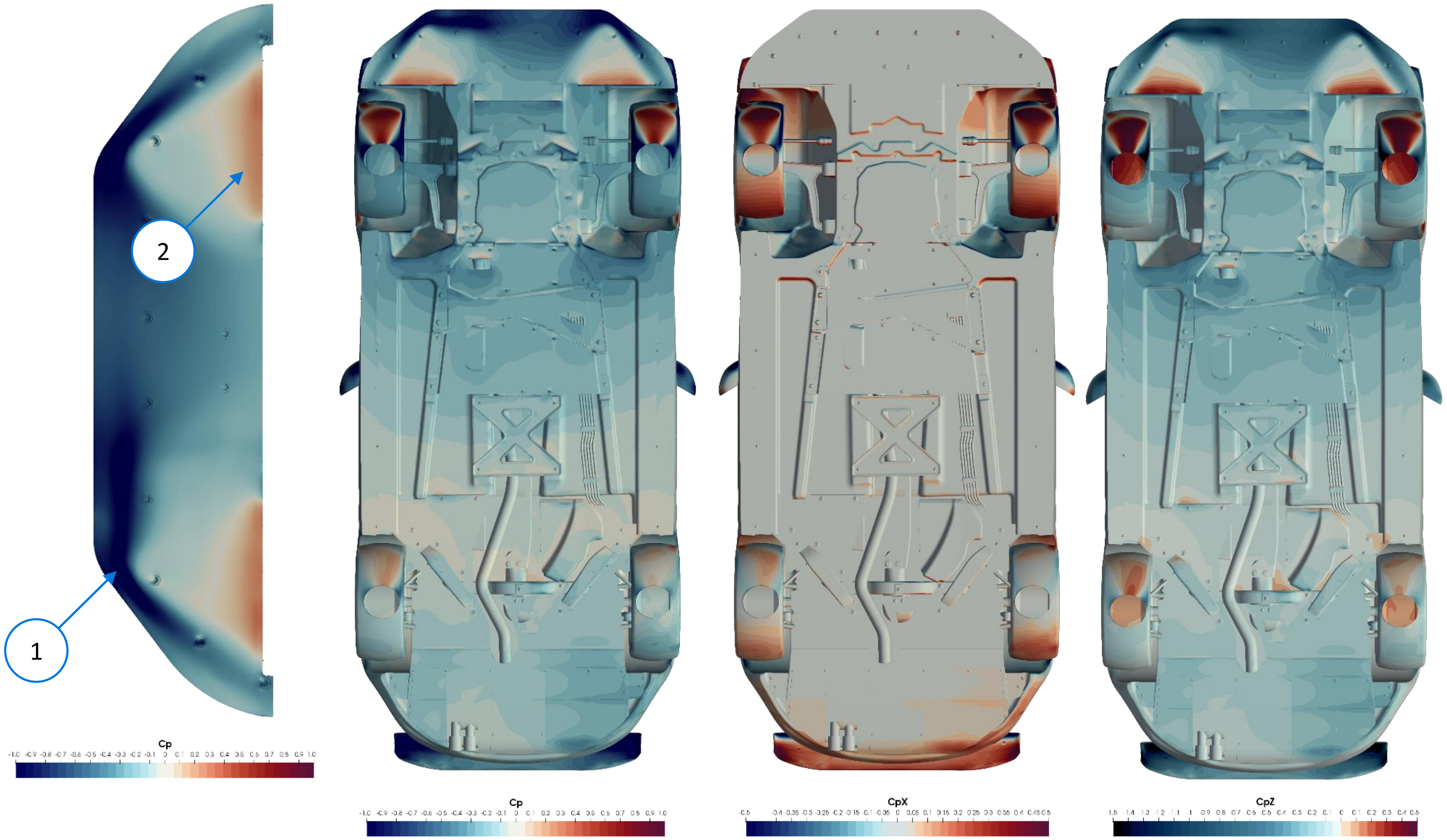
1. The outer diffuser sections see fully attached flow.
2. There is stressed flow on the center section of the diffuser. The stressed flow is directly caused by exhaust and subframe running down the center of the car.



SPLITTER DETAILS

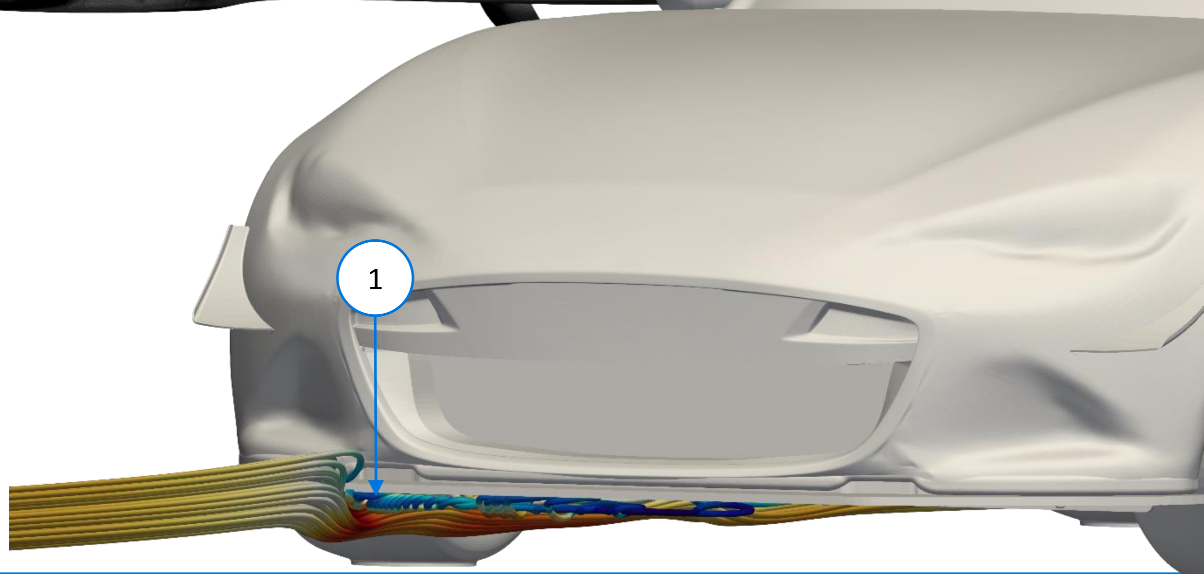
The Verus Engineering Front Splitter is ideal for increasing front-end downforce. While the splitter is a flat component, it makes significant front downforce since it is using ground effects. The full splitter assembly is simulated. The full splitter assembly has an efficiency [L/D] of 72. Splitters are a very efficient downforce creating component for vehicles.

1. Peak low pressure region on splitter
2. High pressure caused by factory tire deflectors



SPLITTER DETAILS

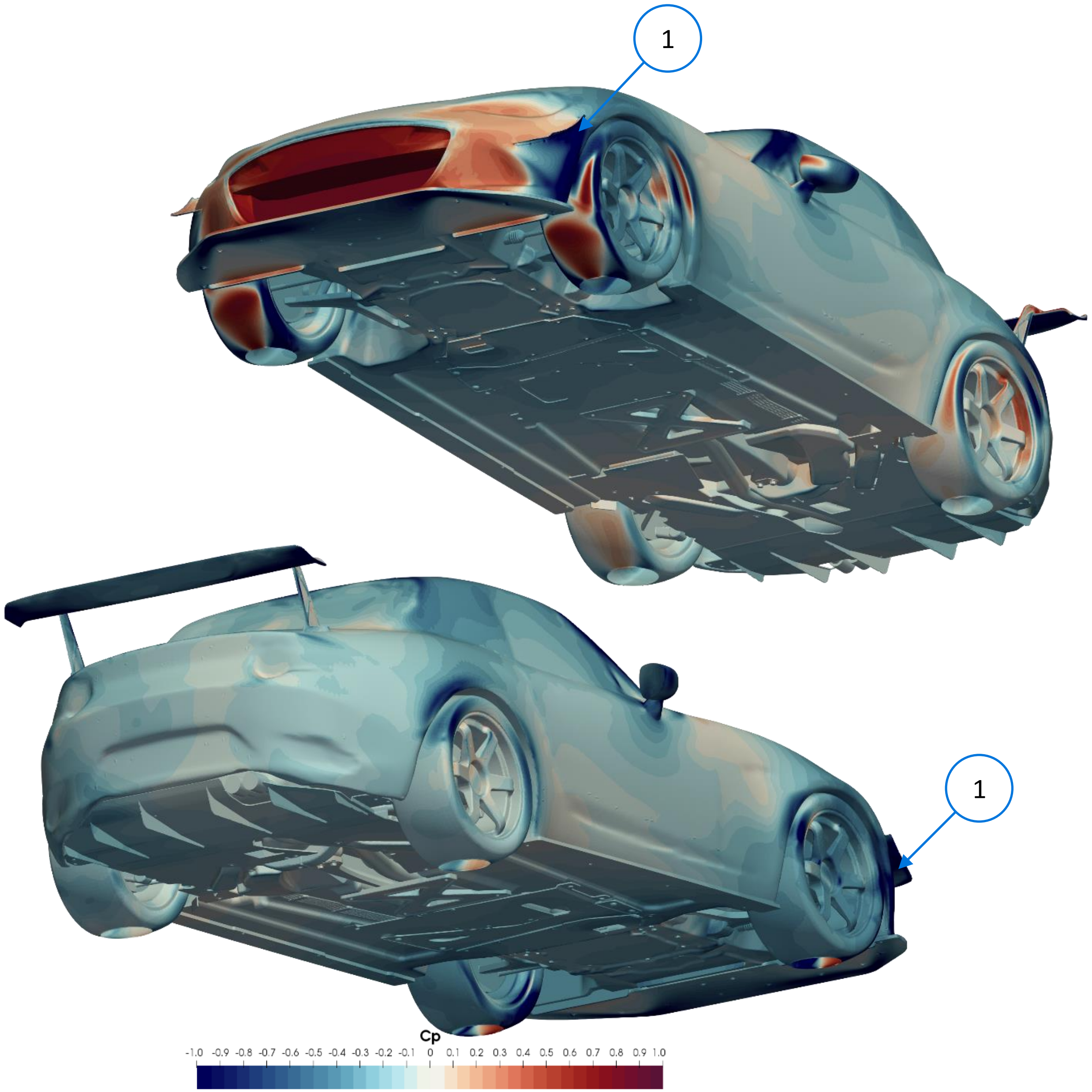
1. Vortex formed on the leading edge of splitter and moving out and rear. This causes a large low pressure zone which creates downforce. The vortex lines can be seen on the LIC Plot. The vortex can also be seen in the Streamline Plot.
2. Attached flow in the center of the splitter. Some separation at the leading edge however.



DIVE PLANE / CANARD DETAILS

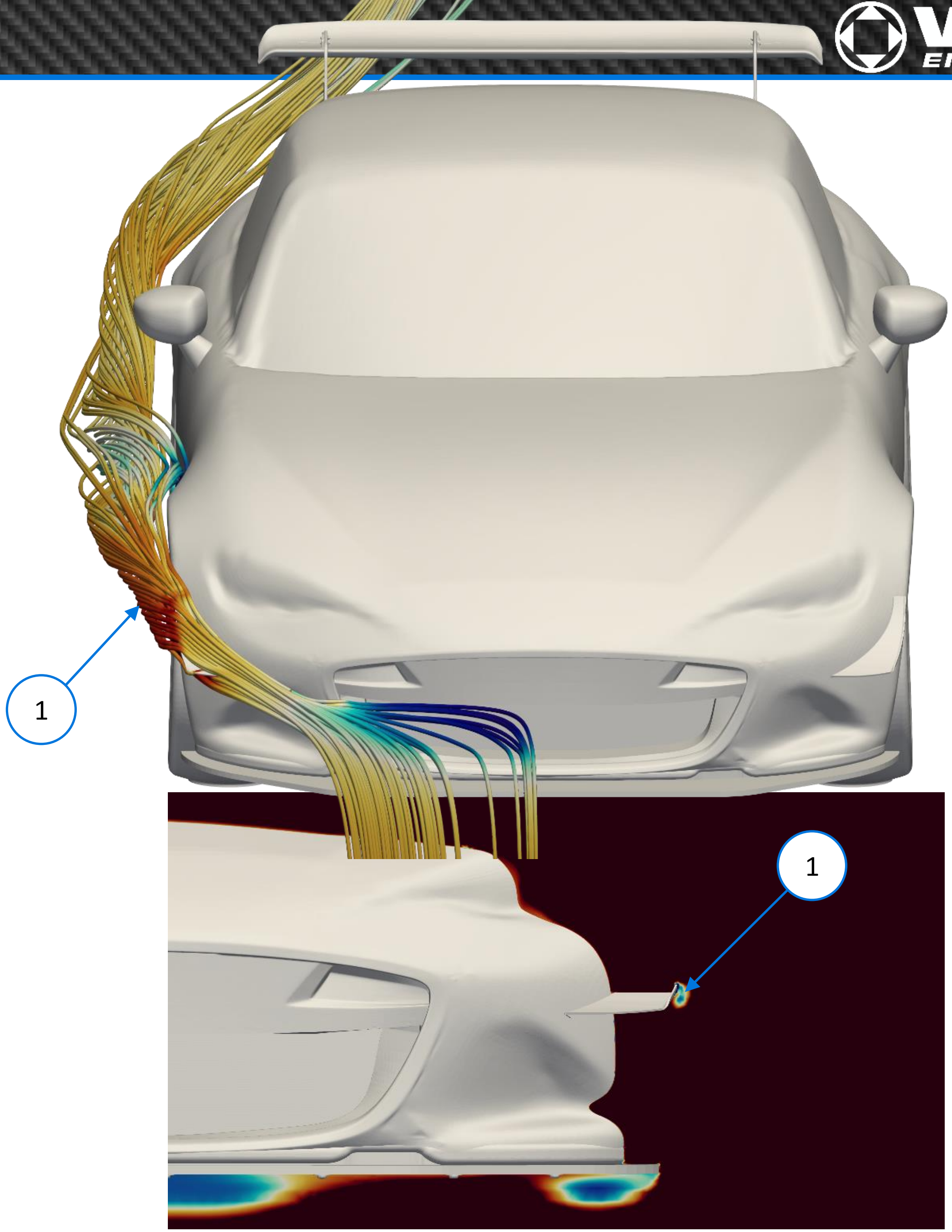
Dive planes can serve a variety of purposes. While most people believe dive planes produce downforce by the airflow on the units themselves; Verus Engineering does significantly more with the development of these units to increase effectiveness.

1. A small part of the downforce created by the addition of dive planes is from the forces on the surface of the dive planes themselves. The bottom side of the dive planes are lower pressure while the top side is higher pressure. This creates a downward force. This is not the full story however.



DIVE PLANE / CANARD DETAILS

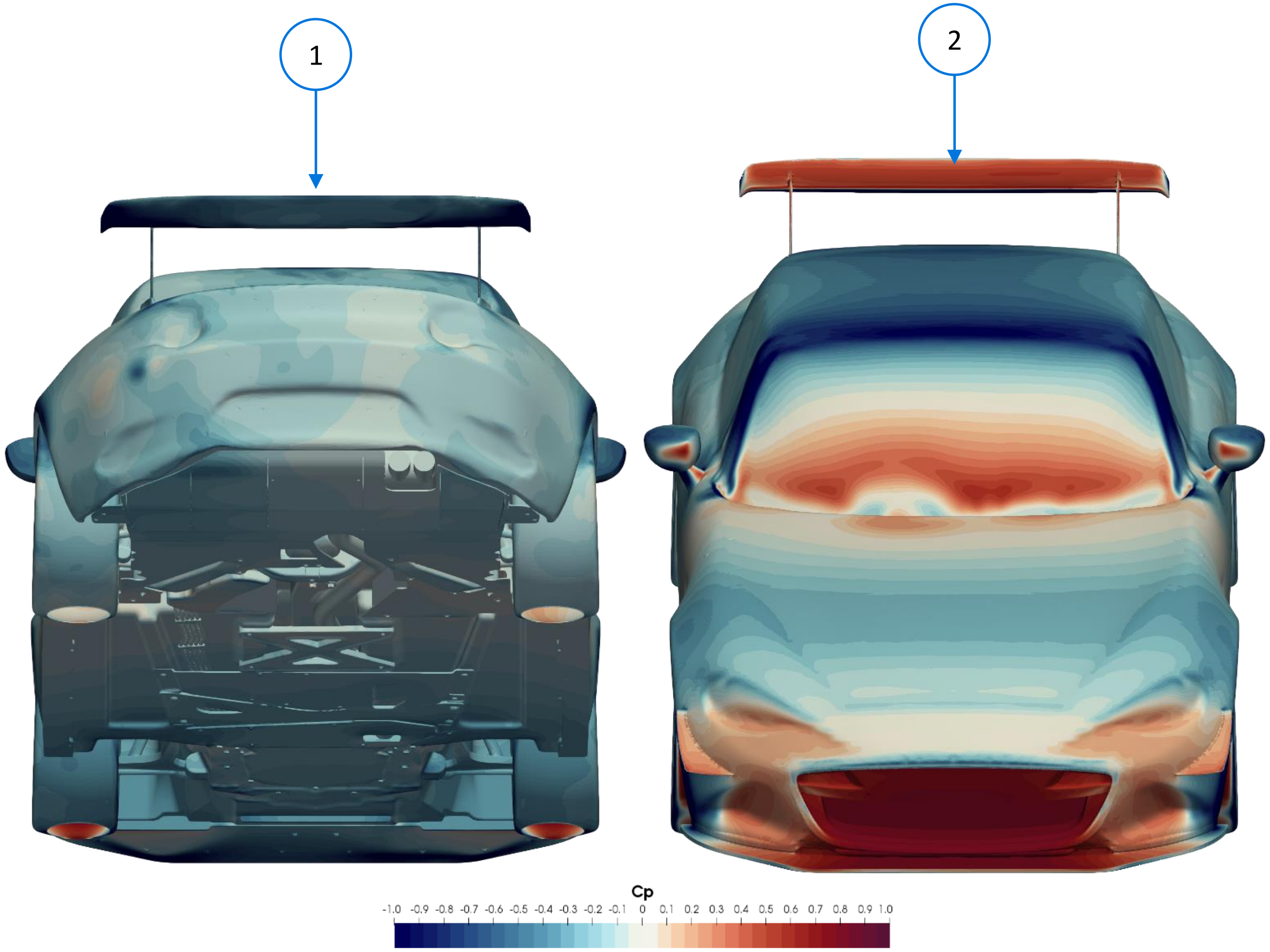
1. The main way downforce is created with Verus Engineering Dive Planes / Canards is controlling airflow around the car. We use the dive planes to create a vortex which helps pull air out of the fender wells. This helps reduce lift on the body of the car. We have specific templates for the dive planes since location and placement are critical for maximum performance.



REAR WING DETAILS

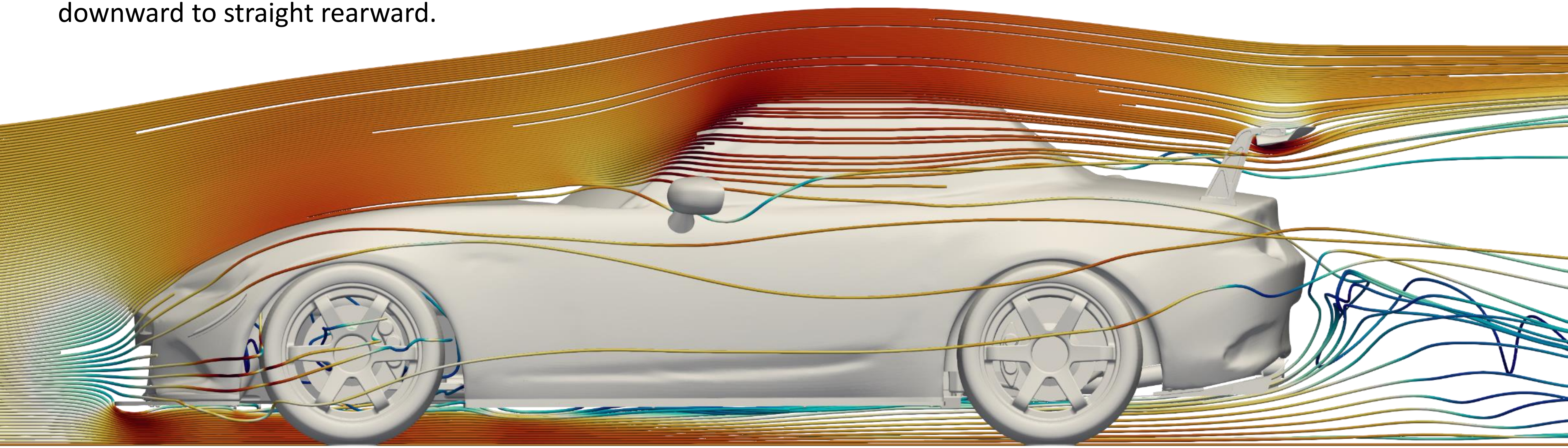
The Verus Engineering Rear Wing for the ND Miata is our High Effificency Wing developed specifically for lower powered cars. The profile was developed and optimized using adjoint optimization solvers and produces very efficient downforce for rear wings.

1. The bottom surface is where all the work is done for making downforce on the wing. It is low pressure which is pulling the rear of the vehicle down.
2. The top surface also creates downforce, just not as much. The Cp does not go above 0.6 compared to the bottom which is less than -1. In other words, the bottom side is working significantly harder than the top at producing downforce.



REAR WING DETAILS

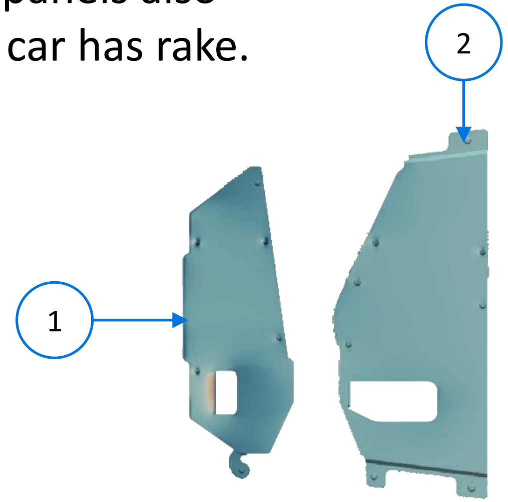
The velocity on the bottom side of the wing is higher than the top side which causes the pressure differential between top and bottom surfaces. The wing also changes the direction of the overall airflow from aiming downward to straight rearward.

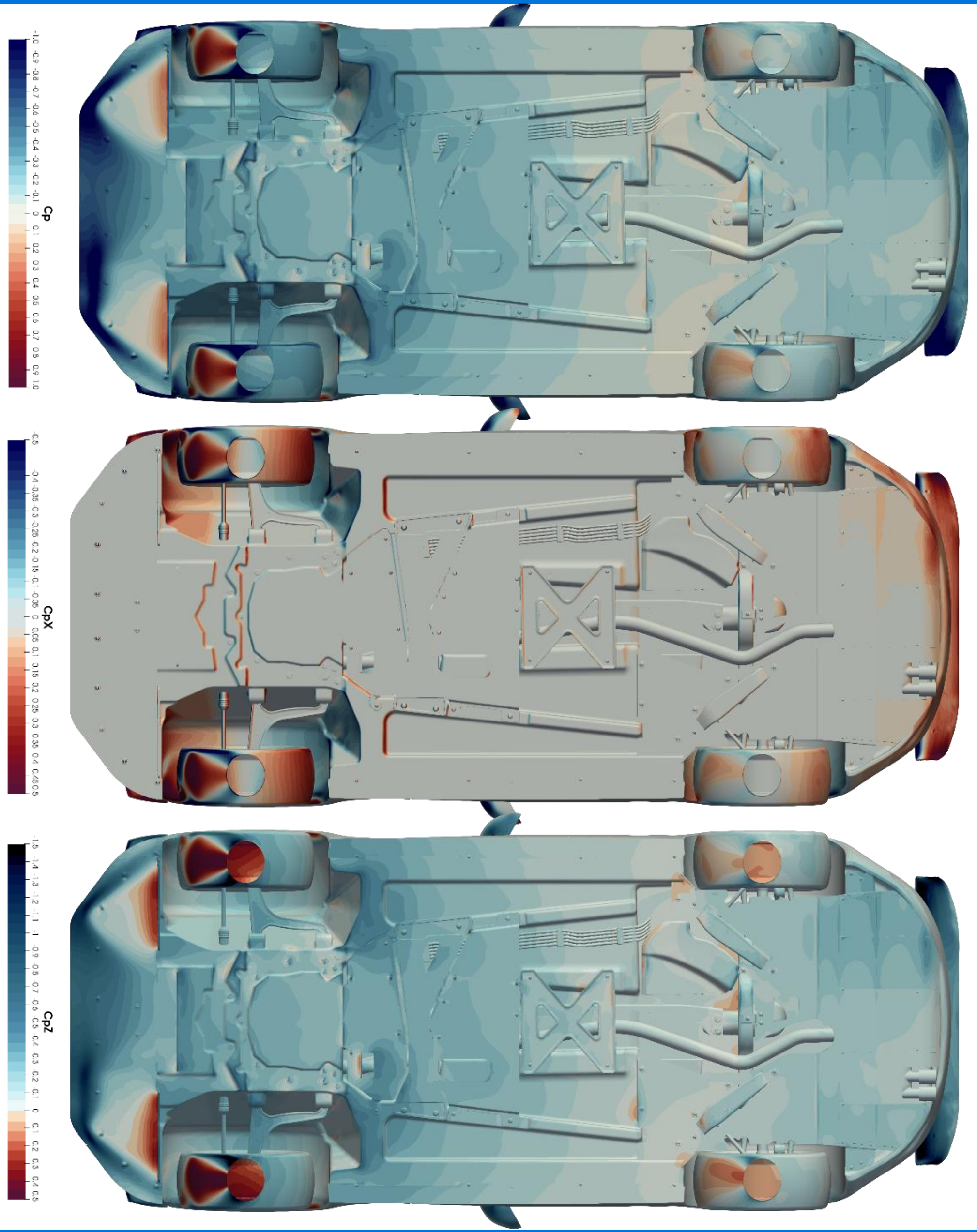


UNDERBODY PANEL DETAILS

The Verus Engineering Flat Underbody Panels reduce the vehicles drag. The 2 panels reduce drag by decreasing the dirty air under the car and closing up large openings. The underbody panels reduce vehicles coefficient of drag (Cd) by 10 points. The panels also increase downforce when the car has rake.

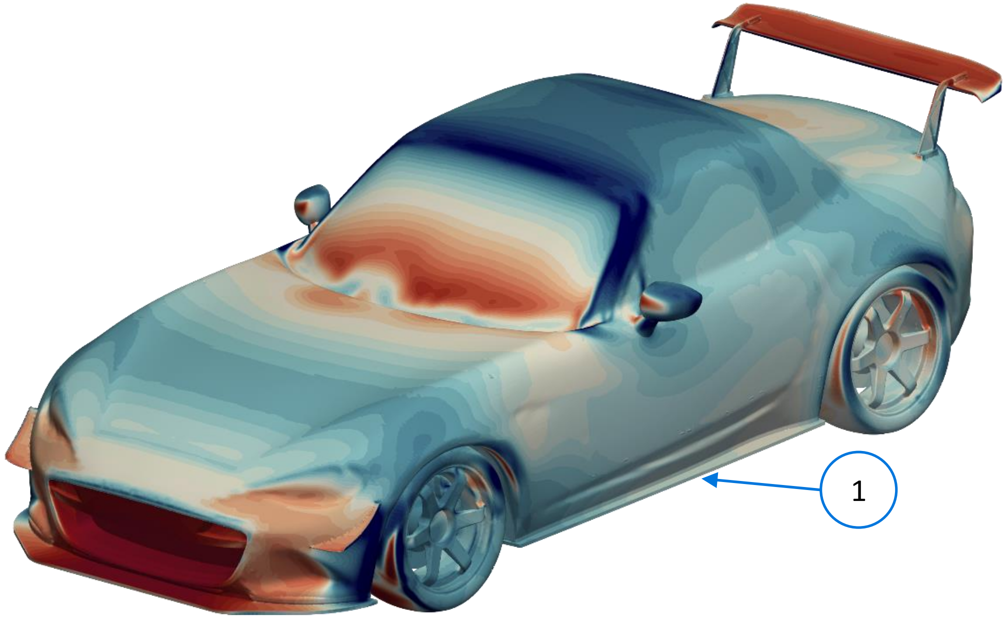
1. Front underbody panel
2. Rear underbody panel

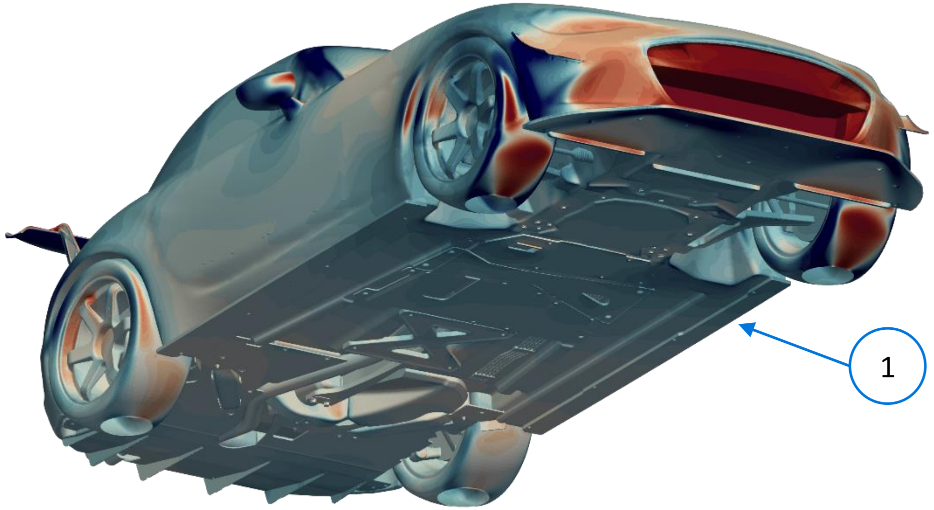




SIDE SPLITTERS

The Verus Engineering Side Splitters reduce the amount of flow from the top side to the bottom side of the care. It adds 6 points of downforce with no additional drag. It improves even more at more sustained yaw angles. The downforce is added in the center of the car and aerodynamic balance is not altered.

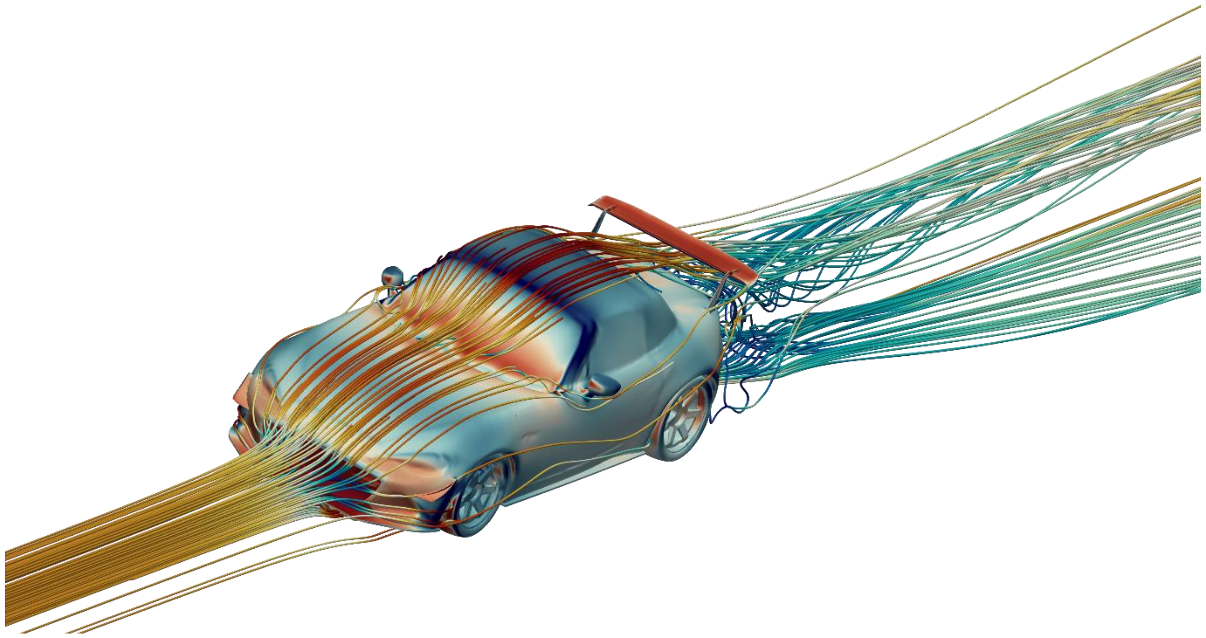




SUMMARY

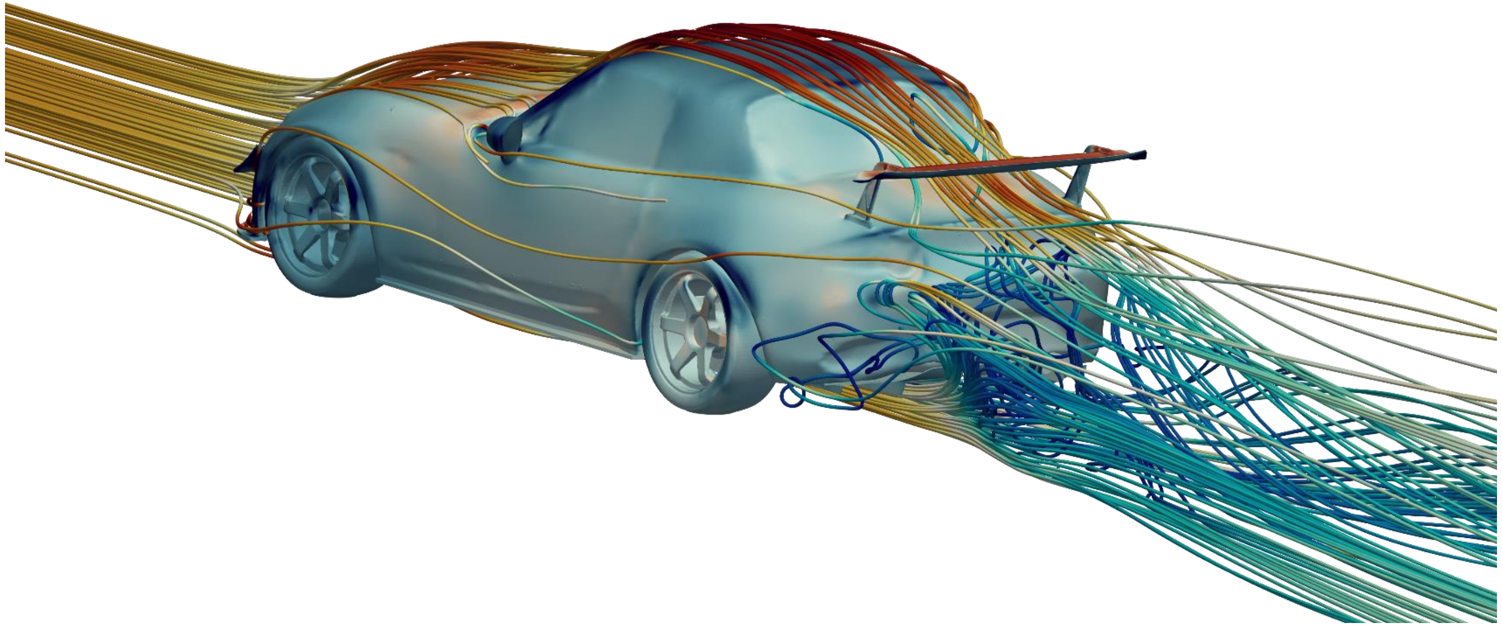
The Verus Engineering Ventus Packages for the ND Miata is designed to decrease lap times utilizing well developed and functional aerodynamic components. These packages are designed to fit like OEM and increase the factory performance **all while keeping the factory warranty.** The research and development of the package was done using cutting edge technology in CFD and proven designs from previous work.

The individual components do not need to be installed as a package, but that will give the best performance for decreasing track times.

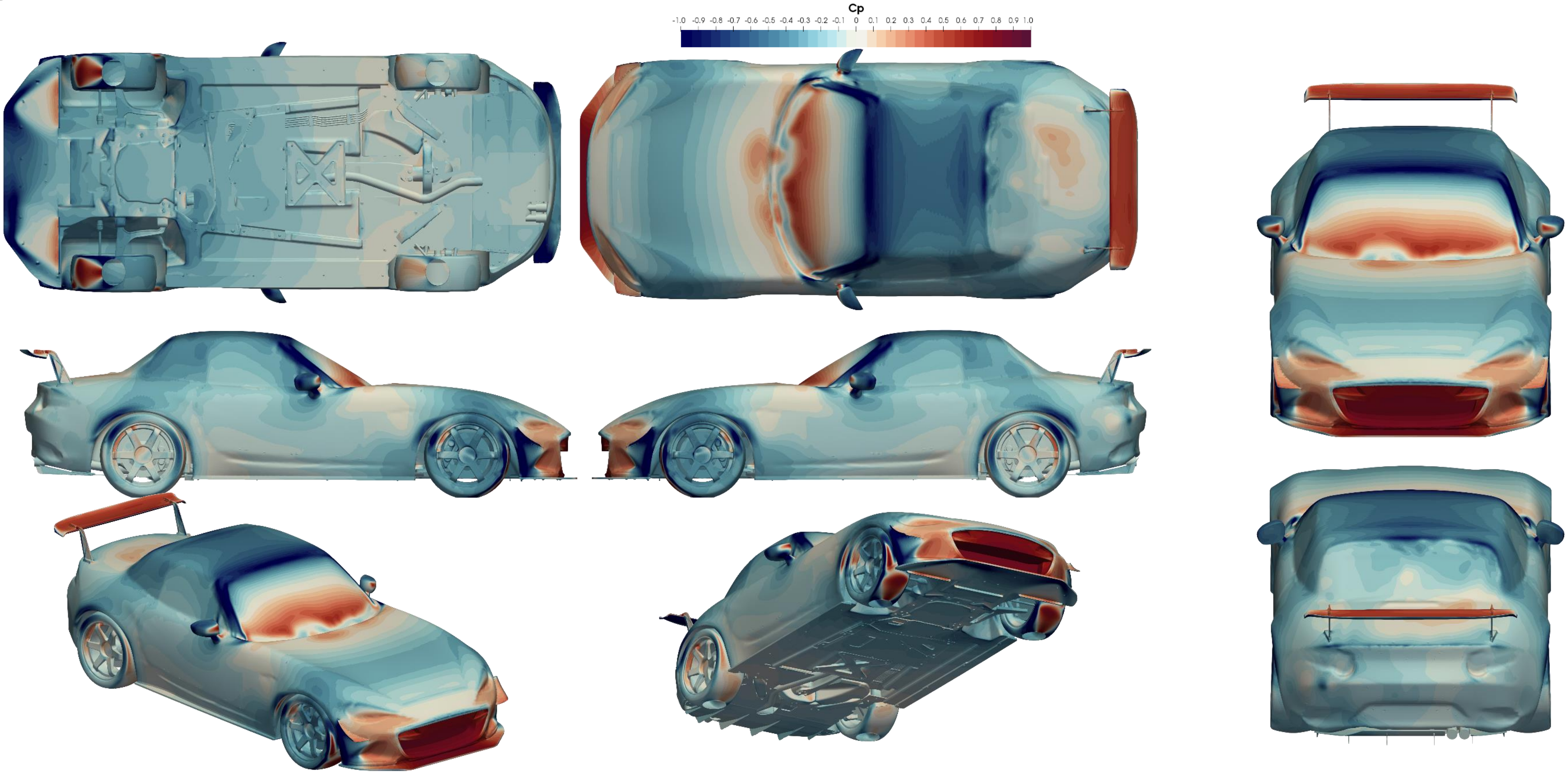


THE SCIENCE

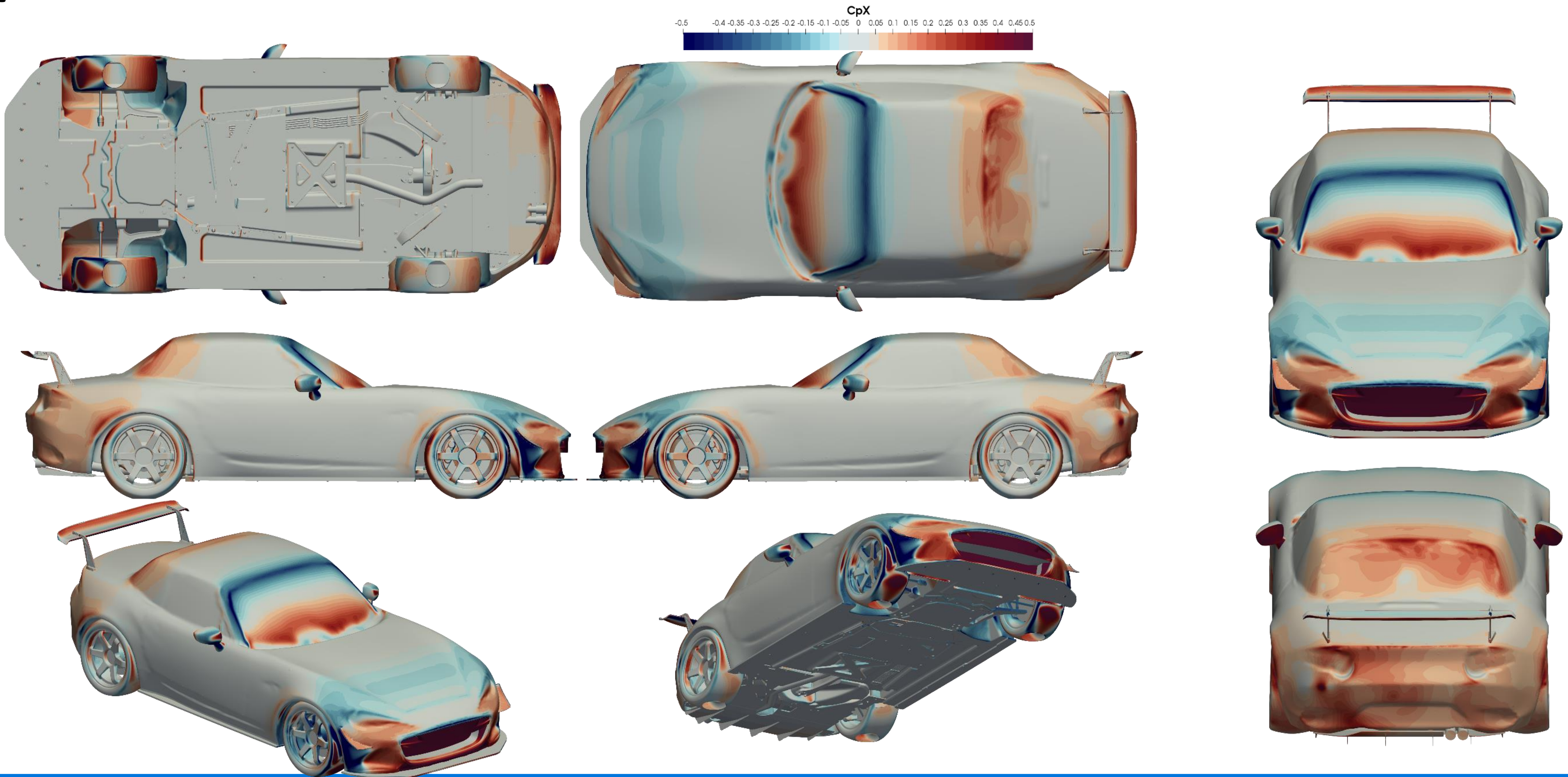
This analysis was done using OpenFOAM V6 which is a finite volume CFD software. The solver was SIMPLE and the turbulence model was K-Omega SST using standard wall conditions. We used standard automotive arrangement when setting up boundary conditions and running a full-car. The case was simulated using 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.



Cp PLOTS



CpX PLOTS


CpX
-0.5 -0.4 -0.35 -0.3 -0.25 -0.2 -0.15 -0.1 -0.05 0 0.05 0.1 0.15 0.2 0.25 0.3 0.35 0.4 0.45 0.5

CpZ PLOTS