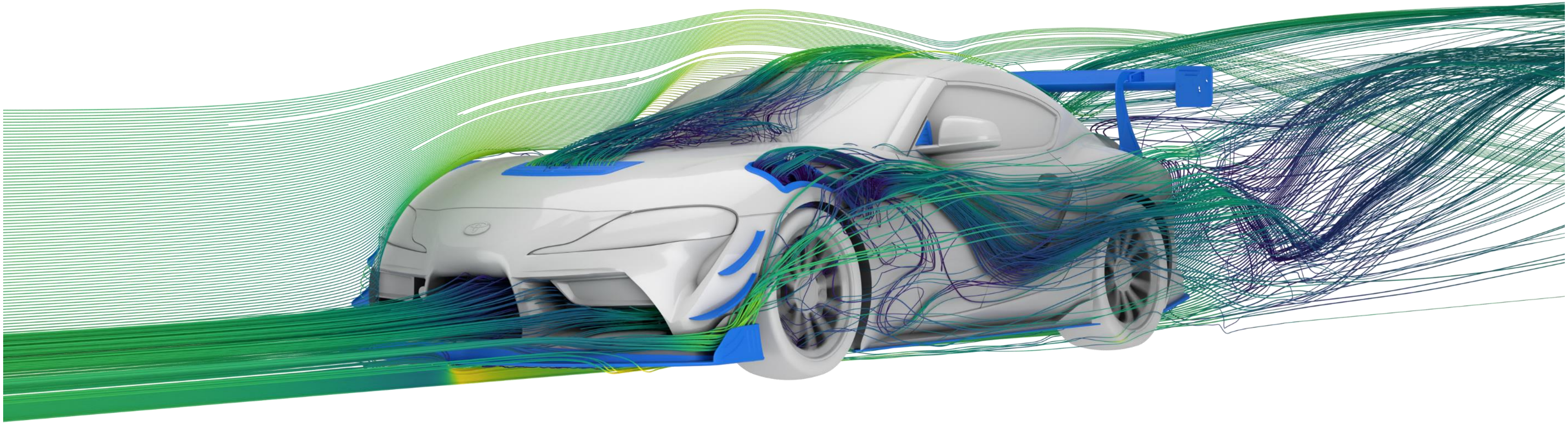


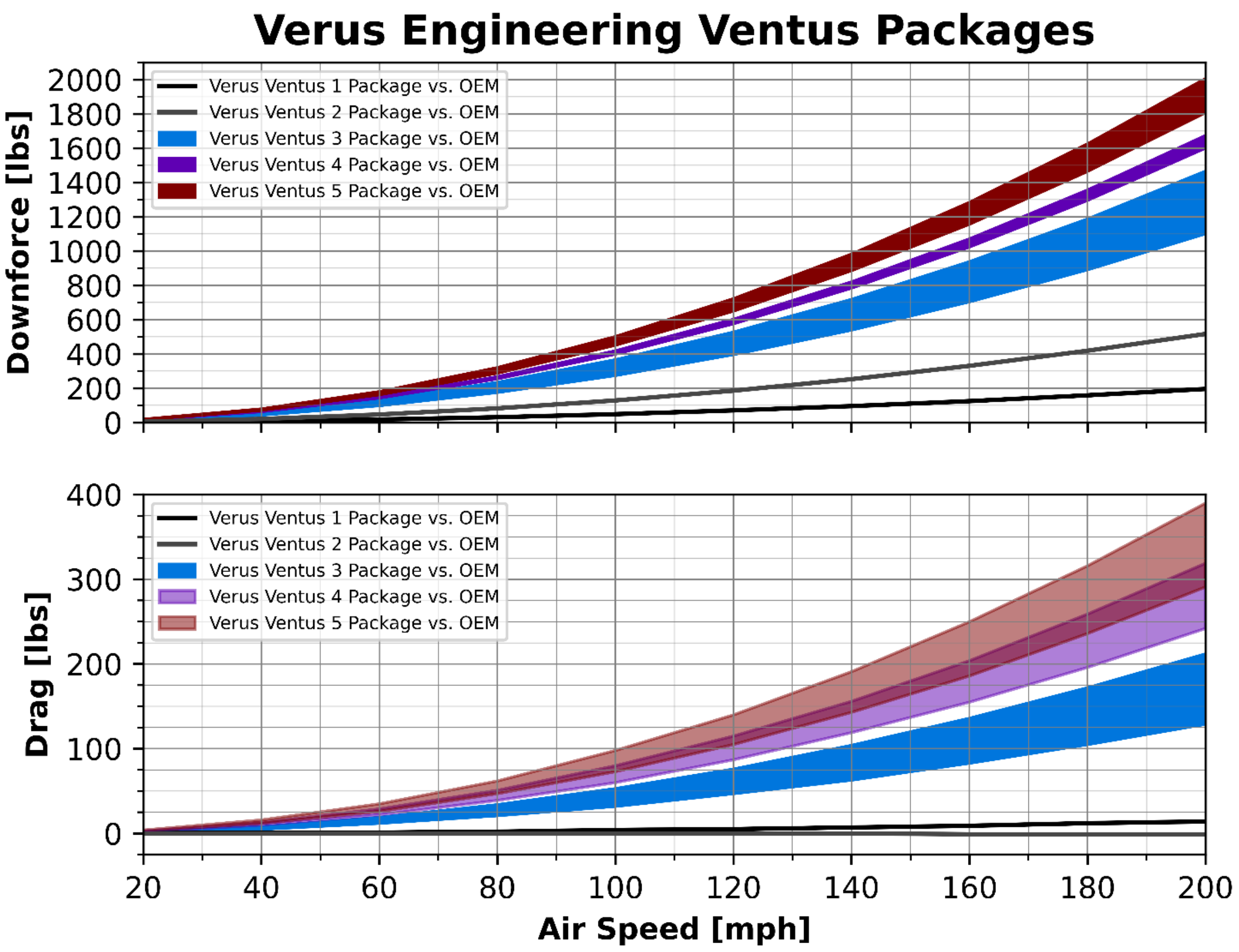
TOYOTA A90 SUPRA PLATFORM

PERFORMANCE OF VERUS ENGINEERING VENTUS PACKAGES

OVERVIEW

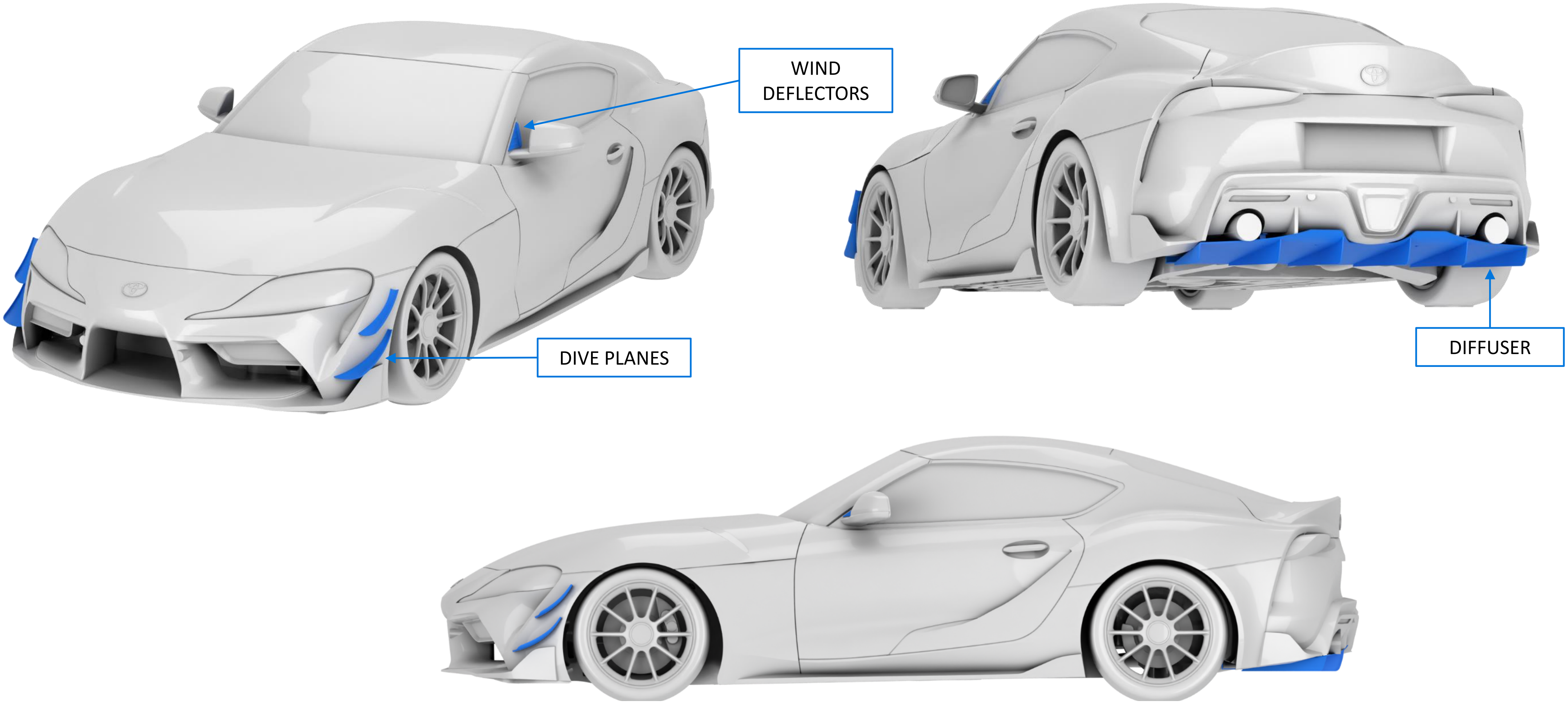
SUMMARY : AERODYNAMIC FORCES

- 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 (Ventus 2 reduces drag compared to OEM).
- The Ventus 3 & 4 packages create significant downforce and are a popular choice amongst track enthusiasts and competitive racers alike.
- The Ventus 5 package is our highest downforce package which provides the highest downforce potential thanks to the V1X wing and carbon fender vents. At lower AoA it actually offers a drag reduction compared to the Ventus 4 package at higher AoA.
- See the following slides for a breakdown of the components that make up each Ventus package.
- Angle of Attack adjustment allows the driver to fine tune aerodynamic balance to his or her preference.
- The Wind Deflectors and Hood Louver are a great addition to any Supra.

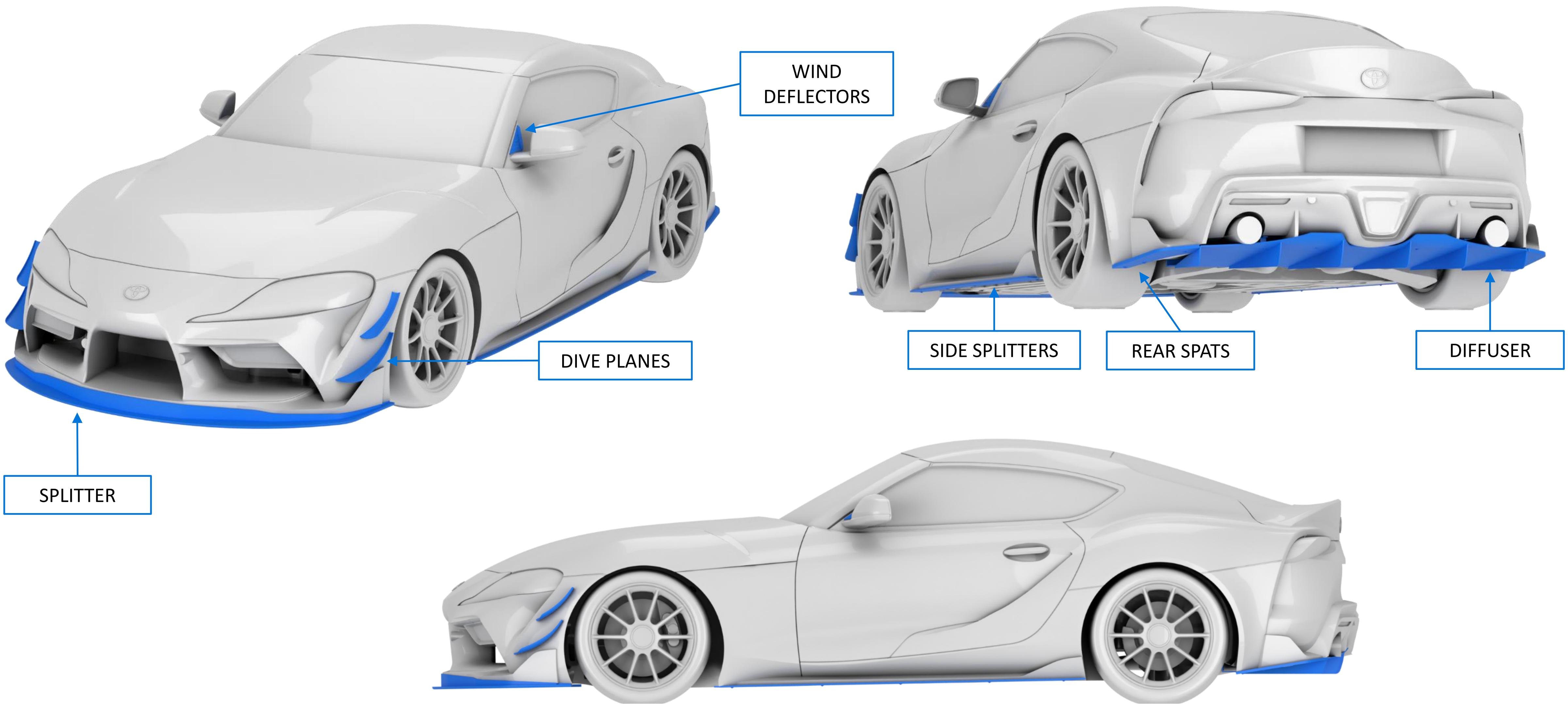


Note:	*The force values are comparisons to the factory A90 Supra*	
	Wing Angle: 0° - 8°	*(Ventus 3 UCW)*
	Wing Angle: 6° - 14°	*(Ventus 4 UCW)*
	Wing Angle: 2° - 12°	*(Ventus 5 V1X)*

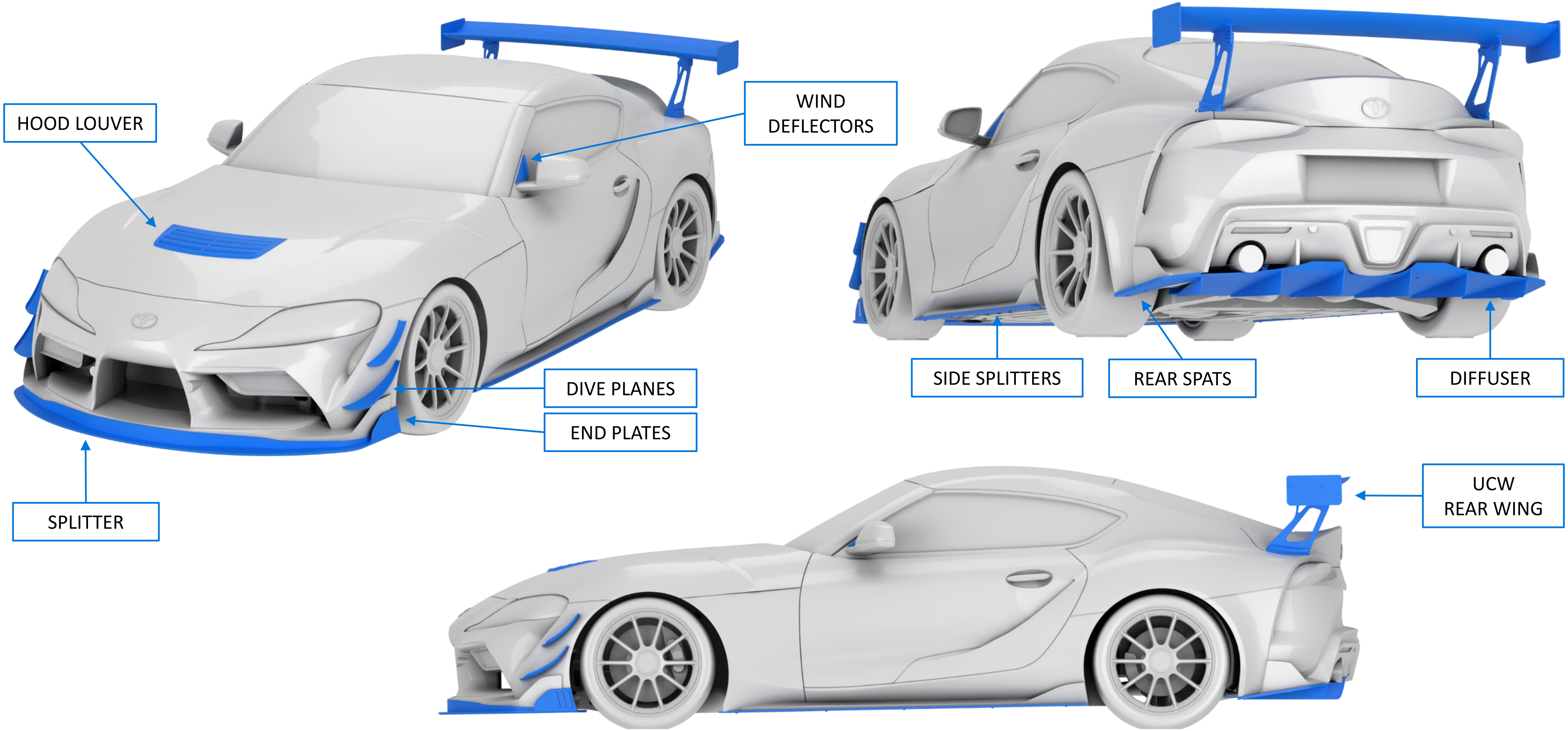
VENTUS 1 PACKAGE



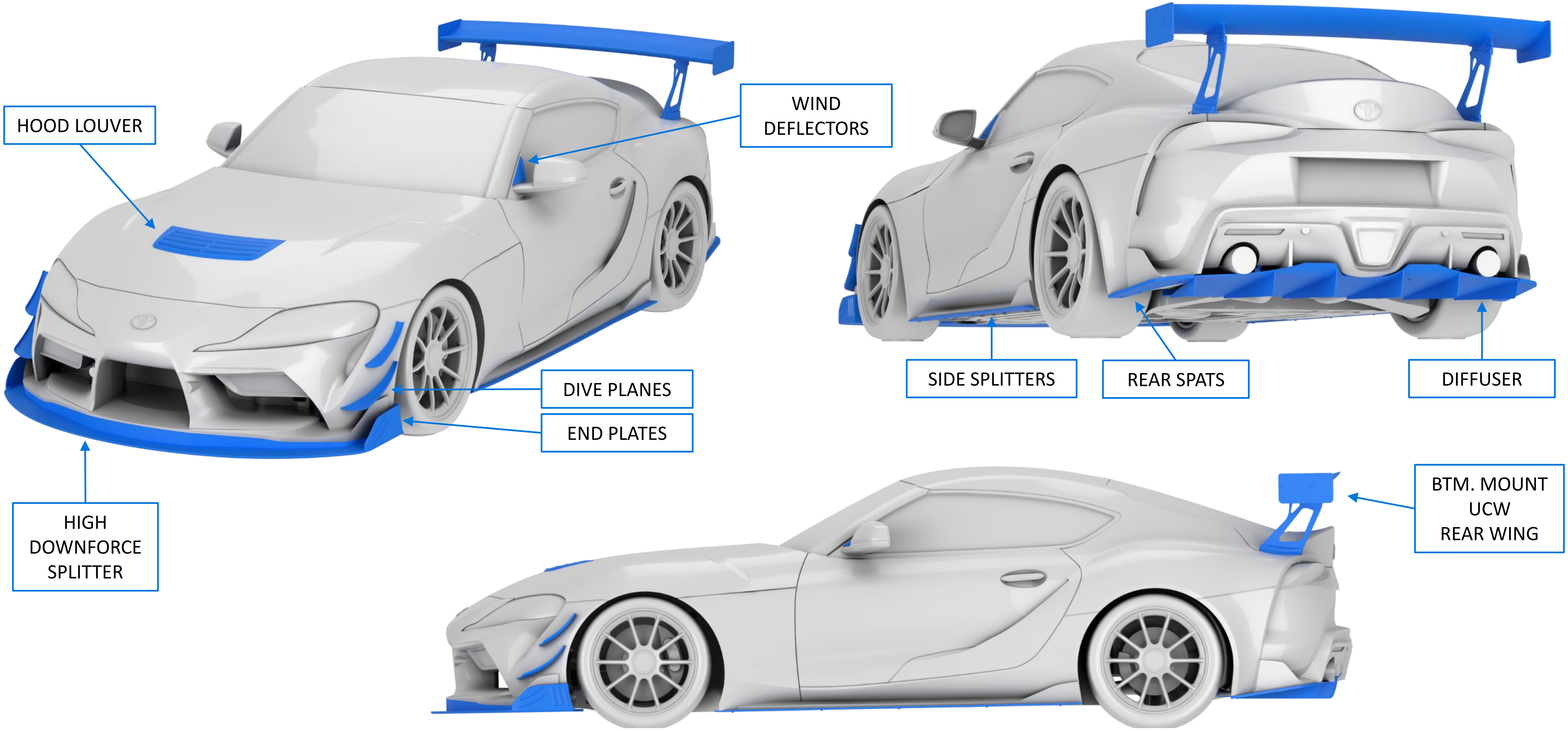
VENTUS 2 PACKAGE



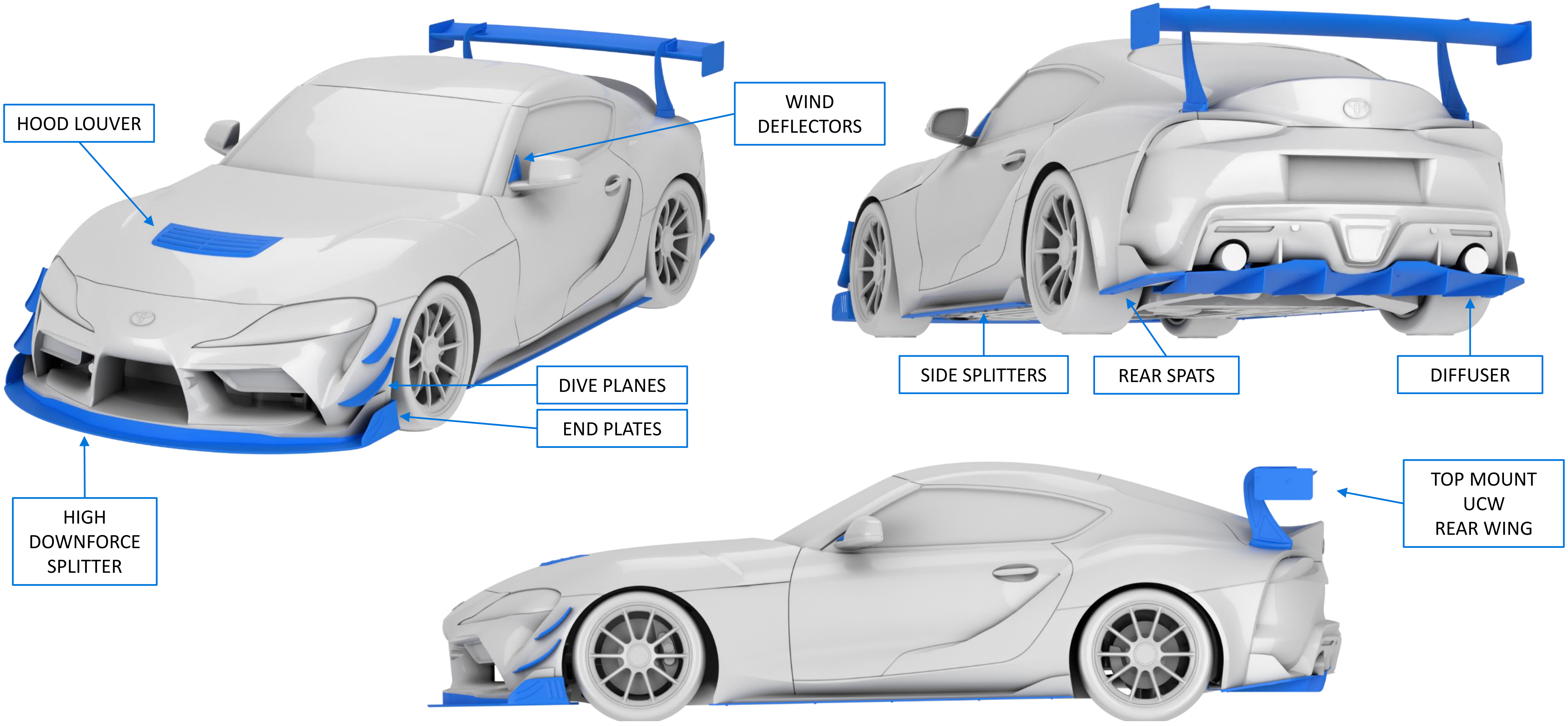
VENTUS 3 PACKAGE



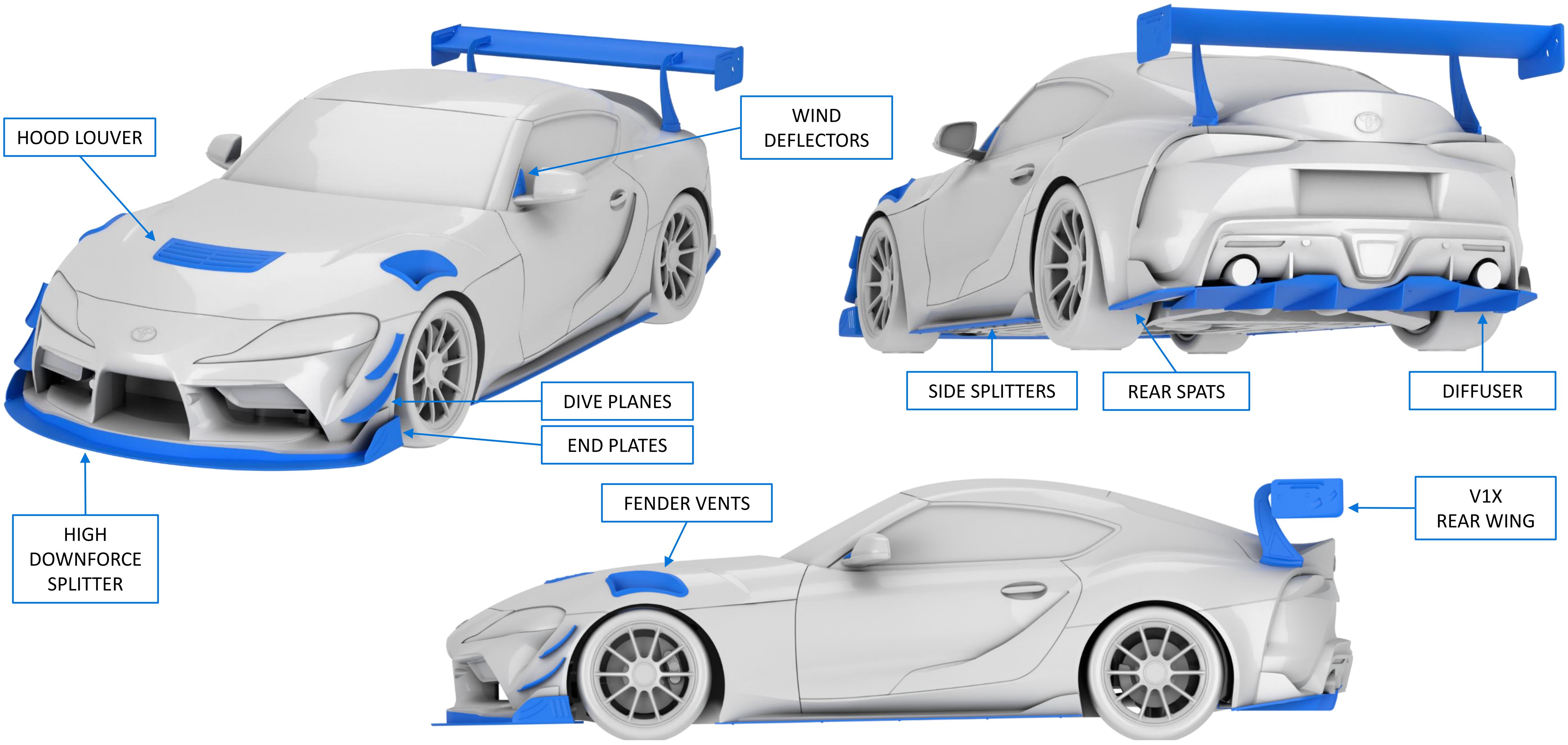
VENTUS 4 PACKAGE (BTM. MOUNT)



VENTUS 4 PACKAGE (SWAN NECK)



VENTUS 5 PACKAGE

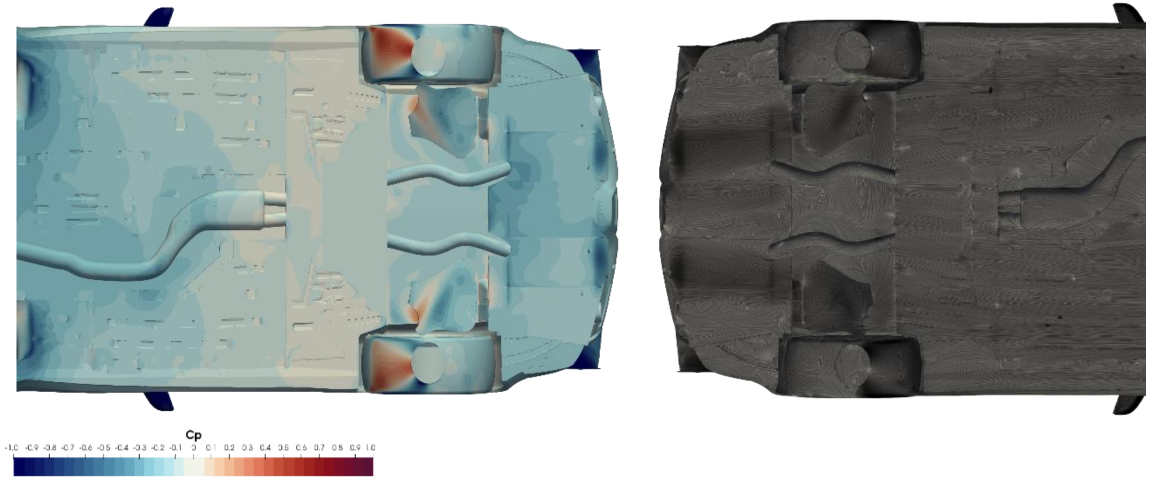


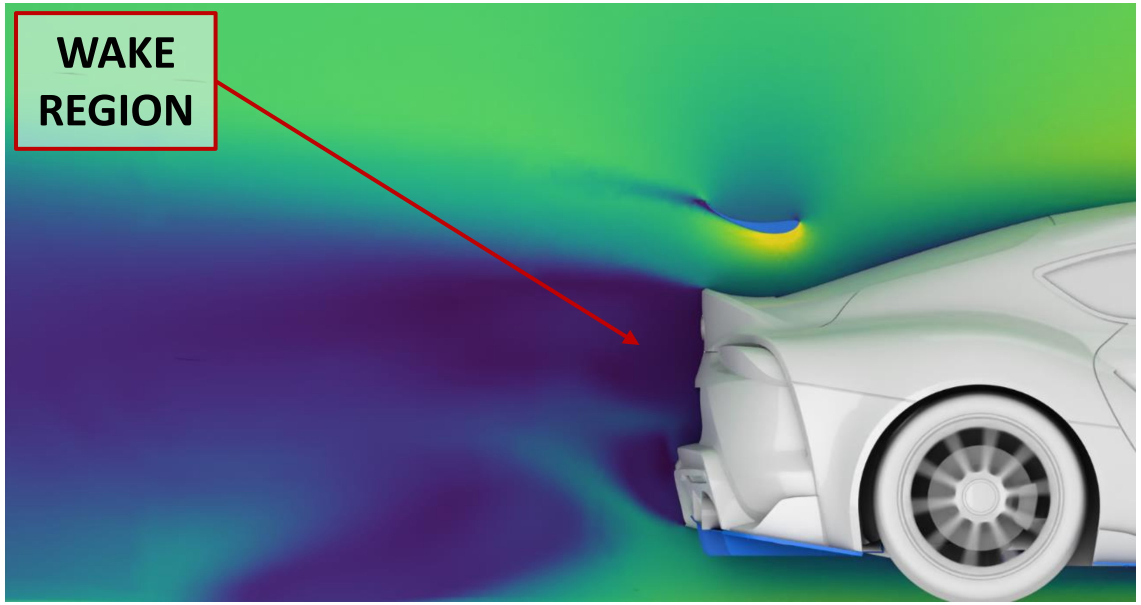
DIVE PLANE / CANARDS

- 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

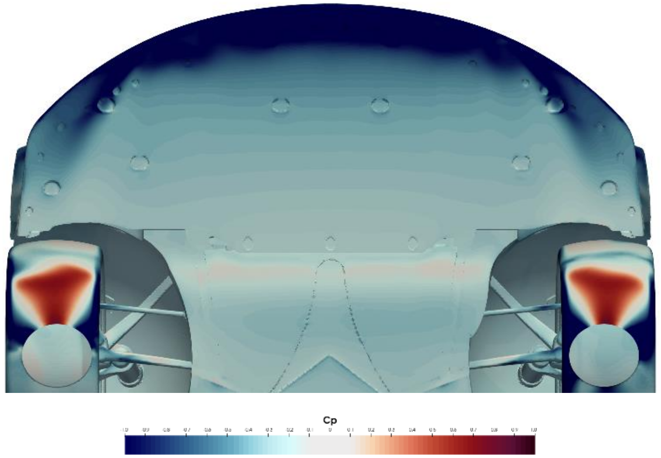
- The rear diffuser is a key component in creating efficient downforce.
- A diffuser is perfect for a street car as it will add stability (downforce) *and* reduce overall drag, when designed properly.
- The diffuser functions by creating low pressure on the bottom surface and reduces drag by filling 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.

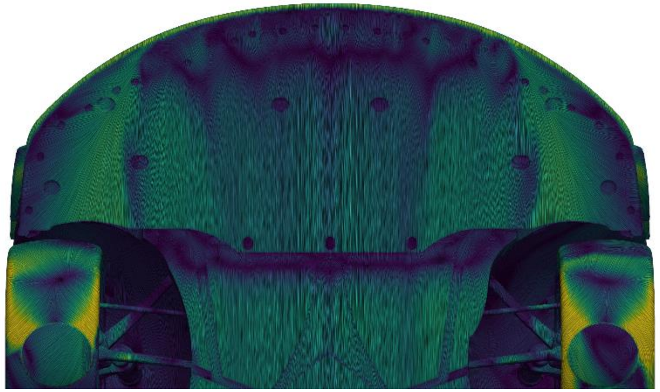


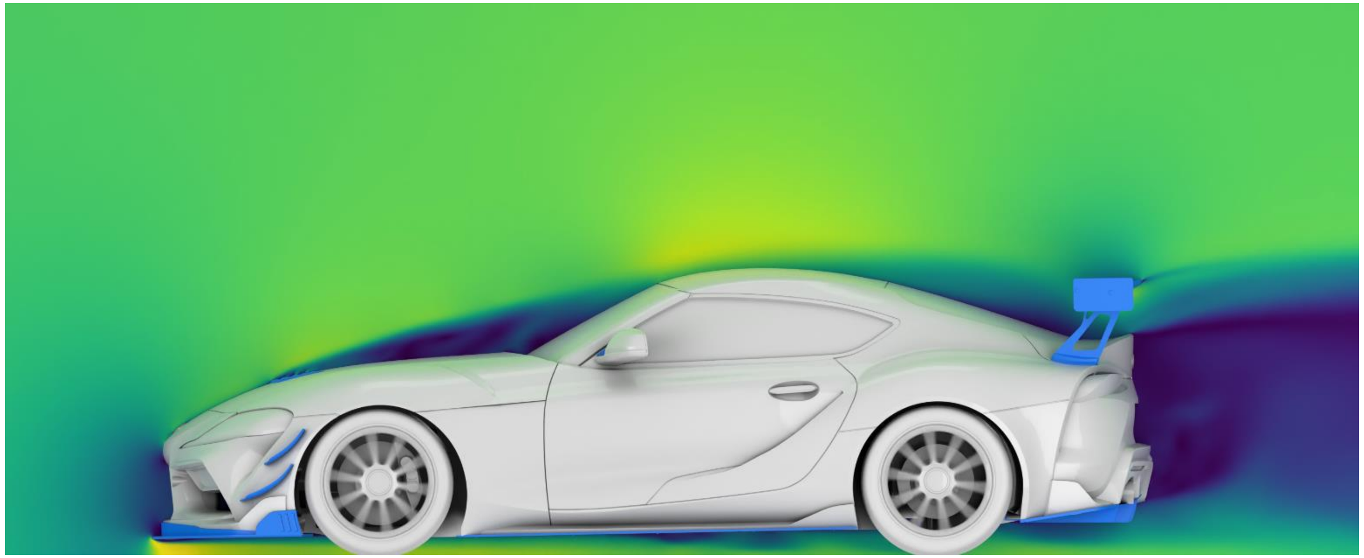


STANDARD SPLITTER

- 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.
- 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.
- 3D printed carbon/nylon splitter end plates can be purchased to increase front end downforce by increasing the high pressure zone on the top of the splitter, and improving wheel well evacuation

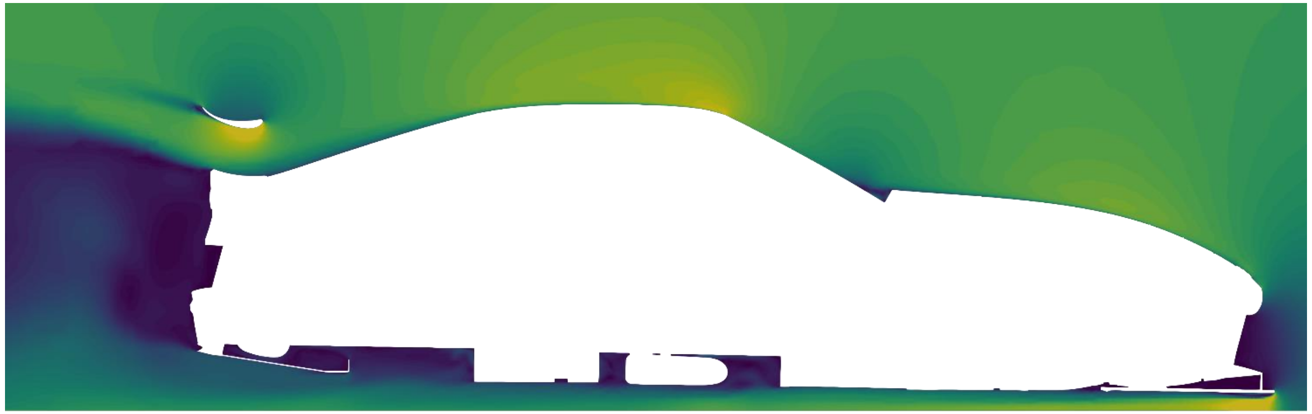






UCW REAR WING: BOTTOM MOUNT

- 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 A90 Supra.
- 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.
- Trunk mounts sandwich the OEM hatch with a precise surface match. Machined from billet 6061 aluminum, there is enough strength and rigidity to transfer loads into the chassis with the UCW or V1X wings.
- The UCW is produced from 2x2 twill carbon fiber finished in an automotive clear coat.

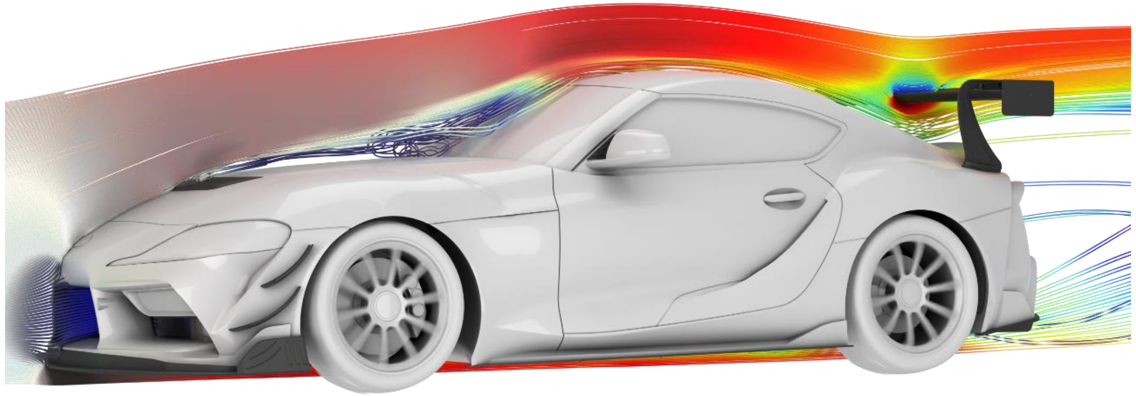


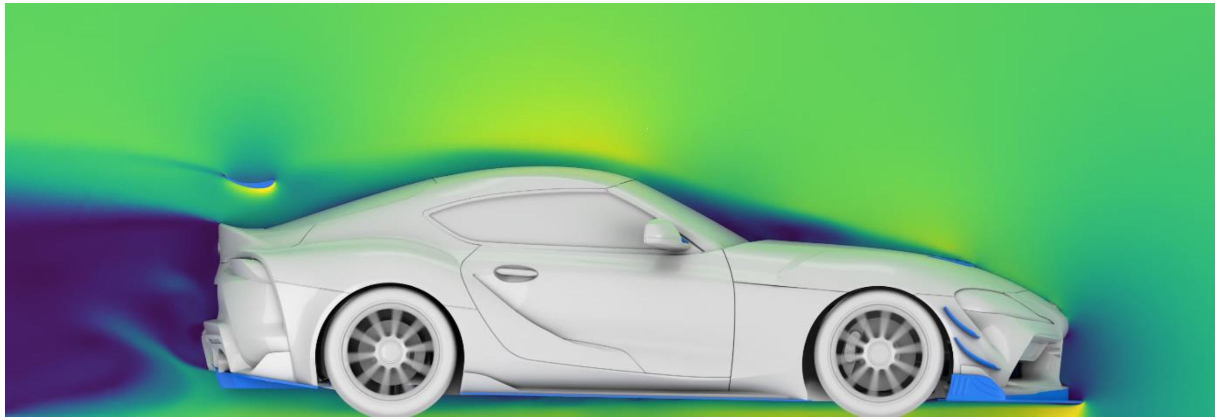
UCW REAR WING: TOP MOUNT (SWAN NECK)

The same wing element as our original UCW but with the swan neck appearance.

The top mount UCW:

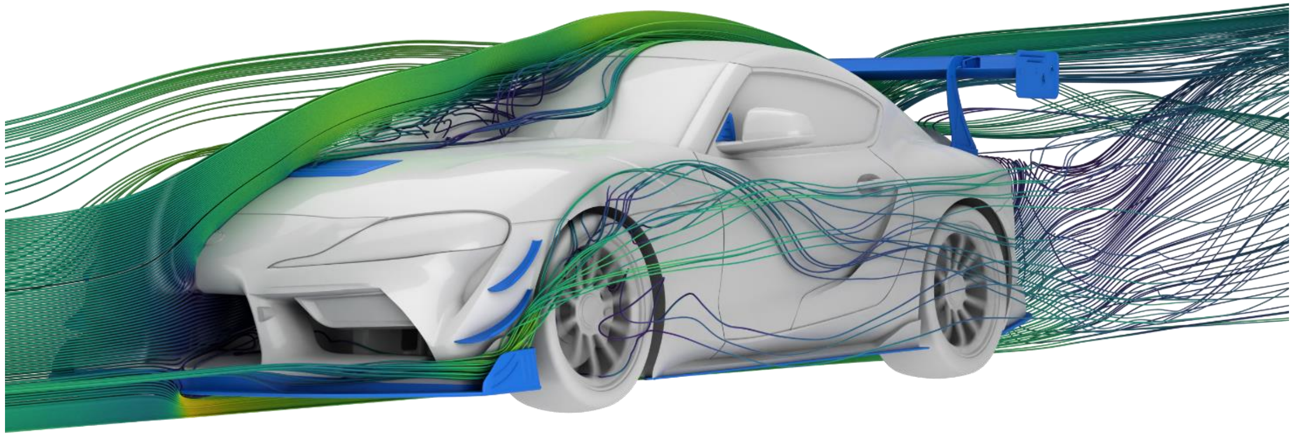
- The wing element/mounting is more efficient than the bottom mount UCW. The top mount UCW re-uses the mounts from the Verus swan neck V1X. This position isn't as well suited to the UCW element, therefore overall performance is essentially the same for the top/bottom mount UCW.
- Retains the same trunk mounting system for an easy swap.
- If you are struggling to choose between the top and bottom mount UCW wings, choose the one that you like more.

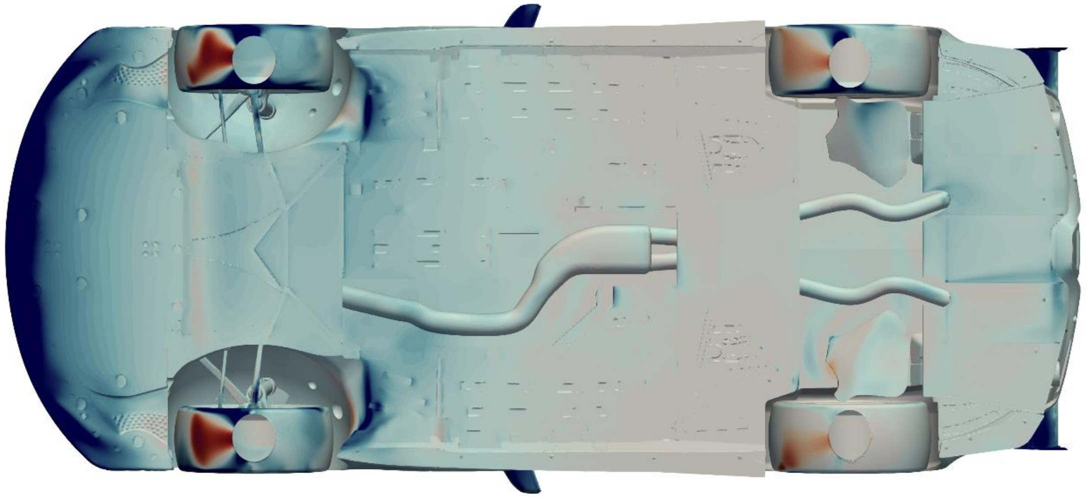


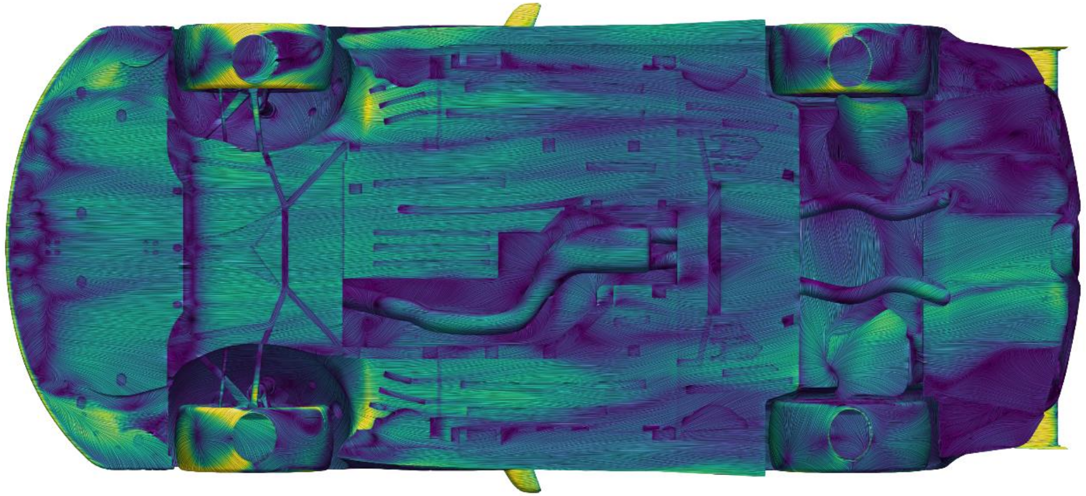


HIGH DOWNFORCE SPLITTER

- Greatly increased downforce with minimal drag penalty compared to standard splitter.
- Capable of balancing UCW wing at maximum angle of attack.
- Well suited to the V1X wing.
- The entire splitter assembly is modeled and simulated.
- This splitter retains all of the features of the standard splitter while adding:
    - Extended leading edge
    - Dimpled carbon fiber diffusers
    - Optional, larger 3D printed carbon fiber nylon end plates





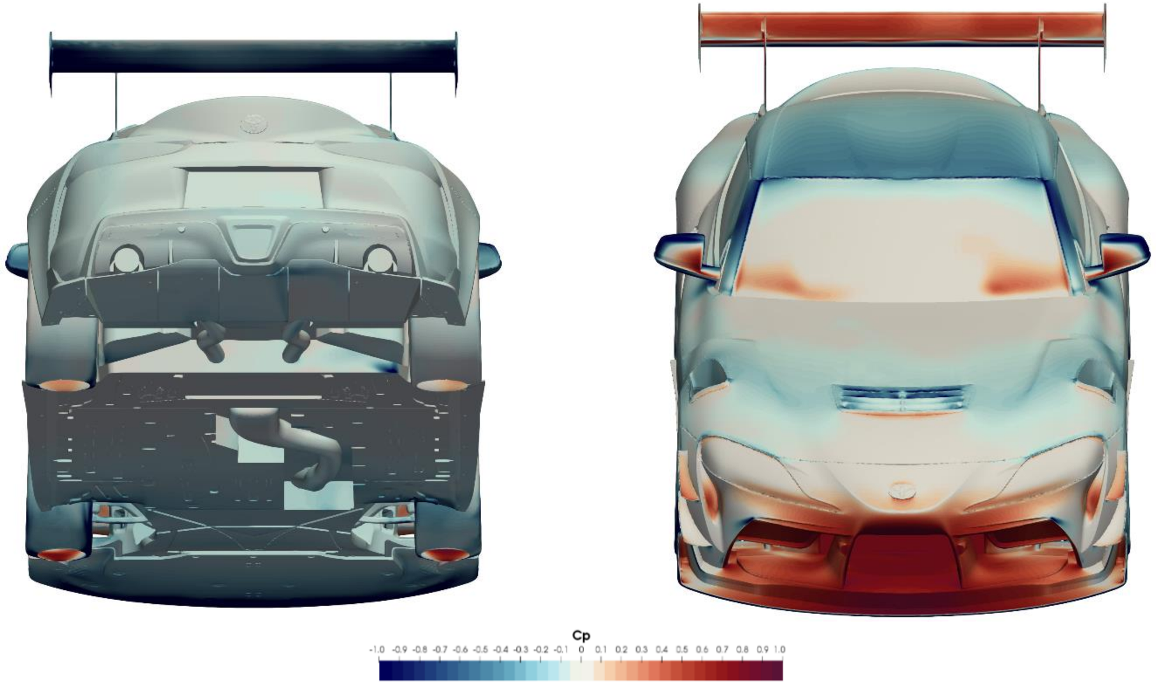


V1X REAR WING

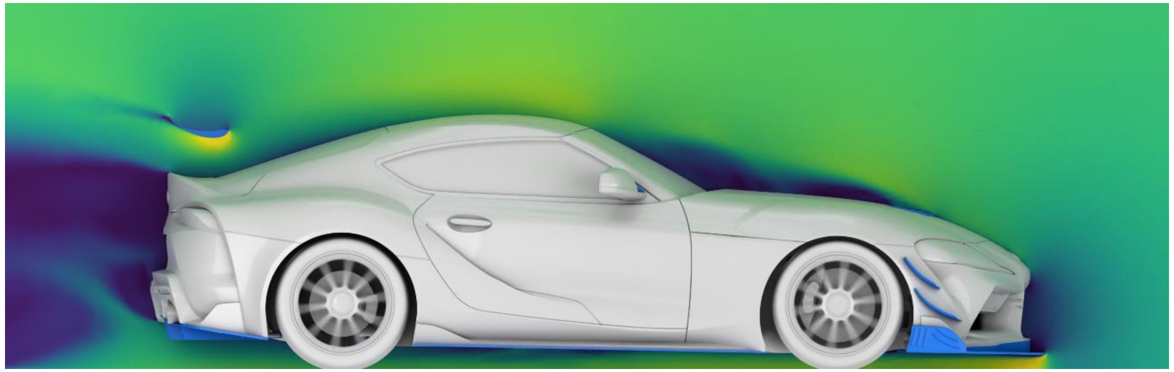
The same methodology as the UCW but with capacity for much higher downforce (see charts on the following page).

The V1X was designed with efficiency in mind:

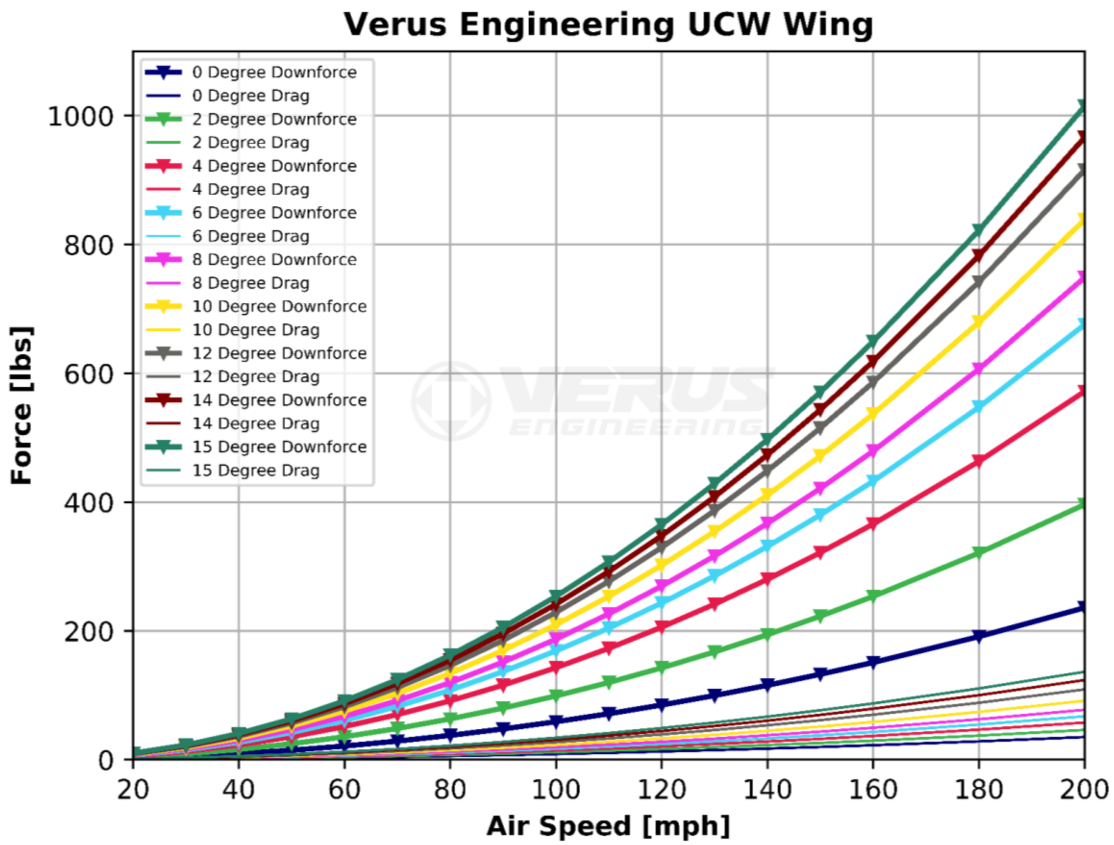
- The airfoil shape was optimized using adjoint and optimization methods in CFD and correlated in the wind tunnel.
- Slots on the endplate decrease vortex energy off the endplate. Decreasing vortex energy reduces pressure drag.
- Swan Neck mount provides the V1X with cleaner air and more bottom surface area to make more efficient downforce.
- 1650mm is the recommended wing width for the Supra. However, you can custom order the width you want up to 1950mm.

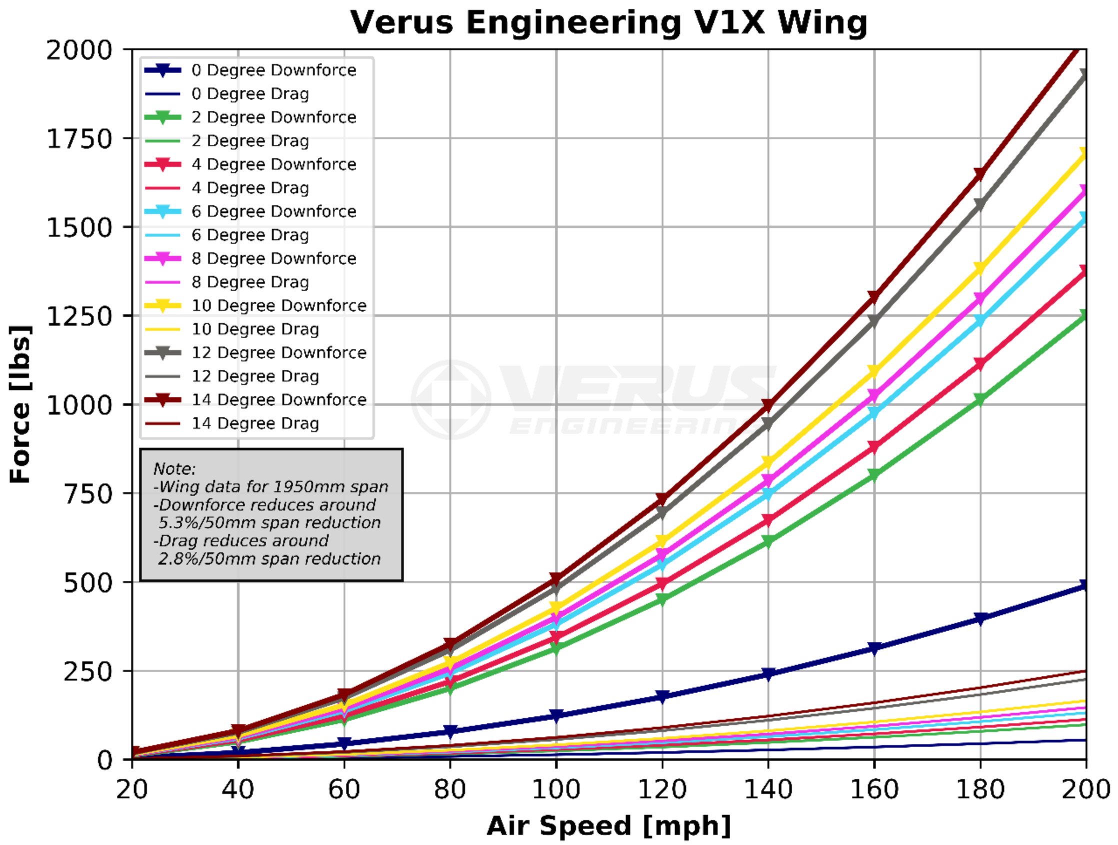


	Ventus 4 UCW @ 14°AOA	Ventus 5 V1X @ 2° AOA	Percent Difference
Chord (mm)	250	300	+ 20%
Downforce (lbs) @ 120 mph	563	611	+ 8.5%
Drag (lbs) @ 120 mph	423	413	- 2.3%
Balance (% Front/Rear)	56.3 / 43.7	53.5 / 46.5	- 5.0%



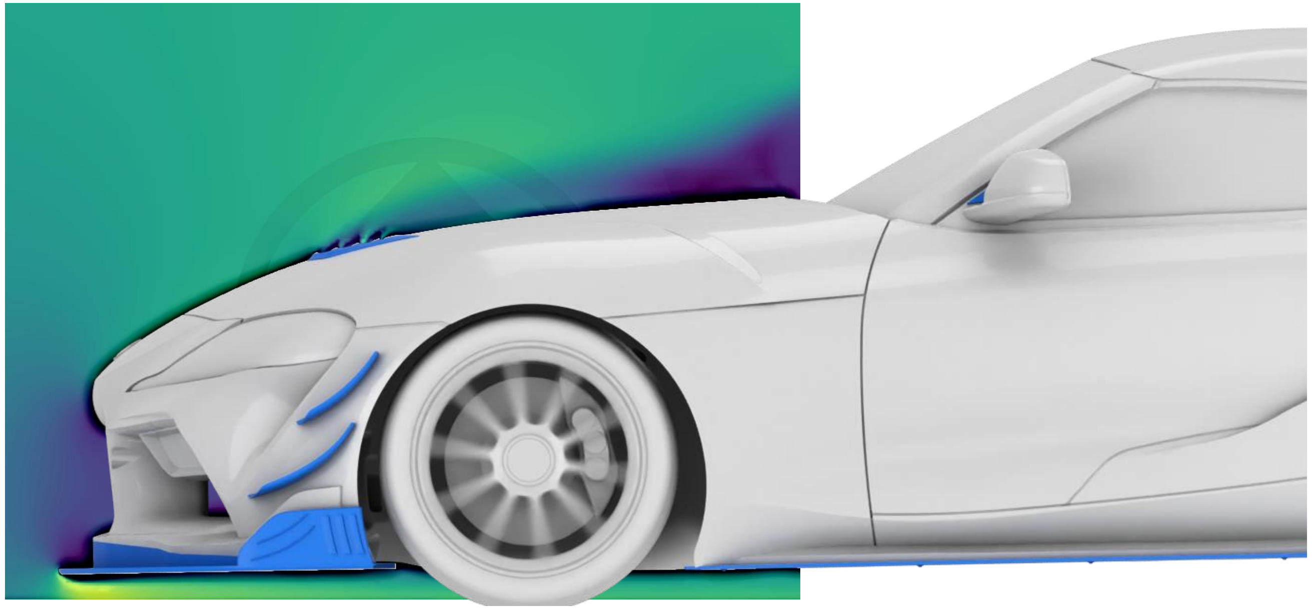
SUMMARY : UCW & V1X REAR WINGS

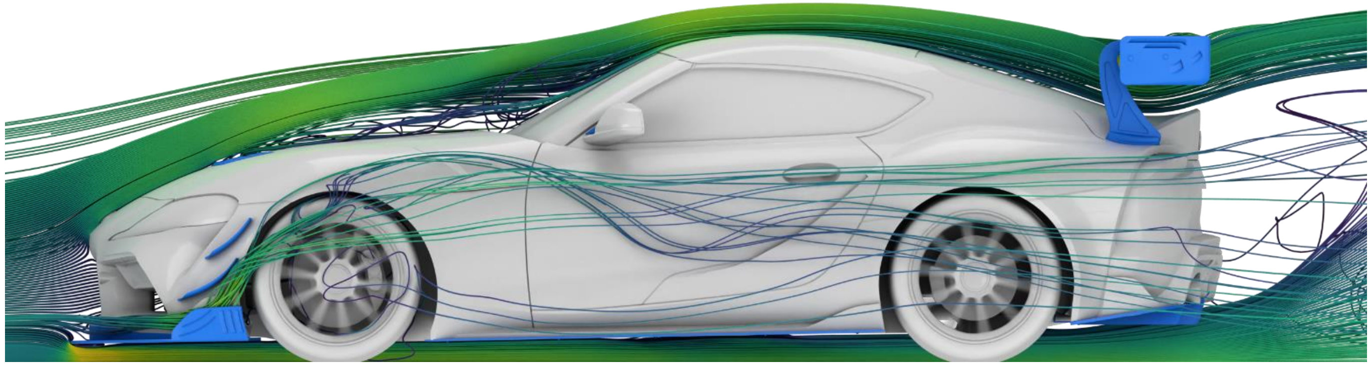




HOOD VENT / LOUVER

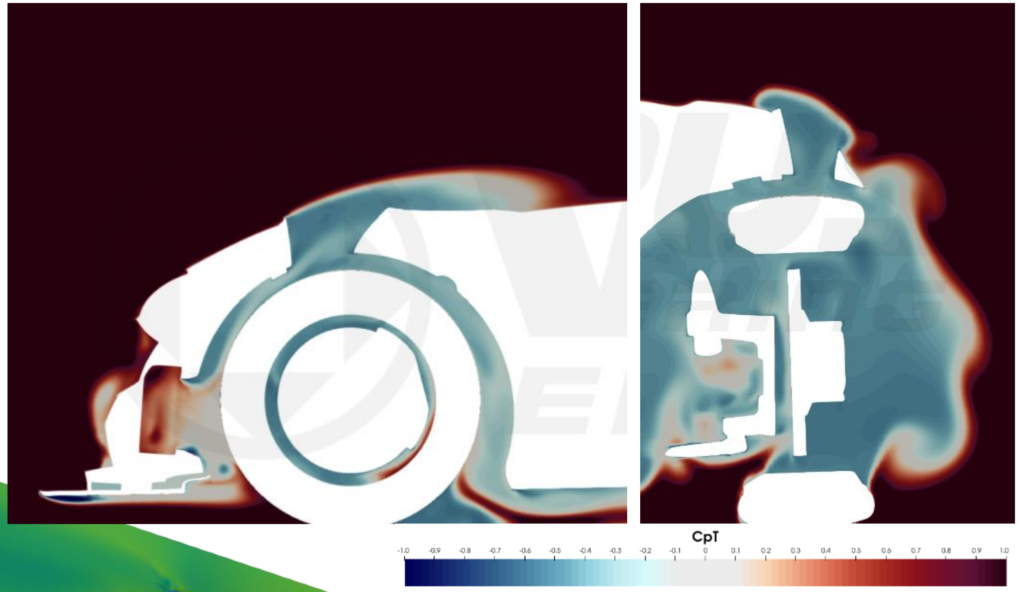
- Reduces engine bay heat and pressure.
- The louver improves cooling stack efficiency and under hood component longevity.
- Adds a bump in the front end downforce by alleviating air pressure in the engine bay.
- Developed using 3D scan data to have an OEM type fit and finish to the hood's contour.
- Placed in an area that removed ***minimal*** under hood structure as well as in an area of low pressure 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.

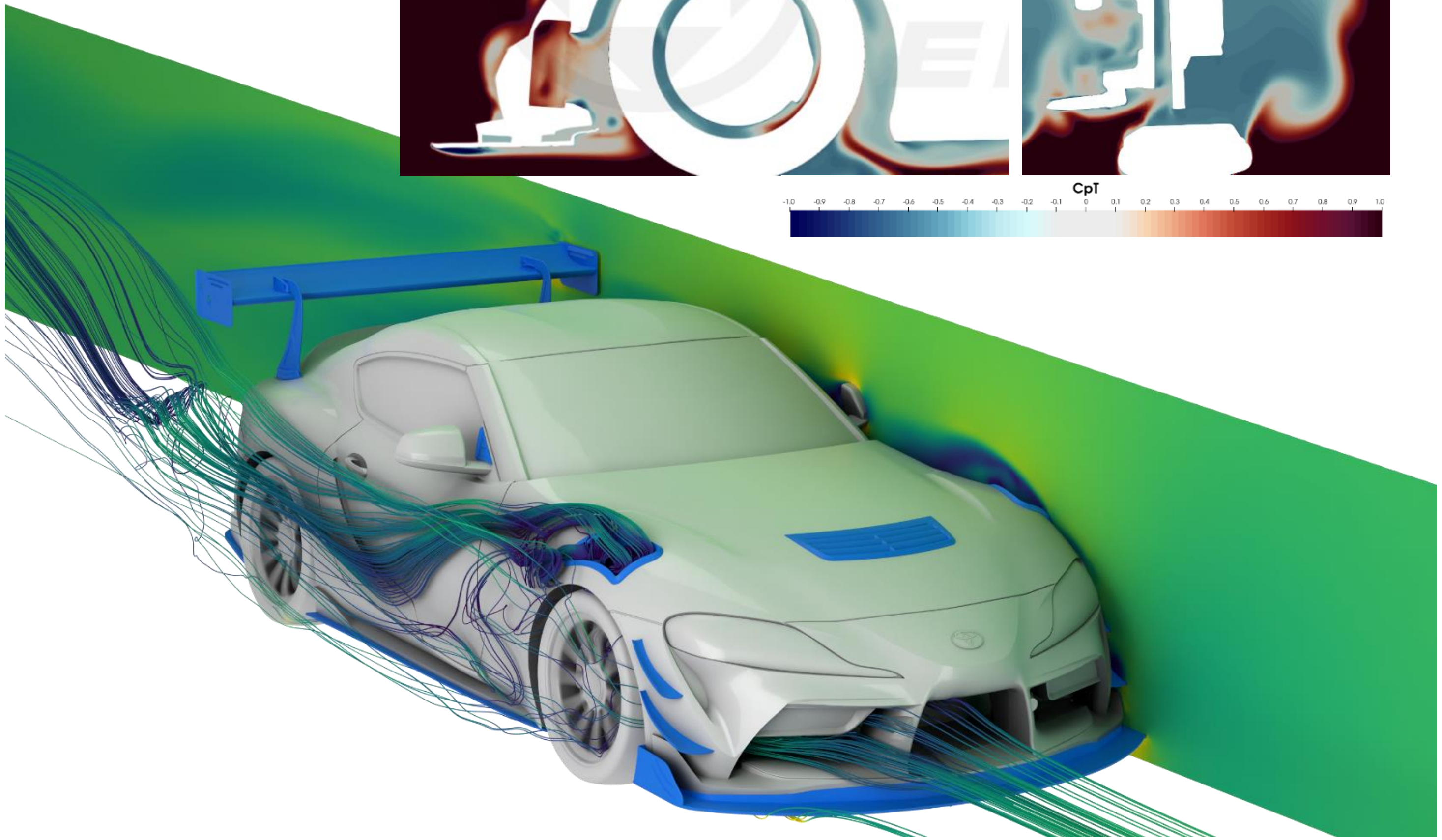




AUX. RADIATOR FENDER VENTS

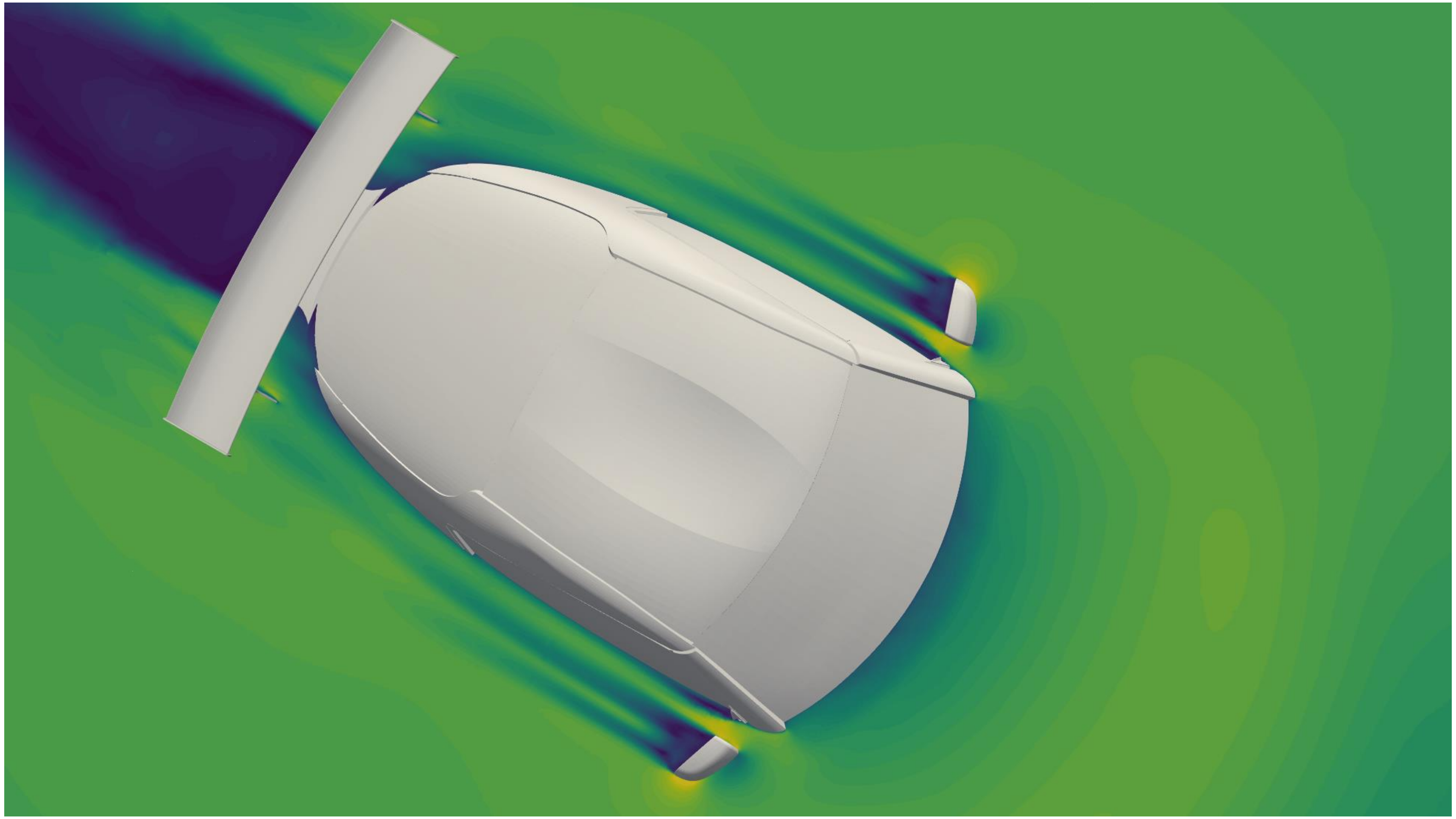
- Reduces wheel well heat and pressure.
- Lower wheel well pressure encourages flow through the aux. radiators by increasing the pressure differential across the core.
- Adds a bump in the front end downforce and shifts aero balance forward.
- Developed using 3D scan data to have an OEM type fit and finish to the hood's contour.
- Two piece design incorporates an under-hood flange to minimize cutting provide an OEM+ look.
- Upper vent is ducted all the way into the wheel well to prevent debris from entering the engine bay and provide a smooth exit path.
- Completely open design eliminates pressure drop caused by louvers.
- 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.





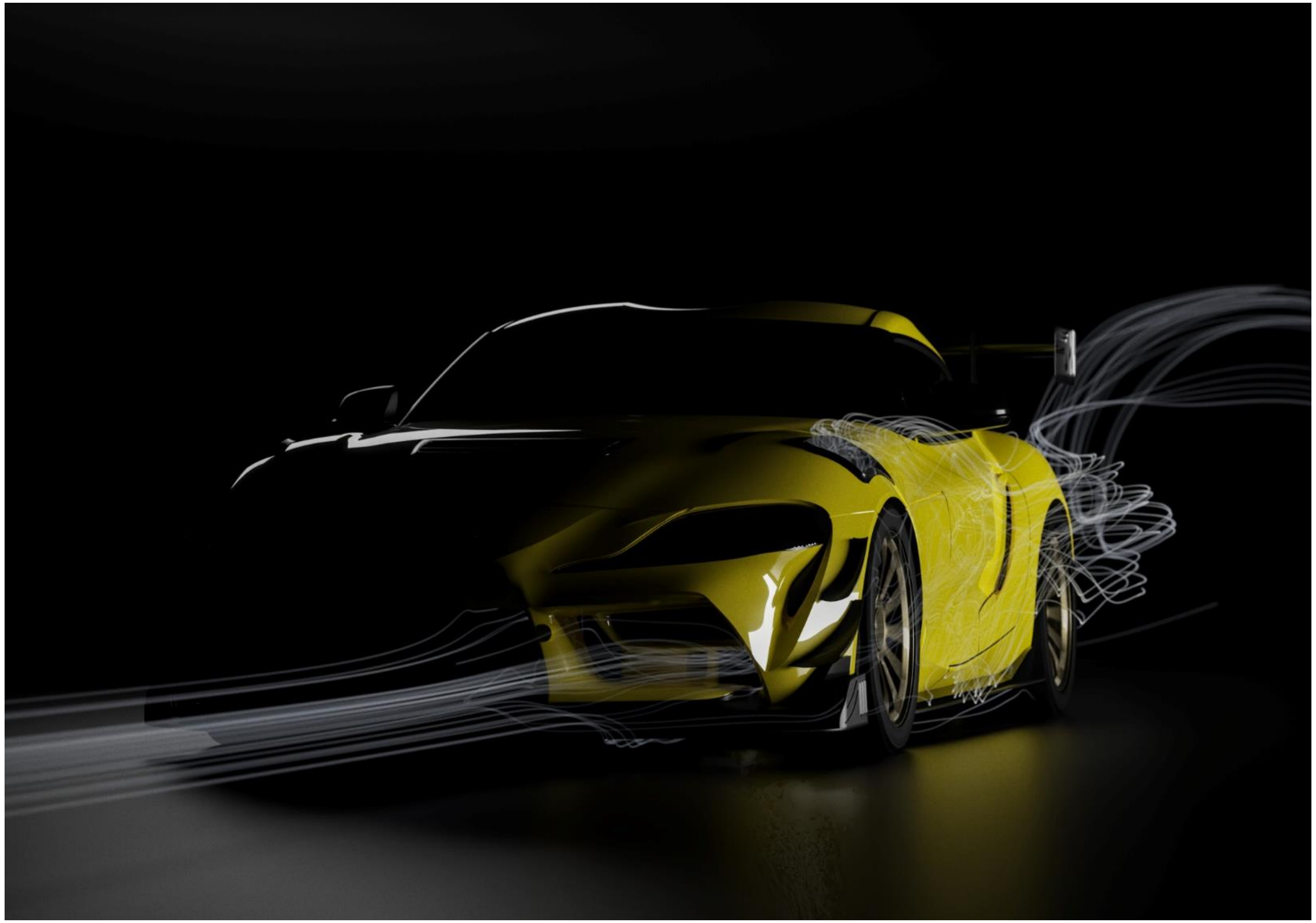
WIND DEFLECTORS

- The velocity cut plane at the wind deflectors depict how the flow is disrupted.
- This disrupted flow solves the wind buffeting issue that is prevalent on the A90 Toyota Supra.
- The wind buffeting cause pressure resonance that is unpleasant during driving with one or both windows down.



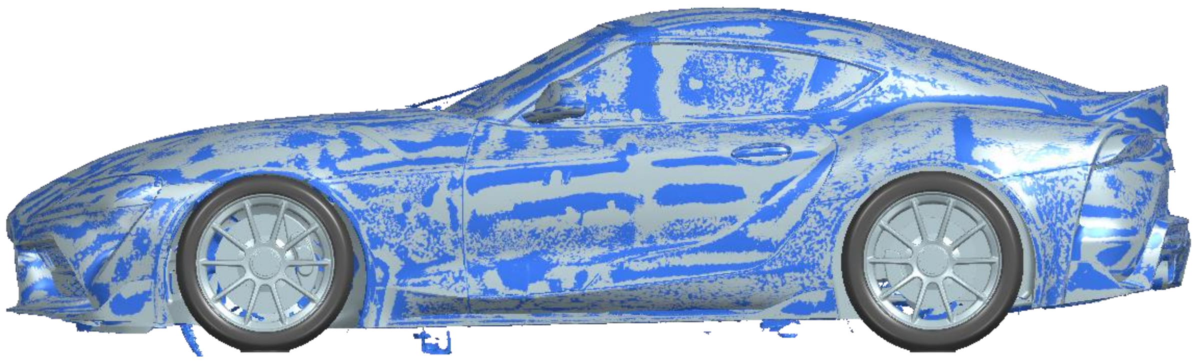
SUMMARY

- The Verus Engineering Ventus Packages for the A90 Toyota Supra 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 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 Toyota Supra 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).