AERODYNAMIC - CFD LABORATORY

Evaluation of aerodynamic performances with CFD simulation of Alfa Romeo MiTo

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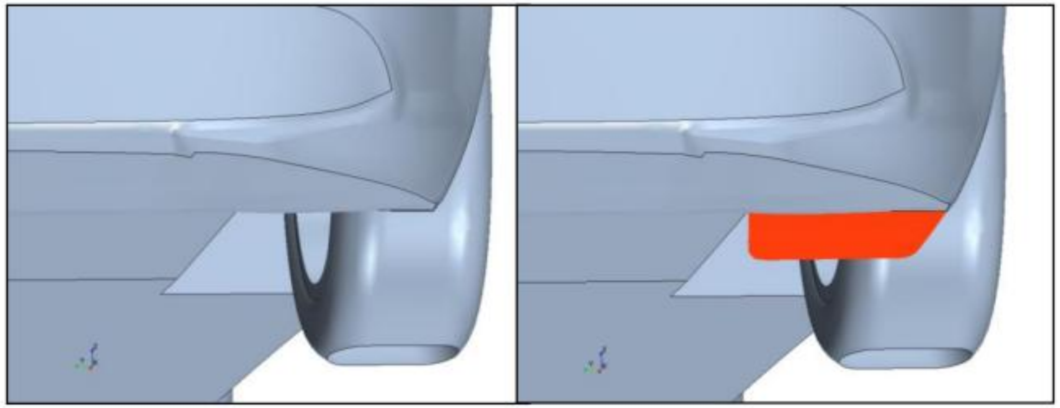
OUTLINE

- RESIDUAL ANALYSIS OF THE SIMULATION
- AEREODYNAMIC COEFFICIENTS
- POST-PROCESSING

TARGETS

- Evaluate the aerodynamic efficiency of the Alfa Romeo MiTo model in different configurations.
- Identify critical areas for drag generation through CFD simulations.
- Analyze the impact of spats on the aerodynamic of the car.
- Analyze the changes in flow behavior, pressure distribution, and wake structure with and without spats.

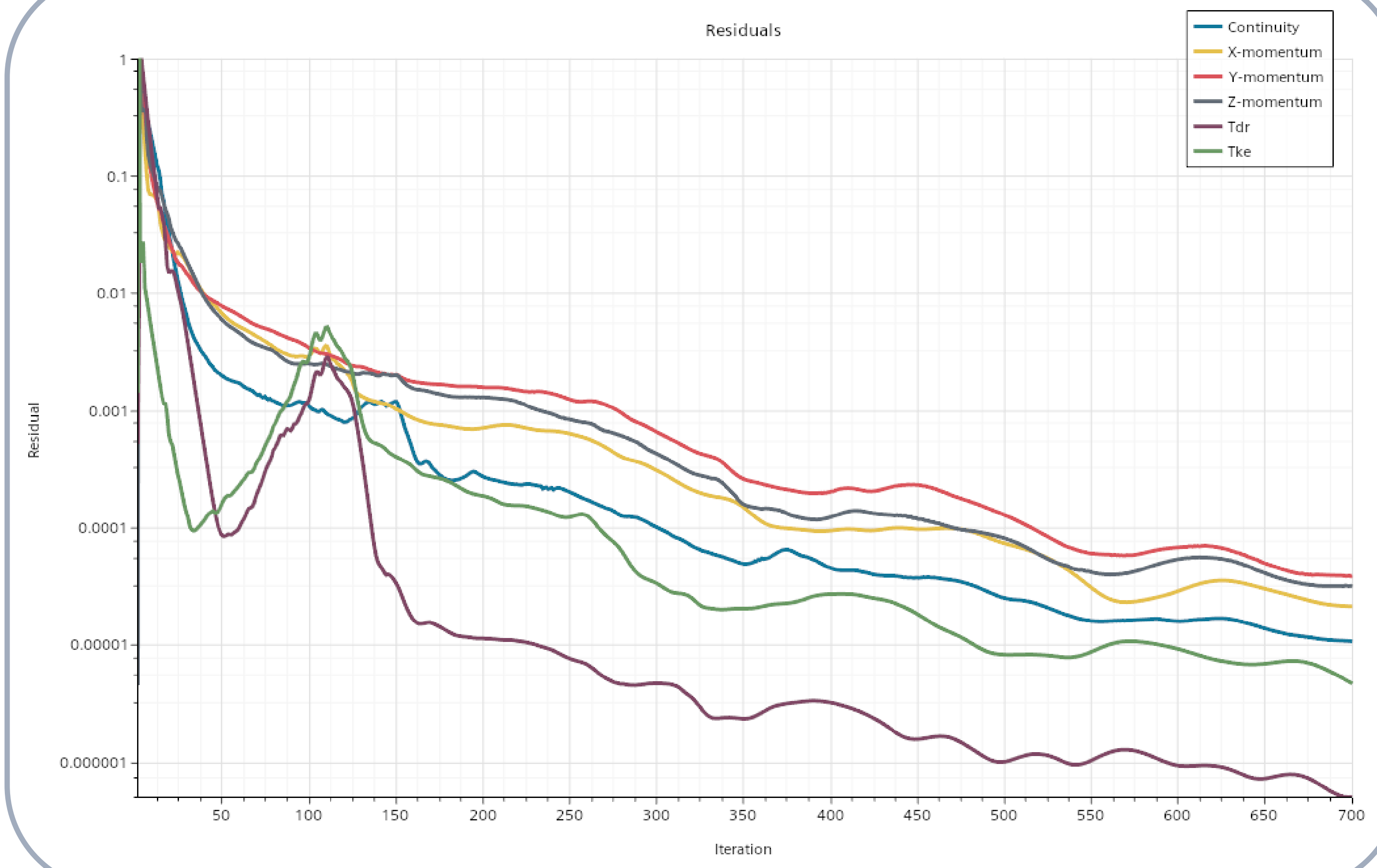


Baseline | Baseline + front wheel spats

RESIDUALS

A simulation has been set-up with a reasonable number of iteration equal to 700.

The residuals are shown in the figure on the right.

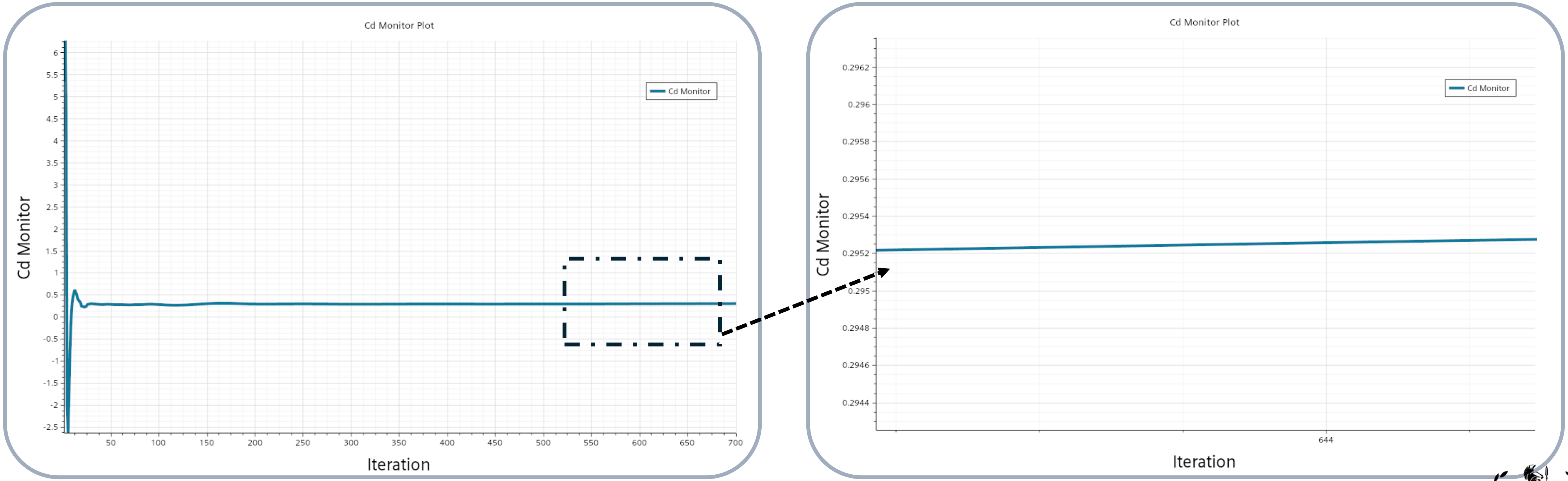


C_D COEFFICIENT

The drag coefficient C_D computed in the simulation converge at 0.295; instead, in the wind tunnel, the experimental value is 0.290, so the error is:

$$\frac{0.295 - 0.290}{0.290} \approx 1.7\%$$

This means that the simulation has been lead in the correct way with a good mesh which can represent with a reasonable error the result obtained in the wind tunnel.

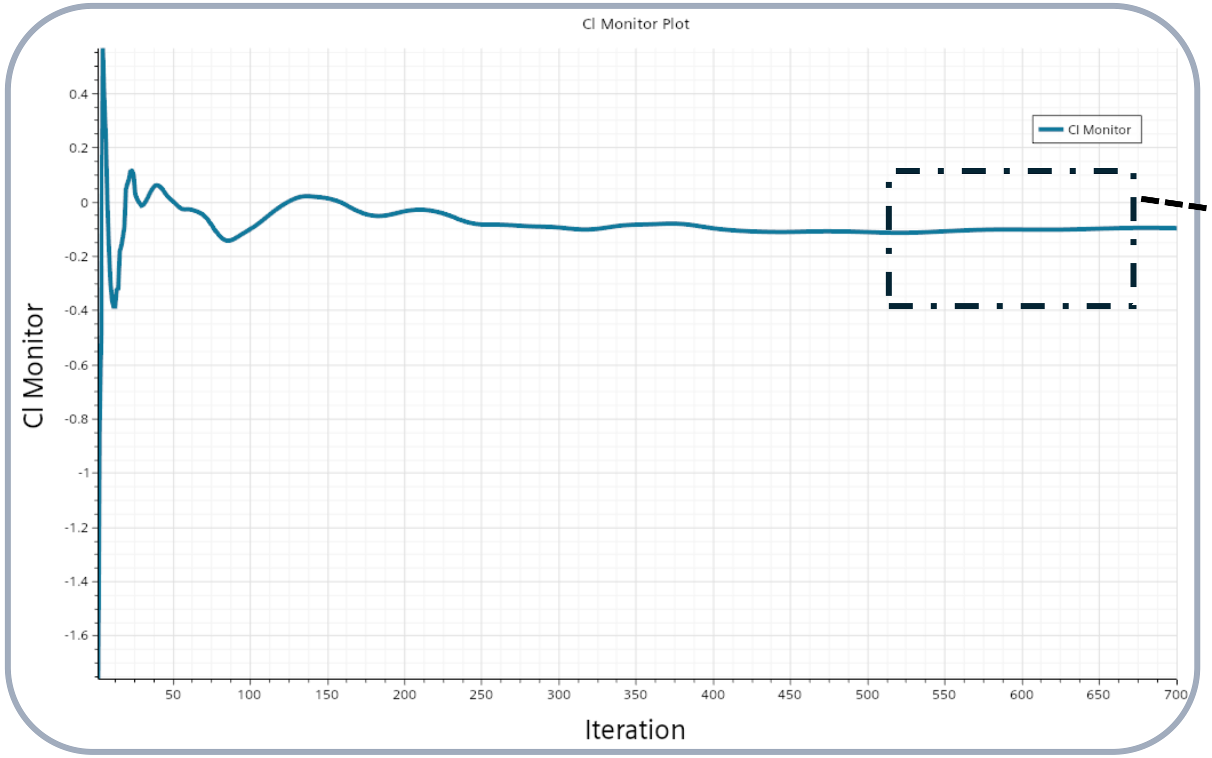


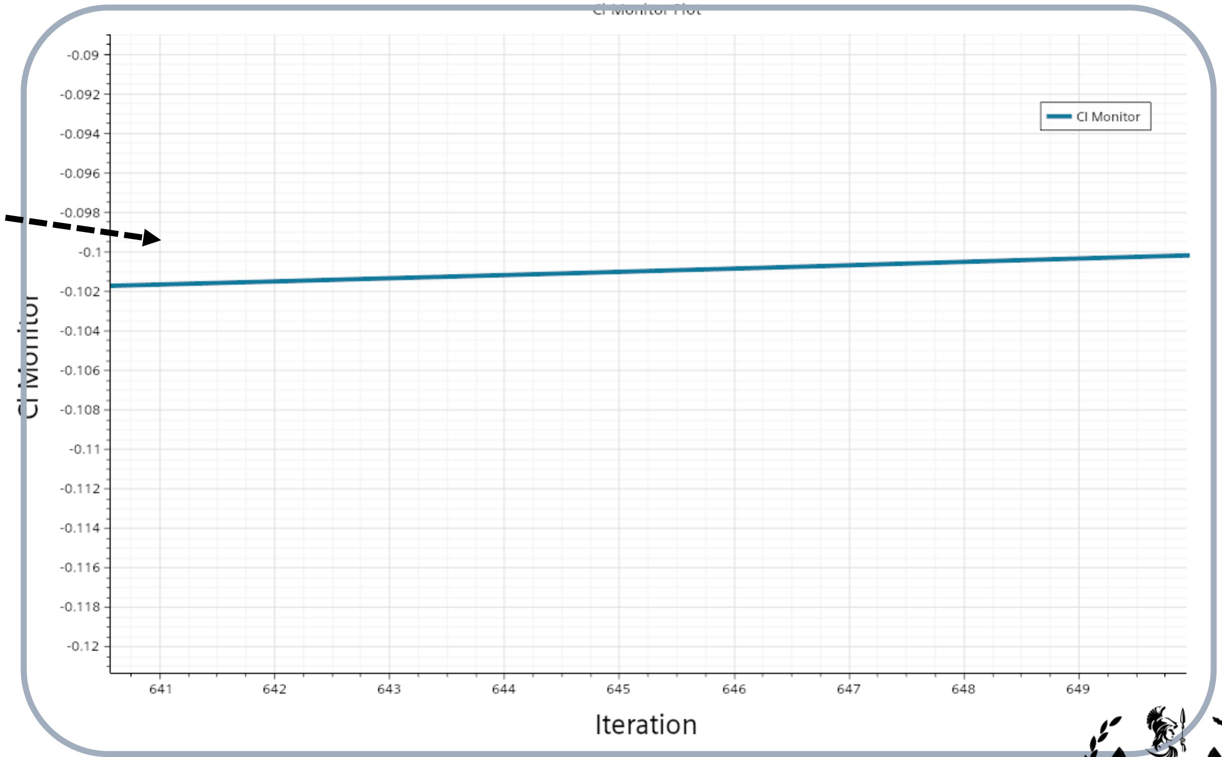
C_L COEFFICIENT

The drag coefficient C_L computed in the simulation converge at -0.101; instead, in the wind tunnel, the experimental value is -0.100, so the error is (considering the absolute values):

$$\frac{0.101 - 0.100}{0.100} = 1\%$$

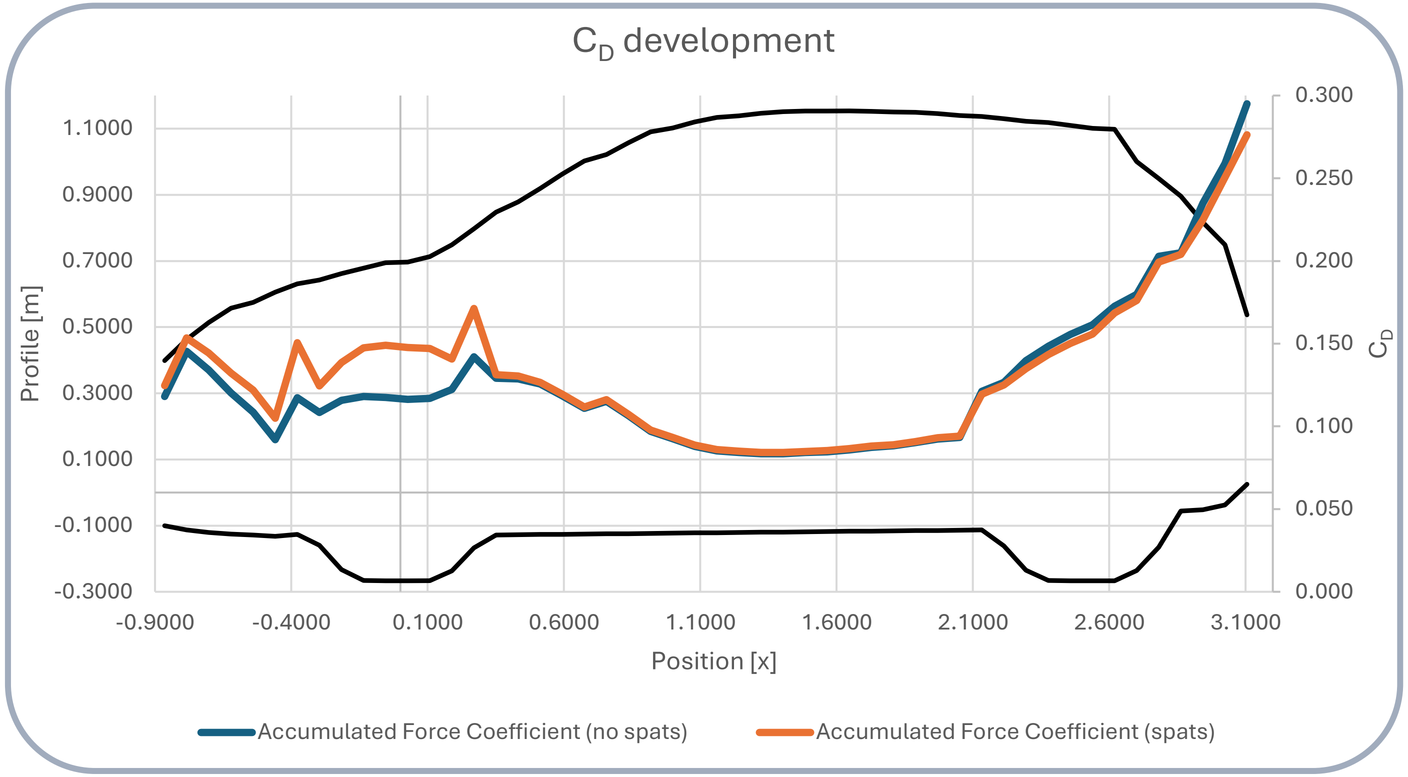
Also in this case the simulation has been lead in the correct way with a good mesh which can represent with a reasonable error the result obtained in the wind tunnel. Furthermore, we can notice that the value of C_L is negative so we can affirm that downforce is generated.





C_D DEVELOPMENT

Using the C_D development, we can identify the areas where drag is generated and where recovery occurs.
There is a noticeable increase in drag in the front bumper area and around the wheels, as further illustrated in the next slide with an analysis of the pressure coefficient.



Notably, there is negative pressure at the rear of the car. However, due to the force acting normal to the surface and the flow separation, this results in a significant increase in drag.

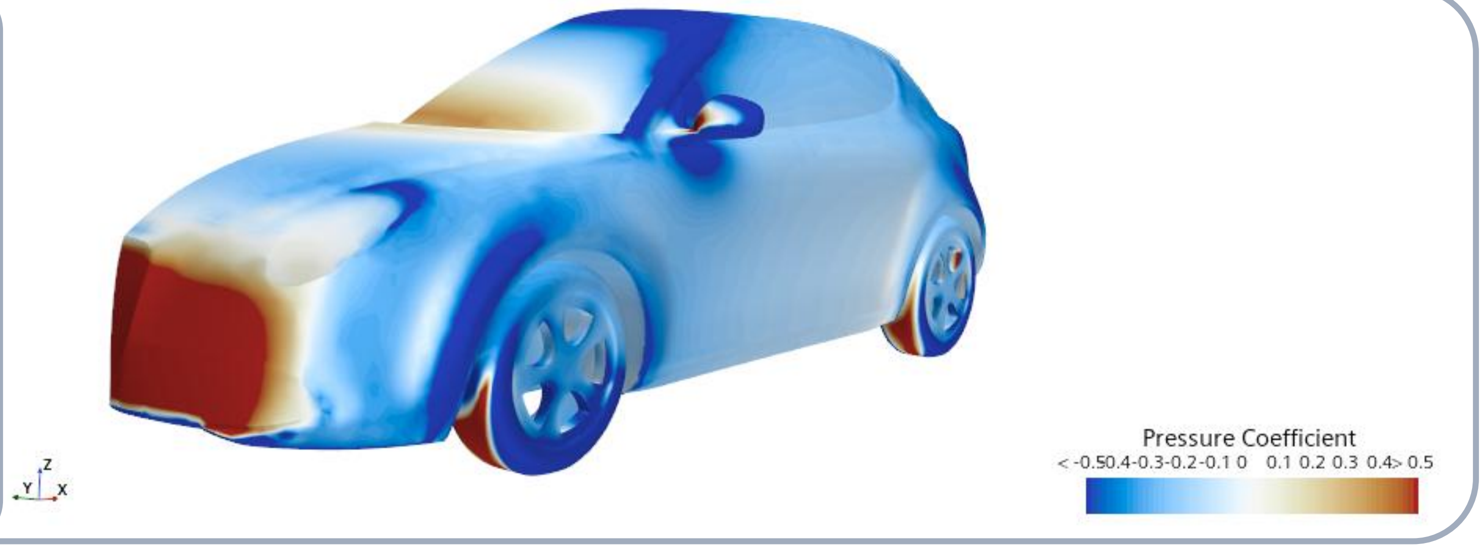
It's also possible to notice the ΔC_D between the two configuration, without spats and with spats.

On the other hand, drag recovery is observed on the hood, at the beginning of the roof and along the A-pillar.

$$\Delta C_D = C_D(no\ spats) - C_D(spats) = 0.295 - 0.276 = 0.019$$

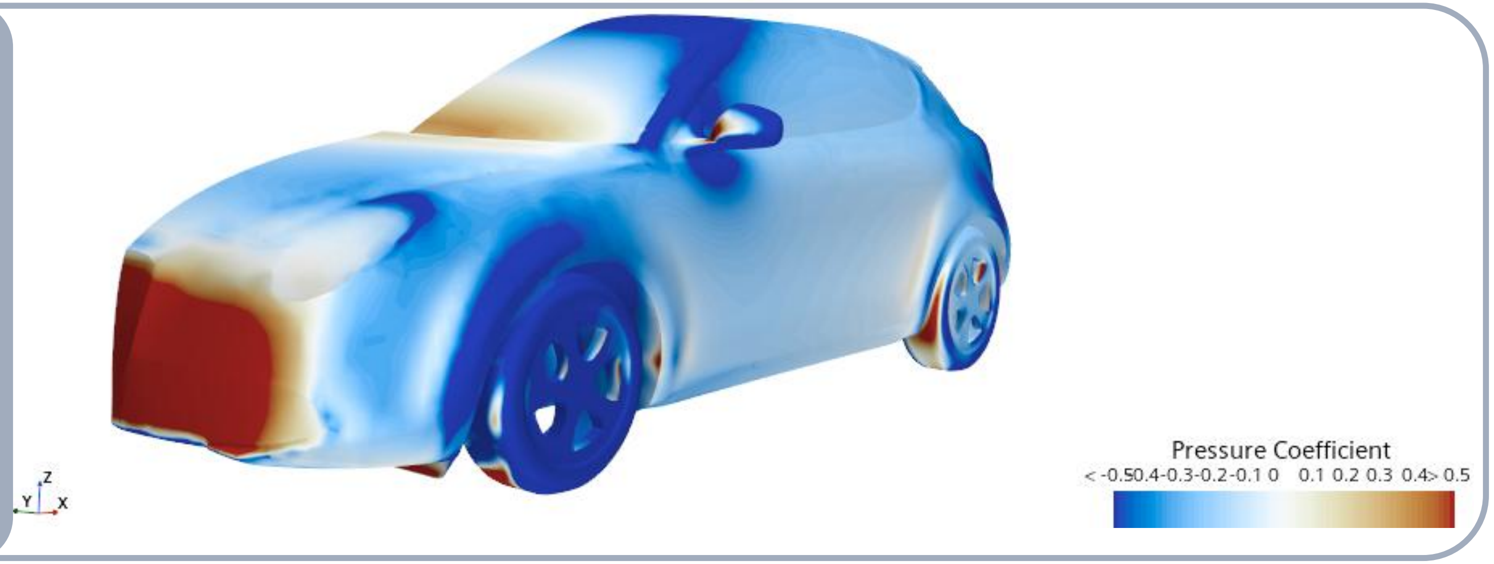
PRESSURE COEFFICIENT - CP

WITHOUT SPATS



Analyzing the pressure coefficient, we observe a significant overpressure on the front bumper, the wheels (both front and rear), and the front section of the side mirrors. Additionally, positive pressure values can be noticed at the base of the windscreen.

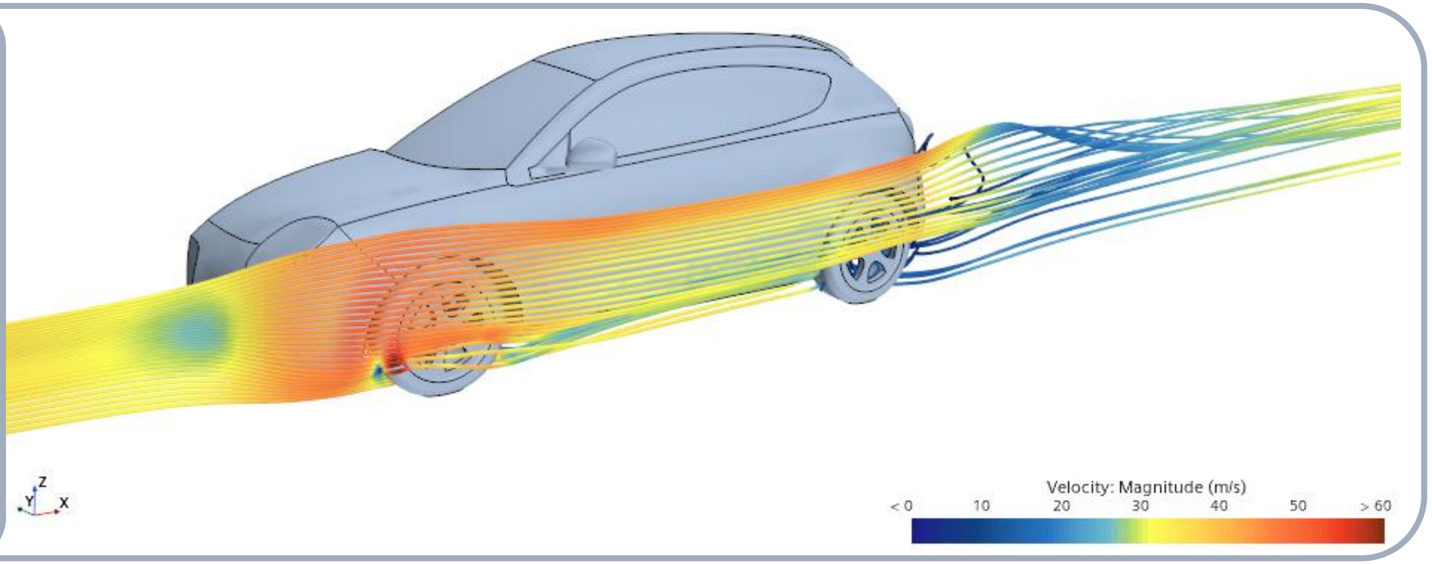
WITH SPATS



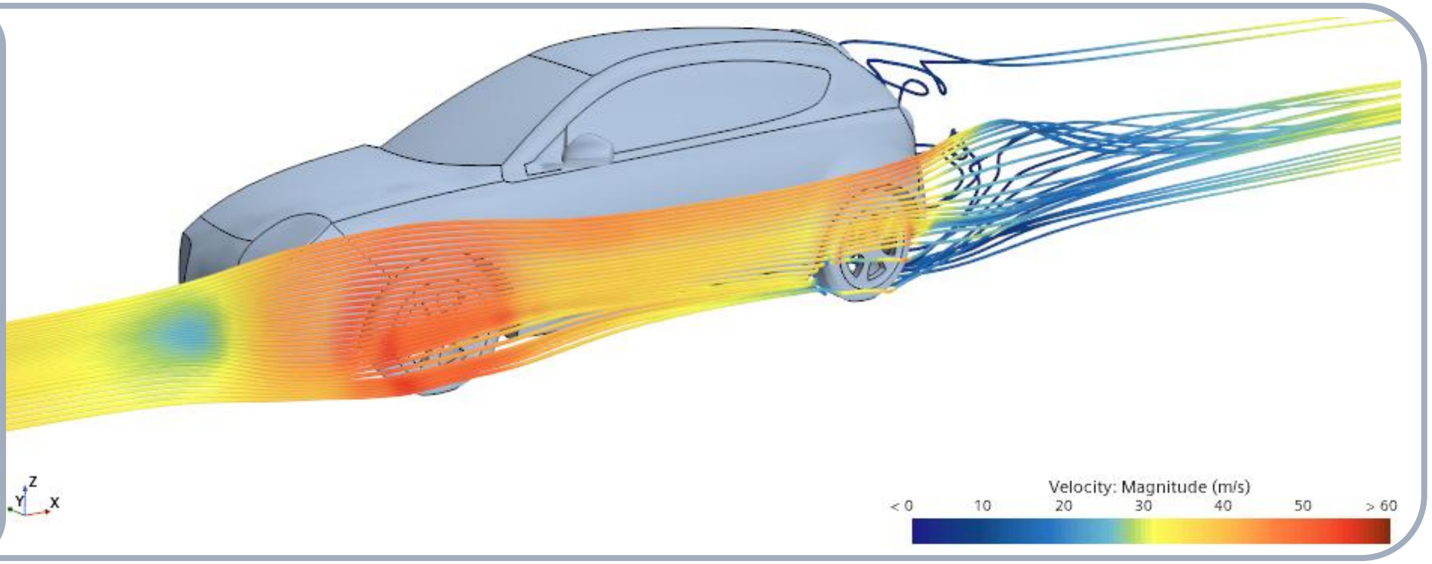
When introducing the spat, there is a reduction in flow velocity at the front. Locally, on the surface of the spat, we observe an increase in pressure; however, this results in a much more favorable pressure distribution on the wheel. The use of spats also induces changes in the rear wheel.

STREAMLINES

WITHOUT SPATS



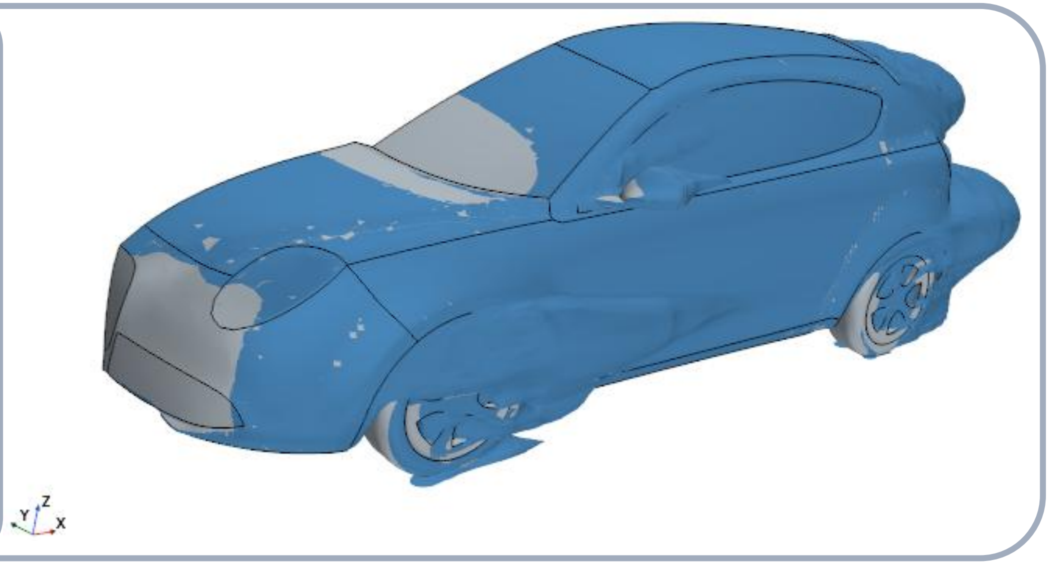
WITH SPATS



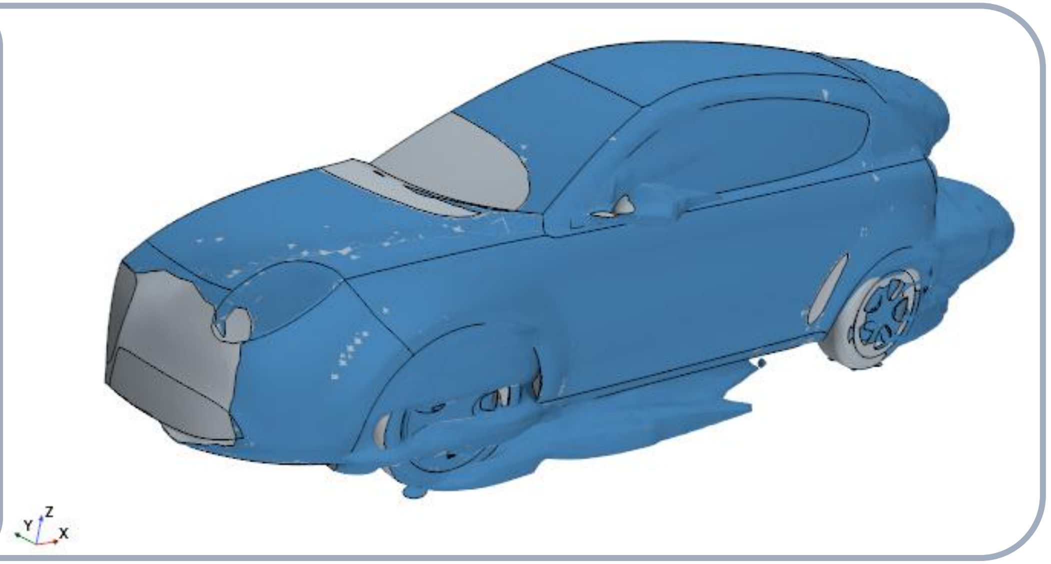
Using streamline analysis, it is evident that in the first case, the flow directly impacts the front wheel, whereas introducing the spats results in an improvement in this phenomenon.

TOTAL PRESSURE

WITHOUT SPATS



WITH SPATS

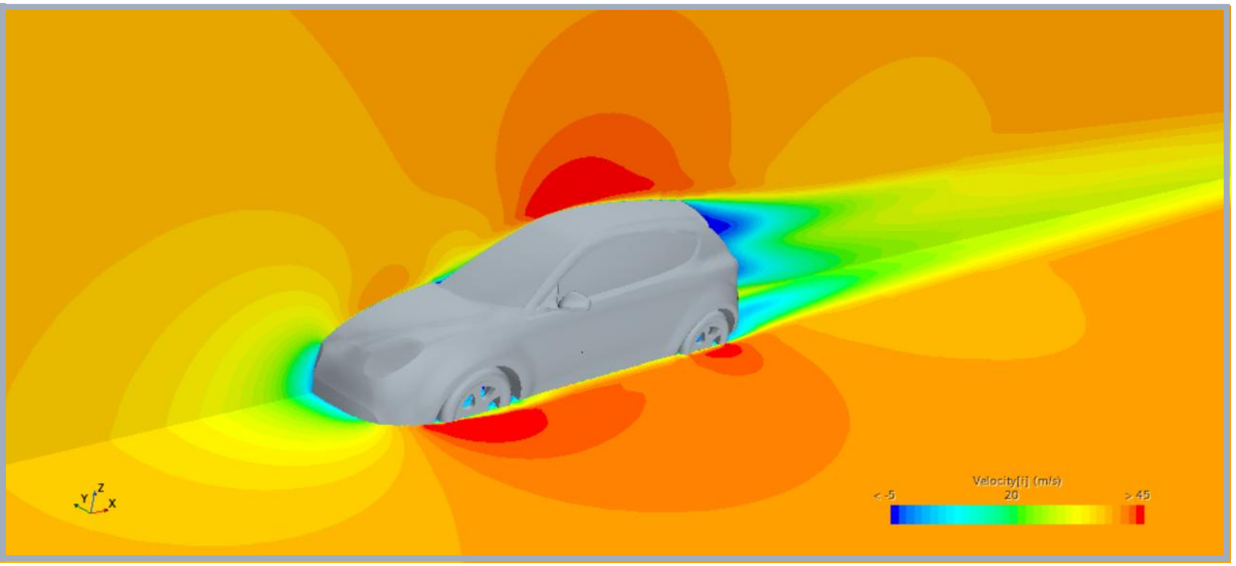


Analyzing the total pressure confirms the significant impact spats have on the car's aerodynamic behavior.

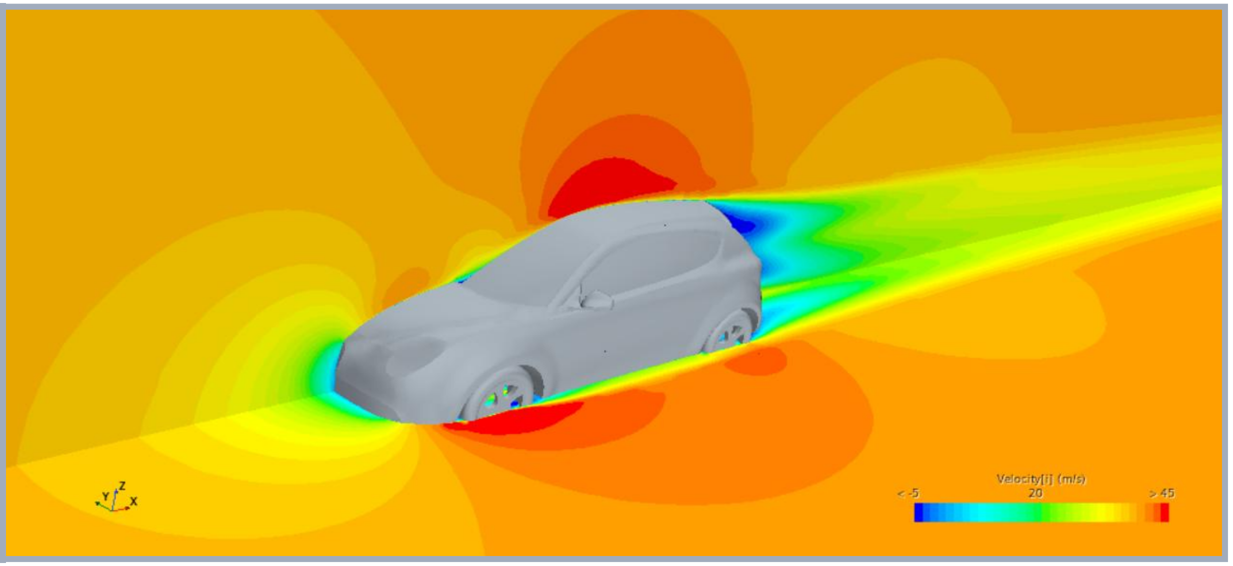
For instance, it is evident how much the flow changes behind the front wheel.

VELOCITY

WITHOUT SPATS



WITH SPATS



By analyzing the velocity flow, it can be observed that, in the area around the car's wheels, there is a strong region of flow acceleration.

However, when "spats" are installed, this behavior becomes less pronounced and, above all, more gradual.

Additionally, a noticeable difference in the wake can be observed between the two cases, particularly at the rear.

CONCLUSIONS

- Key areas of aerodynamic loss were identified in the front section (bumper, side mirrors), in the wheels and on the rear of the car.

- The installation of spats demonstrated a reduction in flow acceleration around the wheels and improved the overall pressure distribution, contributing to a decrease in drag.

- The aerodynamics of the car showed improvement with the addition of spats, highlighting the potential of such solutions for enhancing aerodynamic performance.