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CHALMERS UNIVERSITY OF TECHNOLOGY

MTF236 - Road Vehicle Aerodynamics

Assignment: Wind tunnel project

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Abstract

Today's demand for reducing the emissions in turn lead to reduce the fuel consumption of the vehicles which is more challenging in the commercial purpose vehicle like trucks. The improved aerodynamics is a solution for reducing the fuel consumption which is leading to work on developing the least drag exhibiting vehicles while being aerodynamics is the complete vehicle attribute, it is needed to find the sources of the pressure and velocity responsible for the drag and lift forces.

One such way to analyse the complete vehicle in the Computational Fluid Dynamics is with Star CCM+, where the base vehicle model is subjected under certain velocity and observed for the sources of the drag forces. Evaluation of the different stagnation pressure regions, high pressure drag, high friction drag, high velocity vortexes is understood and the CFD plots been extracted for these parameters.

Areas for the improvements of aerodynamics is analysed for the complete truck and implementation of the aero devices for these areas is decided. Wind tunnel experiment for the analysis of the impact of these devices individually and also the different combinations of the devices is conducted. Since trucks being long, they are subjected for the side winds as well, so the Wind tunnel experiment is conducted for the yaw angle of 10 degree and also for 0 degree.

Gap treatment, undercarriage treatment, trailer designs tends the scope to install the devices like side skirts, sealed wheels, cab roof fairing, trailor boat tailing, cab frontal fascia which are implemented for the calculations. Combination of these behaves differently in the wind tunnel exhibiting different drag forces but the objective is to make the system more profit with respect to aerodynamics.This leads to find the optimal design for the given base model with integrating the different combinations.

Trailer side skirts helps to avoid the side winds projecting underneath from the sides contributing to lower the drag. Also,cab roofing fairing has contributed significantly since it creates the soft curvature for the high velocity stream winds to pass without creating the pressure drop at the corners. Shorter wheel base and boat tailing did not contributed alone in this set up model, but they do contribute significantly when integrated with other devices.

Furthermore, the calculations for these integration is done and the least drag exhibiting configuration is taken to optimise further more.Final optimised configuration is counted for the drag reduction comparing with the base vehicle drag and been concluded with the results.

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1 Introduction

In the recent times the need of efficient, economic and environment friendly vehicles tends to emerge the ways to satisfy these needs. Vehicle manufactures focus on these demands requires to find the way of making the most fuel efficient and less polluting vehicles which lead to the scope of aerodynamics as an attribute. For heavy trucks as it is known that the total drag force will be dominated with the aero drag over the rolling drag at certain velocity above 100 kmph in general. Trucks being bluff body with the tractor and trailer, where the focus to reduce, the aero drag is narrowed to bring the shape changes on only the tractor and not much on the trailer as it is custom variant and dependent on the supplier as well.But here in this assignment considering both the trailer and the tractor for our experimental study purpose. Also, considering the importance of the high-speed stability and crosswind stability performance at higher speeds. [1]

Companies focus to enhance the fuel efficiency and the CO_2 emission, where the aerodynamics play its importance to contribute for fulfilling these needs. Trucks being designed with the tractor and the trailer here in this assignment is for understanding the aero package and the influence of these into the vehicle system in a motivation to reduce the drag force which in turn responsible for the better fuel efficiency.

In this assignment the truck with the trailer is taken as the base line for the future aero package designs and configurations. STARCCM+ is used to study the typical pressure and velocity flow behaviour of the truck in the virtual environment, understanding the areas prone to create drag. Proposing the solutions for the improvements with the design changes that would help to reduce the drag. Our objective to reduce the drag force by implementing the aero design where the structures will be attached or modified to give the better aero profile and shape. The combination of many of this configuration is tested in the wind tunnel laboratory keeping the base vehicle design as the base line for the calculations. Comparing the different configuration approaches and its impact on the drag forces is studied and obtaining the best and optimal aerodynamics configuration is concluded.

This assignment does not consider the cost and the feasibility in the implementation of the aero devices on to the vehicle, being considering only the impact of the devices or the aero configuration on drag force attaining the objective of the assignment.

2 Theoretical Background

Aerodynamics drag in truck is dominant at higher speed, which is eventually dependent on the rolling resistance of the vehicle with different axle configuration. As the capacity of the trucks increases the set axles to propel the vehicle increases, leading to increase in rolling resistance. In general, the rolling resistance is dominant in at lower speeds and as the speed of the vehicle increases aerodynamic drag force eventually dominates the rolling resistance causing the main contributor fuel consumption. Typically, Aerodynamic drag (Cd) in trucks without aerodynamic devices is 0.7-0.9. Cd is measured in i.e., 1count=0.001Cd. Drag reduction devices give a notable change in Cd i.e., 20 counts or more while compared to the exceedingly minor change in a passenger car. Thumb rule is that reduction of cd by 20 counts is equivalent to reduction of fuel consumption by 1 % . In brief the drag reduction devices, governing equations and terminologies are discussed.

The main sources for aerodynamic drag in a truck are portrayed in the figure below depicting the high-pressure stagnation areas, vortex, wake, cross winds, flow separation areas.

Vortex being a component of turbulent flow is a region of fluid where the flow is swirling around an axis line as caused in the gap between the Tractor and Trailor due to the difference in velocity of air.

Wake is the low-pressure area formed in the rear end of the vehicle causing a suction opposite to the vehicle leading to higher drag force. Wake is the major contributor of drag force in commercial vehicle rear end as the design is not streamlined. Boat-tailing is a counter measure for balanced wake rendering reduction in drag.

Flow separation areas are the boundary layer detachment of flow causing increased pressured drag. Major contributors are sharp edges in the frontal area and along length of vehicles.

Pressure stagnation areas are dominated by high pressure with local velocity zero. The main victim for pressure stagnation point is the front nose. European trucks having a flat surface, square shaped nose has more stagnation area compared to long nosed commercial vehicle with smaller frontal area.

Pressure coefficient is the relative static pressure divided by the dynamic pressure; it is derived by the Bernoulli equation denoted as Cp. At stagnation points Cp=1

Main principles governing fluids dynamics:

Conservation of mass (continuity equation)

Conservation of momentum (Newton's 2nd law)

Conservation of energy (1st law of thermodynamics)

Aerodynamic devices used in Commercial vehicles to reduce the drag and co-efficient of pressure at different locations in the truck cabin and trailer:

- Gap treatment: Cabin end fairing can be used to enhance the flow over the over the roof to reduce the high pressure at the edges of trailer front and the upper corners.
- Cab side edge radius: This is important in implemented to direct the airflow from the front around the cab to the sides of the truck.

- Cab roof fairing : It is integrated on the roof of cab decreasing the stagnation pressure on the trailer and giving a smooth transition of the low pressure flow from the frontal area of the truck and flow sticking on to the length of the trailer.
- Vortex stabilizer: This consists of two parallel equal plates at the trailer front. It reduces the disturbance from cross winds which creates stable vortices in the gap.
- Trailer Side skirts- It is a device fixed undercarriage of trailer to reduce the air turbulence ,drag caused by the tires under the body of trailer .It is very efficient in obtaining better fuel consumption.
- Boat tailing rear trailer- The rear end wake is stabilised by reducing the flow separations and increasing the rear low base pressure .

3 Methodology

3.1 Wind tunnel L2 description

The low speed wind tunnel is a closed circuit with a test section of 1.25m*1.80m*3.0m. In this tube the air is blown at the given velocity without the ground movement and readings for different configurations were noted. The maximum free stream velocity and free stream turbulence intensity of 63m/s and 0.1 percent respectively. The truck model inside the tube was kept stationary during the testing and also was flexible enough to change the orientation of the model without been detaching it completely.

In the first step of the project, the post processing analysis was carried out, where the flow field around the truck model was examined and different propositions were made and discussed. Subsequently, from the propositions made, different configurations were designed and these different configuration are discussed in the sub chapter 3.2. Later, with base model and with different configurations the model was tested in the wind tunnel and with the data obtained, further study was carried out on the drag.

3.2 Configurations for the model

3.2.1 Base model

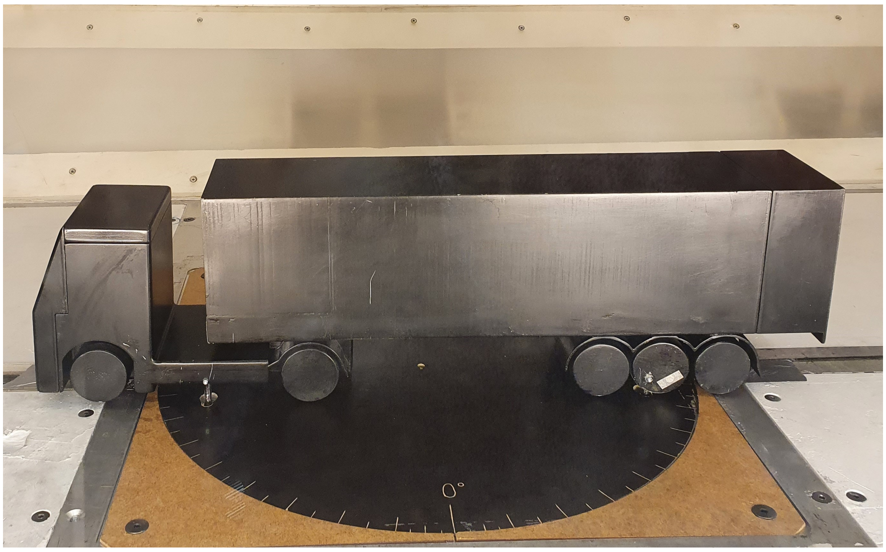

Figure 1: Base model

Figure 1 represents the base model of the truck. As the model was tested without any configurations, the frontal area of the truck model is one of main contributor to the higher drag. Length of the trailer contributes to drag, as the surface of the trailer flat, the flow around the trailer will be poor.The opening between tractor and trailer also adds some drag to the total drag of the model.

3.2.2 Configuration 1: Roof fairing

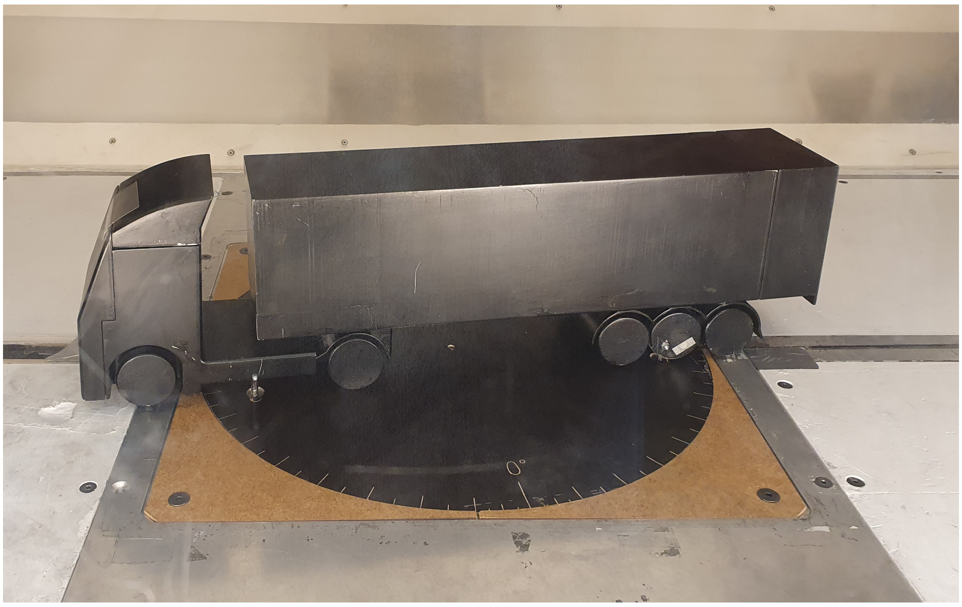

Figure 2: Addition of Roof fairing

The roof fairing as seen in the figure 2, was added to the model and is one of the most common features to improve the drag.This design was more aerodynamic and also reduced the drag by small margin. The inclusion of cab roof fairing also improves the air flow around the fairing and gives better stability.

3.2.3 Configuration 2: Nosecone

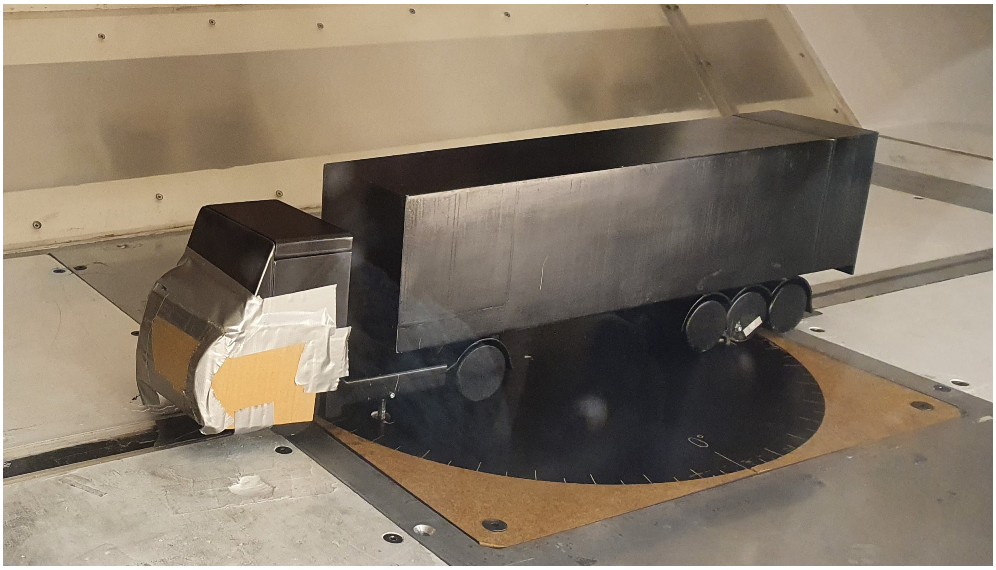

Figure 3: Addition of Nosecone

The inclusion of nosecone as seen in figure 3 resulted in a good aerodynamic design and also improved the drag around the tractor. This design of front fascia directs the air flow through the sides of the tractor. The directed air from the front fascia should be assisted by the smooth side edges which governs in easy flow of the air across the side and also reduces the turbulence.

3.2.4 Configuration 3: Side skirt

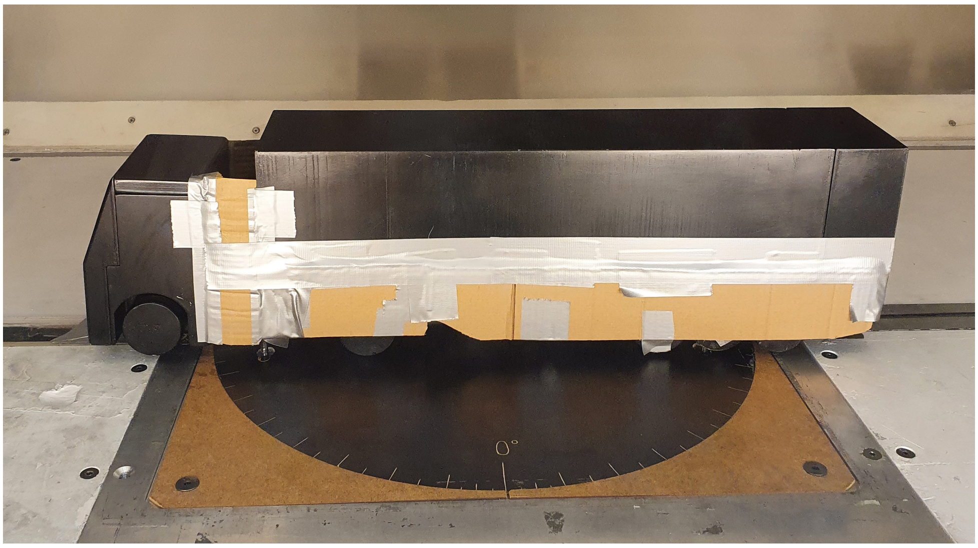

Figure 4: Addition of Side skirt

The under body of the model was also taken into account during the analysis, because the distance between the two wheels creates turbulence and it also acts as one of the contributor to more drag. This can be reduced by using the side skirt as shown in the figure 4. In this in configuration, as seen in the figure, the gap between the tractor and trailer was also shielded, which resulted in better drag.

3.2.5 Configuration 4: Shorter trailer

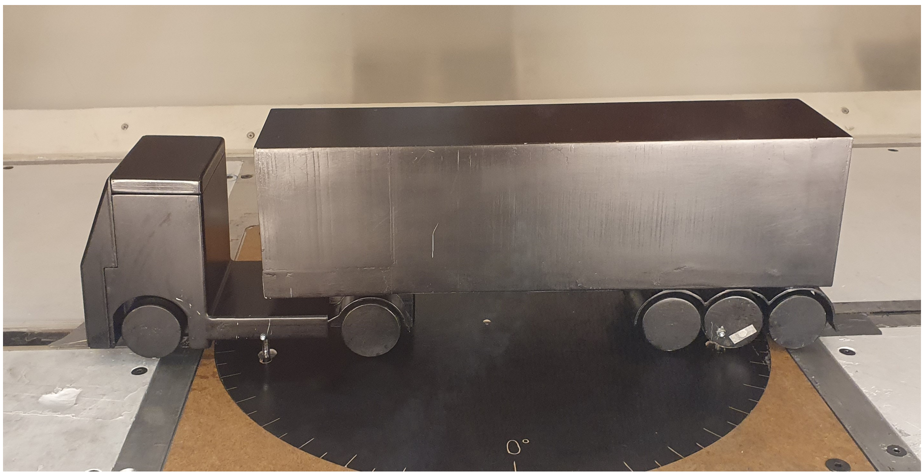

Figure 5: Reducing the distance between trailer wheels

The distance between the trailer wheels was reduced as seen in the figure 5. This resulted in the reduction of drag, because of the shorter length of the trailer, air flow across the trailer will be smooth and also under body will be improved in terms of drag. The result by shortening distance was not drastically changed, but compared to previous configuration slight improvement was seen.

3.2.6 Configuration 5: Short boat tail

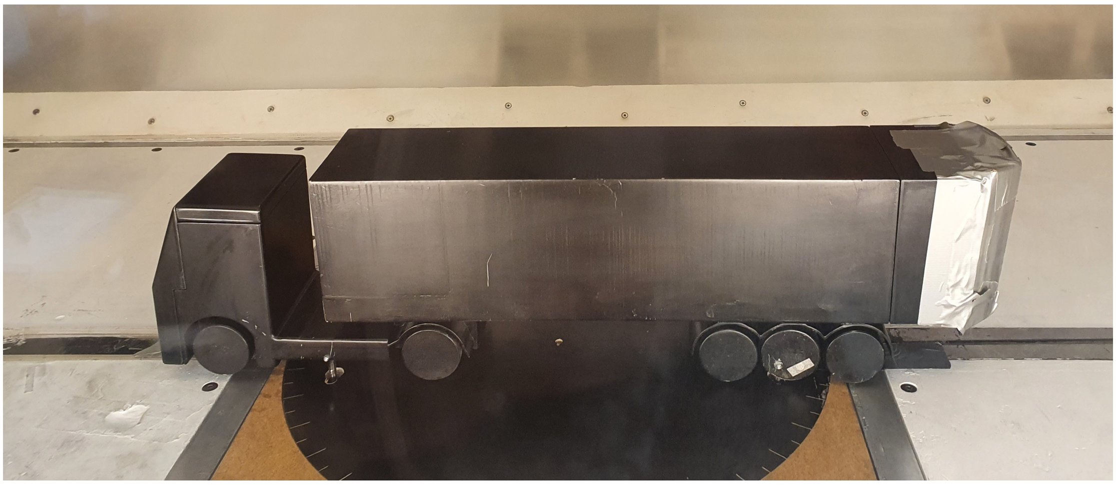

Figure 6: Extending the length of trailer

The extended length by adding the short boat tail as shown in the figure 6, was designed in order to reduce the drag at the rear end of the model.When the extra structure was designed for the trailer, compared with baseline the drag was increased by small amount because of the offset and the uneven cutting of the card boards.Approximately increase of 13 percent of drag was observed.

3.2.7 Configuration 6: Combined Package with Configuration 1,2 and 3

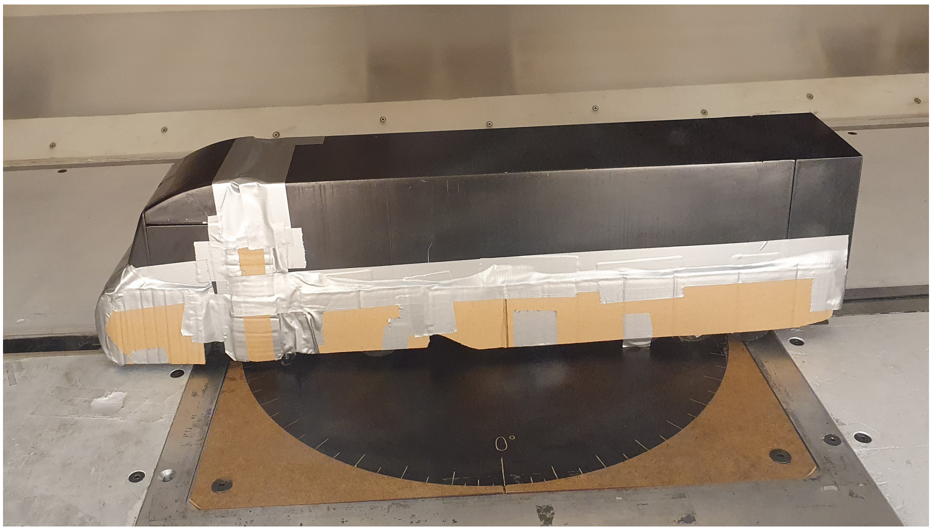

Figure 7: Addition of roof fairing,nosecone ,side skirt

The design is as shown in the figure 7, had a good aerodynamic design compared to previous configurations. The design included roof fairing, front fascia, side skirt. Altogether this design gave a good reduction in the drag for both 0° yaw angle and 10 °yaw angle. Compared to baseline,in the combined package their was a reduction around 24 percent and 47 percent for 0° yaw angle and 10 °yaw angle.

3.2.8 Configuration 7: Optimal package

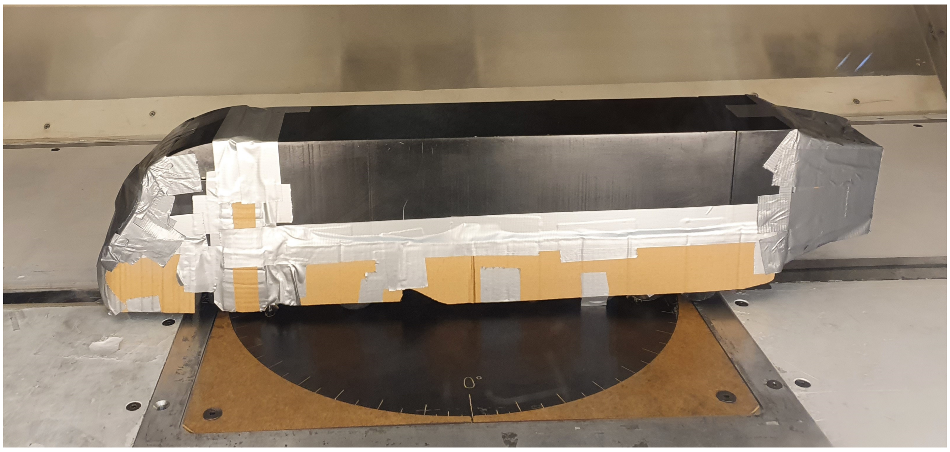

Figure 8: Addition of roof fairing,nosecone ,side skirt and boat tailing

This design as seen in the figure 8, it was a combination of roof fairing, nosecone, side skirt and boat tailing. In addition to this, on wind shield an extra out curved structure was included so as to improve the rake angle and also for the smooth flow of air. This configuration was one of the most successful configuration and was aerodynamically better compared to previous configuration. For 0° yaw angle and 10 °yaw angle, drag decrease was around 33.8 percent and 55.1 percent respectively and this was the highest drag reduction seen of all configurations.

3.2.9 Configuration 8: New boat tail and roof fairing

Figure 9: Addition of boat tailing and roof fairing

This was the final configuration tested in wind tunnel lab. The configuration included the boat tail and roof fairing as shown in the figure 9. The low pressure created at the rear end of the model which cause drag was drastically reduced using the tapered boat tail. By the combination of roof fairing and boat tailing a reduction in drag of 7.4 percent for0° yaw angle was observed.

4 CFD Analysis Results-StarCCM+

Post Processing for base truck(scale model 1:18)configuration CFD analysis was carried out in StarCCM+ software. Isosurface of the truck view depicts the wake size,shape and separation areas along the length of the truck and trailor.The iso surface Figure 2 portrays the wake region created at the rear of the truck which accounts major contribution of drag force.

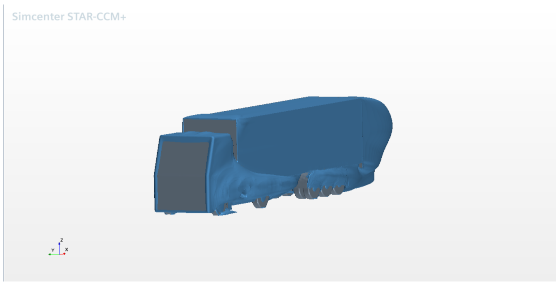

Figure 10: Isosurface of the truck as viewed from a diagonal perspective.

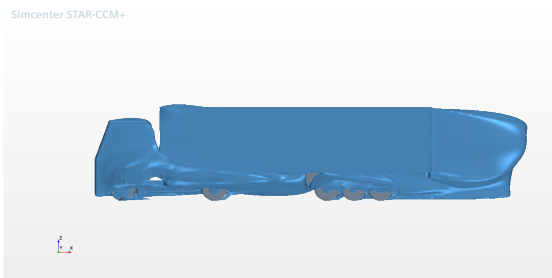

Figure 11: Side view of the truck's iso-surface. It is apparent that the majority of the affect that the truck has on air displacement is accounted for behind the trailer.

As seen in figure 10, the pressure coefficient is high at the face of the tractor and the top of the trailer where the wind collides with a flat surface. In the rear of the trailer the pressure is very low and it is this difference that causes aerodynamic drag. Therefore the aim is to reduce the delta and this could be done by decreasing the frontal area of the tractor to minimize the stagnation surface. The stagnation areas on the trailer can be reduced by adding a air deflector on the cabin roof.As observed in figure 11 there is high velocity observed at the flow separation areas at the cabin roof and the trailor frontal area.These sharp edges or rake angle deviations are overcome by designing smooth edges and curvatures for a smooth flow sticking to the body.

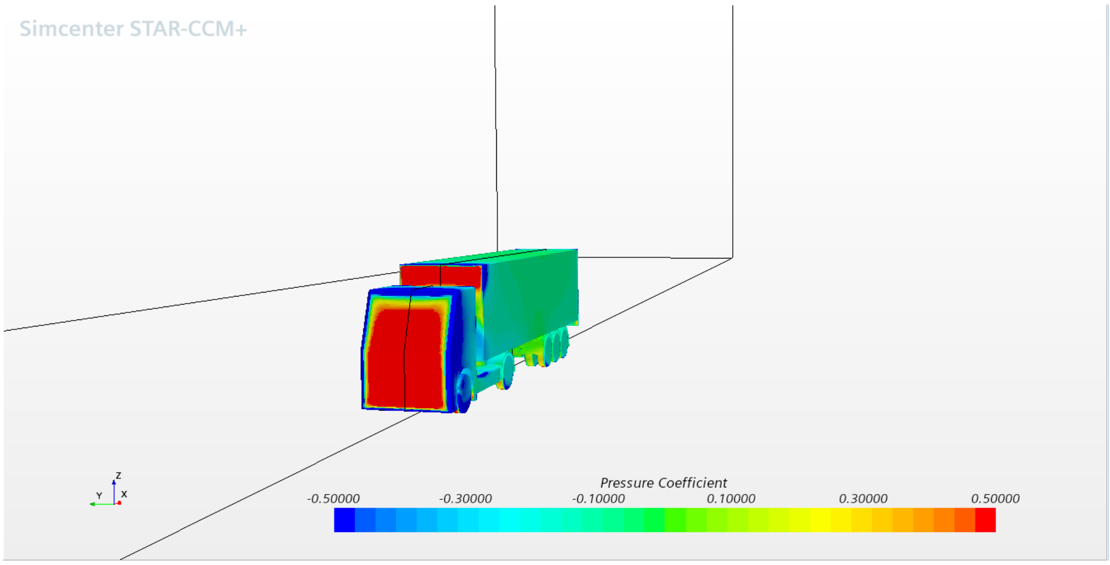

Figure 12: Pressure distribution on the vehicle.

There is a large high pressure zone behind the truck as seen in figure ??. This is due to the non-aerodynamicly designed back of the trailer that doesnt allow a smooth re-entry of the air flowing around the truck to the surrounding flow of air. To improve this low pressure zone our group proposes to use turning veins and/or a boat shaped tail. The expected result is that the drag will decrease

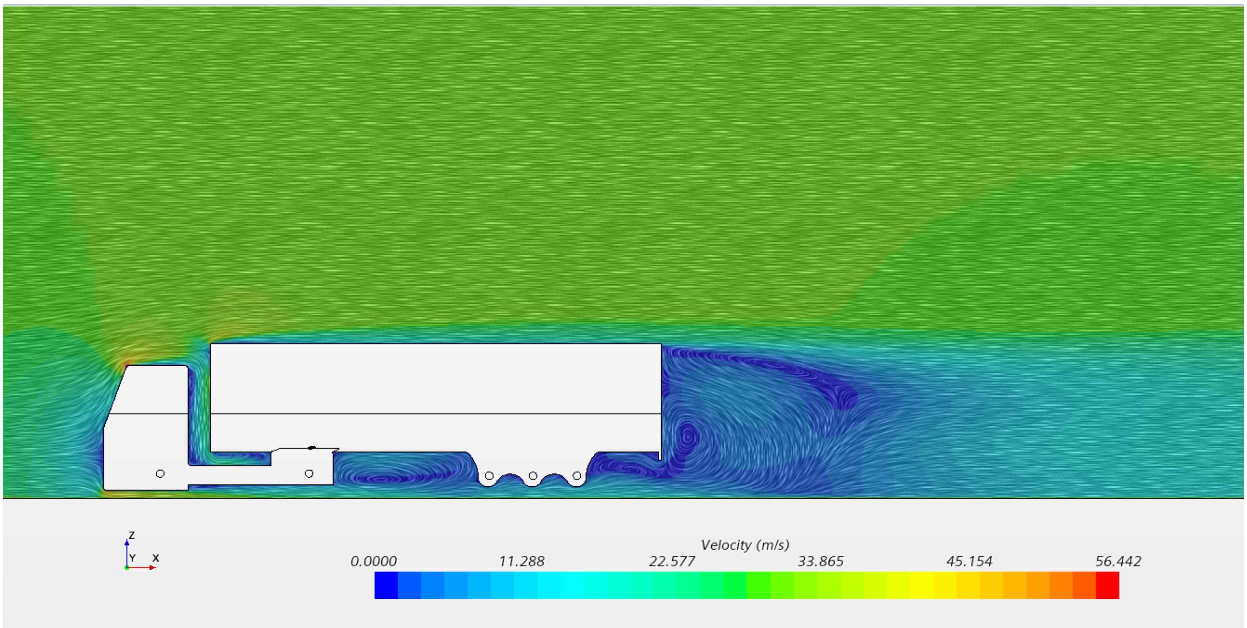

Figure 13: Air flow velocity around the truck as viewed from a plane cutting the truck in half in the y-plane.

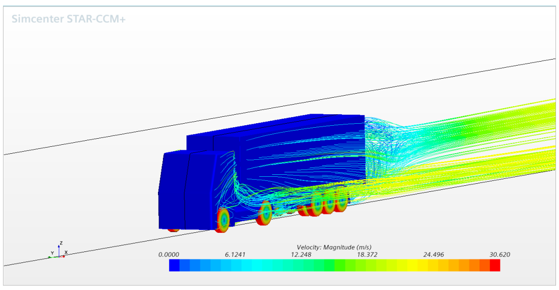

Figure 14: Stream lines in iso-view

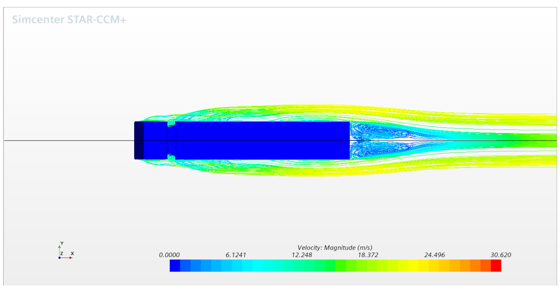

Figure 15: Stream lines in top view

To reduce the wheel wake from the wheels deflectors will be tried to direct air away from the front wheels. Flat surfaced hub caps on the wheel modification will reduce turbulence from forming. The other wheels will be covered to reduce turbulence. The area between the tractor- and trailer wheels will be covered with a skirt to prevent air from going to the under-carriage and to keep the flow connected along the body.

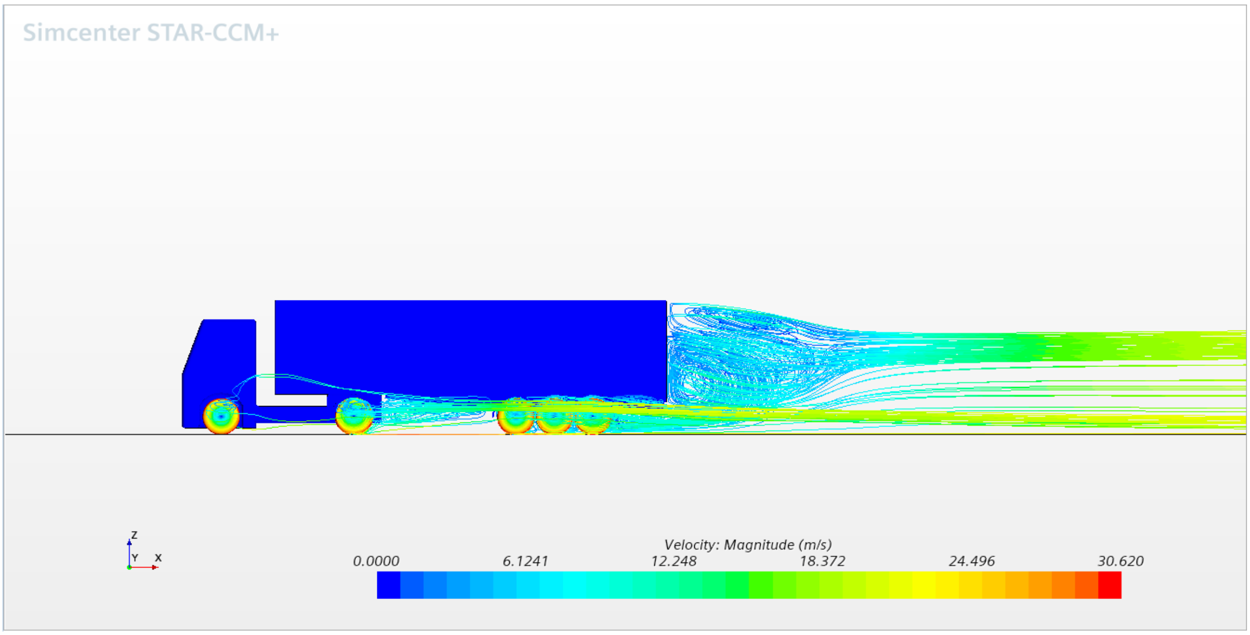

Figure 16: Influence of wheel wake displayed in side view

It will also be worth looking into the smoothening of the leading edges of both the truck and trailer. As seen in figure 17, the magnitude of the yellow and red vector velocity "arrows" suggest that further aerodynamic improvements can be made to the truck to allow for less flow separation and an easier path for the air to follow when flowing around the truck and trailer. This could be done through detuning the leading edges and adding something on the flat surface above the truck. This will allow the air to flow from the truck to the trailer with greater ease, hence inducing less drag. This can be measured by pressure differences using a prandtl meter.

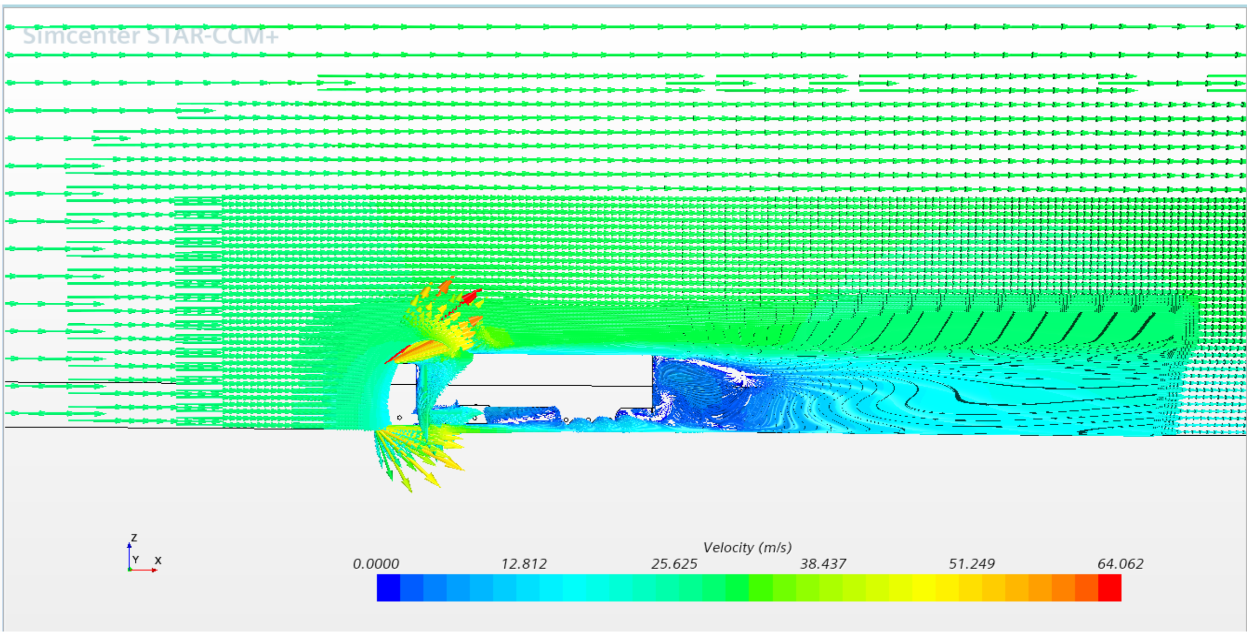

Figure 17: Velocity vector of the air current shown in side view

In order to reduce the high pressure area on the front wheels flaps will be installed in front of the wheels to direct the airflow towards the center of the truck. To keep the airflow connected throughout the whole carriage a channel will be installed along the centerline of the undercarriage to keep the flow away from the wheels. The possibility of making the tunnel narrower close to the rear end of the trailor will be investigated in order to increase the air flow and thus reducing the turbulence in the undercarriage. Along with the channel the undercarriage must be made as smooth as possible to keep the air attached and prevent turbulance.

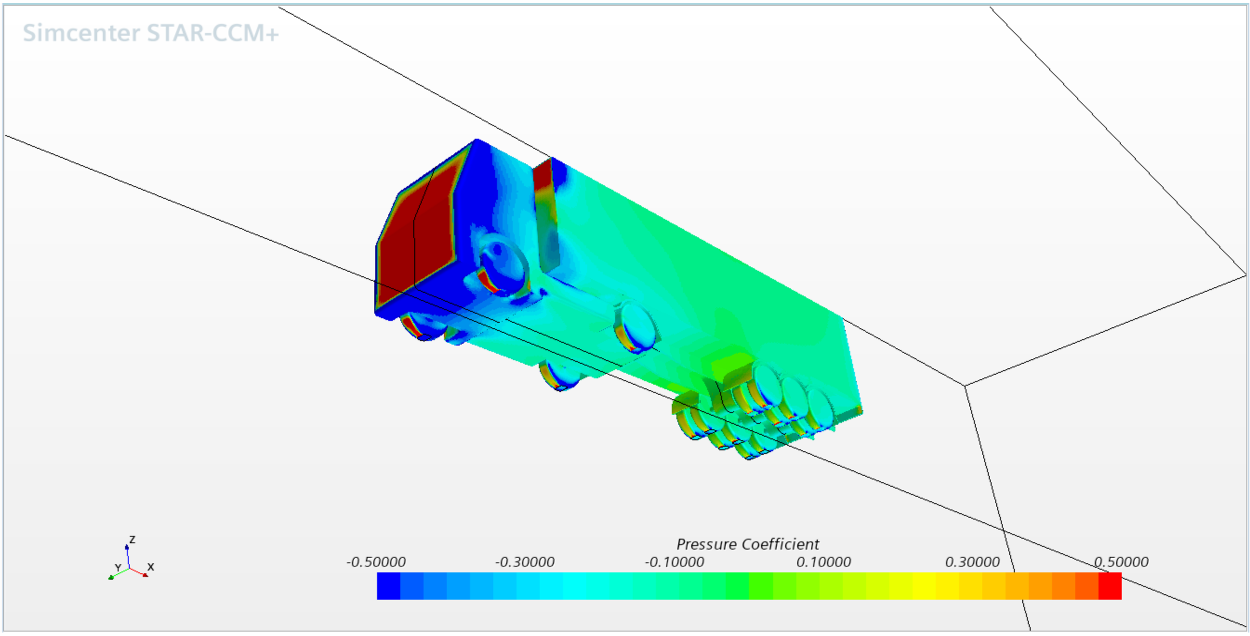

Figure 18: Pressure coefficients on the undercarriage

Accumulated drag coefficient and drag coefficient figures 19,20 depicts the change in drag coefficient ,the contribution of drag along the length of the vehicle.Observations from the accumulated drag give a vague estimation of contributors , in the plot the rear part of the vehicle shows high accumulation of drag force.In the drag force plot individual contribution of drag force is depicted ,there is an increase in cd at the gap between the trailer and tractor and the frontal area of the truck.

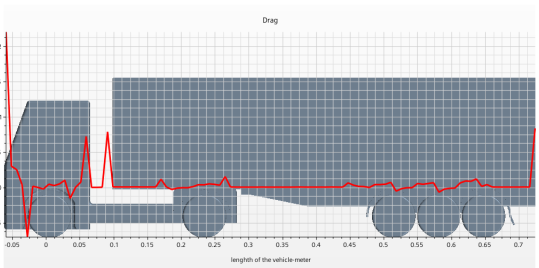

Figure 19: Drag coefficient along the length of the body

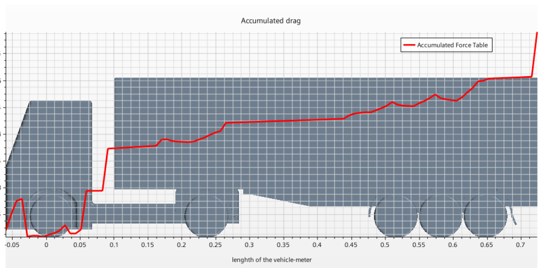

Figure 20: Accumulated drag along the length of the vehicle

5 Results and Discussion

Reynolds Sweep Test

The purpose of this test is to determine the appropriate test speed for which the whole experiment is conducted at which the aerodynamic drag coefficient becomes more stable while attaining the constant drag coefficient above that velocity. This is done by conducting the test at two different orientation to get the presided velocity which is at zero and 10-degree yaw angle for different speeds.

Figure 21 shows the results of the variation of the drag coefficient with respect to velocity. It is observed that the drag coefficient remains quite constant which means the drag coefficient becomes independent of the velocity above 20m/s, but to be more precise the appropriate test velocity is considered as 30m/s, at which the rest of the experiment is conducted and measured at this velocity.

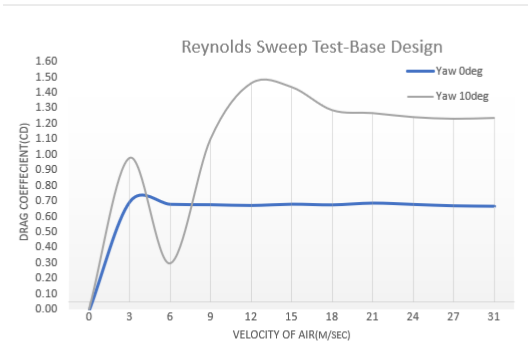

Figure 21: Reynolds Sweep Test

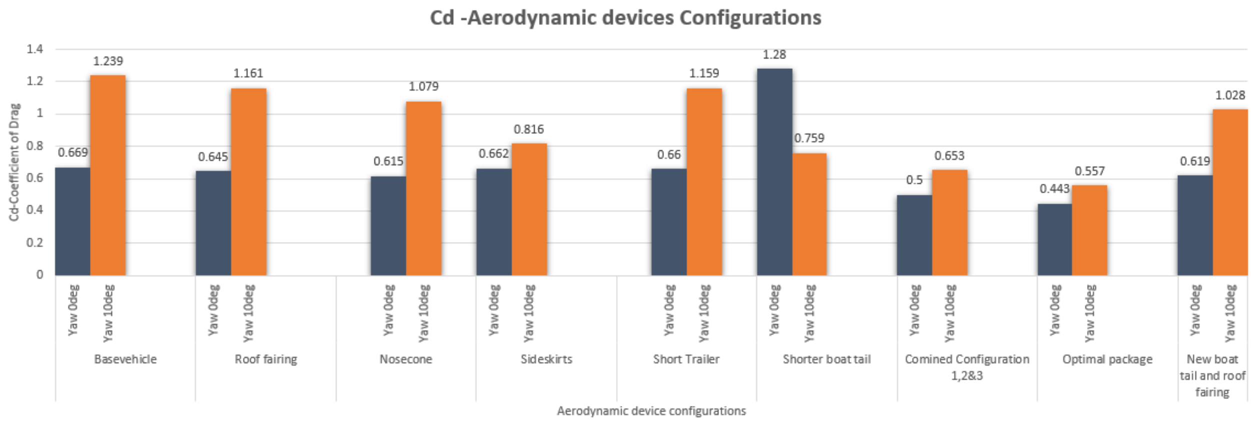

Figure 22: C_d VS Aerodynamic Configuration

5.1 Results

The different configurations was tested to identify the improvement they gave individually and then combined. The results of the configurations are presented in the tables below. Table 1 show the drag, CdA and Cd for the different configurations at 0°yaw and table 2 for 10°yaw.

Table 3 and 4 show the delta value for each configuration compared to the respective baseline. As can be seen the Combined package, configuration 7 gave the best result for the two different angles tested.

Table 1: Wind tunnel measurements at 0° yaw-angle and 30 m/s free stream velocity

Configurations	v [m/s]	Drag [N]	CdA [m^2]	Cd
Baseline	30.56	11.53	0.021	0.670
Config 1 (Roof fairing)	30.67	11.19	0.020	0.645
Config 2 (Nosecone)	30.72	10.72	0.019	0.615
Config 3 (Side skirts)	30.54	10.69	0.019	0.622
Config 4 (Short)	30.54	11.35	0.020	0.660
Config 5 (Short boat tail)	30.52	13.02	0.024	0.759
Config 6 (Config. 1,2,3)	30.60	8.73	0.016	0.505
Config 7 (Optimal package)	30.60	7.65	0.014	0.443
Config 8 (New boat tail, Roof fairing)	30.70	10.78	0.019	0.619

Table 2: Wind tunnel measurements at 10° yaw-angle and 30 m/s free stream velocity

Configurations at 10° yaw	v [m/s]	Drag [N]	CdA [m^2]	Cd
Baseline	30.31	21.00	0.038	1.240
Config 1 (Roof fairing)	30.35	19.72	0.036	1.161
Config 2 (Nosecone)	30.37	18.36	0.033	1.079
Config 3 (Side skirts)	30.37	13.87	0.025	0.816
Config 4 (Short trailer)	30.26	19.56	0.036	1.159
Config 5 (Short boat tail)	30.22	21.54	0.040	1.280
Config 6 (Config 1,2,3)	30.46	11.16	0.020	0.653
Config 7 (Optimal package)	30.53	9.58	0.017	0.557
Config 8 (New boat tail, roof fairing)	30.32	17.44	0.032	1.028

Table 3: Change in C_d compared to baseline at 0° yaw-angle

Configurations at 0° yaw	ΔC_d
Baseline	0
Config 1 (Roof fairing)	3.6%
Config 2 (Nosecone)	8.1%
Config 3 (Side skirts)	7.1%
Config 4 (Short trailer)	1.3%
Config 5 (Short boat tail)	-13.3%
Config 6 (Config 1,2,3)	24.5%
Config 7 (Optimal package)	33.8%
Config 8 (New boat tail, roof fairing)	7.4%

Table 4: Change in C_d compared to baseline at 10° yaw-angle

Configurations at 10° yaw	ΔC_d
Baseline	0
Config 1 (Roof fairing)	6.3%
Config 2 (Nosecone)	12.9%
Config 3 (Side skirts)	34.2%
Config 4 (Short trailer)	6.5%
Config 5 (Short boat tail)	-3.25%
Config 6 (Config 1,2,3)	47.3%
Config 7 (Optimal package)	55.1%
Config 8 (New boat tail, roof fairing)	17.1%

5.2 Discussion

The different configurations gave different results and have different realisation factor where some configurations are perfectly fine to implement in real life and others are purely conceptual. Each configuration is discussed below about the improvement and if it can be implemented in real life.

5.2.1 Configuration 1 Roof fairing

The roof fairing reduced the drag of the vehicle by 3.6% at zero yaw and 6.3% in 10° yaw. This should be considered an essential part on tractors as the roof fairing can be made as a sheet or hollow structure, thus not adding any significant weight. Since the whole point of the fairing is to reduce or eliminate the height difference between the tractor and trailer no added height of the vehicle will be necessary neither. A consequence of the roof fairing is that the flow will keep being attached over the gap between the tractor and trailer and the high pressure area of the roof of the tractor will be heavily reduced

5.2.2 Configuration 2 Nosecone

The nosecone reduced the stagnation area of the tractor and thus reduced the Cd from 0.670 to 0.615 which is a improvement of 8.1 % in the 0 °yaw case.The construction of the nosecone however was not as initially intended and the front of the tractor had several creases and uneven surfaces. This is partly because of the use of cardboard which is not very malleable in more than one direction. A more rounded design would have improved the Cd even more. This was addressed in Configuration 7 where the front was redone with cardboard inserts and tape to form a rounded front. The visualisation from the smoke helped in improving the area on the top edge of the tractor that with its sharp edge caused separation. The iterative process and verification with the smoke made sure that the design could be good. Unfortunately the updated nosecone was not tested by itself but the new gave an improvement in the combined package configuration

5.2.3 Configuration 3 Side skirts

Addition of side skirts from the gap between the tractor and trailer and the rear edge of the trailer proved to be the most significant addition to reduce the drag, reducing drag by 7.1% at zero yaw and 34.2% at 10°yaw. There are however potential issues when implementing these additions in reality. The key purpose of the vertical gap between the tractor and trailer is for the trailer to be able to turn freely around the tractor when taking sharp corners. with a flush connection between the bodies the turning radius of the vehicle would be significantly compromised resulting in a too high turning radius for usage on public roads. One potential solution to this problem could potentially be retractable plates that slides out over the gap when driving on highways and retracts according to the steering wheel angle of the tractor. One other trouble area are that the lower edge of the side skirts on the model reaches almost all the way to the ground. In a real world scenario this would be constrained by the desirable ground clearance of the vehicle and depending if they were to be mounted on the sprung mass or unsprung mass, further compensation for the wheel travel would be necessary to avoid contact with the ground and potential damage of road or vehicle. Covering the front wheels of the tractor will also prove to be difficult to implement since rotation of these wheels most often are significant when turning the vessel. Covering of these wheels will thus reduce their movement and the turning radius of the vehicle. This could potentially be overcome by leaving a slot on the side skirts and focus more deeply on rim design or cover plates for the rims that aligns with the side skirts when traveling straight or at small corrective steering inputs.

5.2.4 Configuration 4 Short Trailer

The idea with the short Configuration was to see if the drag caused by friction was considerable when the trailer is shortened in zero yaw and if the increase in projected area had a big impact in the ten degree jaw case. As can be seen in the results the short trailer gave a improvement of 1.3% in zero yaw and 6.5% improvement in ten degree yaw. This means that there is a considerable benefit of having a shorter trailer if the payload does not fill out the whole big trailer that the baseline model has or put some time in to plan the loading to make it more efficient and fit in the small trailer. This configuration is also one of the most realistic and easy to realise since it does not obstruct any movement of the vehicle and comply with legislation.

5.2.5 Configuration 5 Short boat tail

The short boat tail was the only configuration that was not an improvement over the baseline. It worsened by 13,3% and 3.25% for the two cases with 0 and 10°yaw correspondingly. This was because of poor execution of the boat tail. The top of the boat tail created a spoiler in the shape of a duck tail that created downforce and increased the drag, the opposite of what is was made to do. The roundness of the boattail was to steep and in combination with edges and grooves in the surface, the rear wake increased and created separation where it was not intended. This was also addressed in Configuration 7 and 8 to create a rear that actually does what the intention was.

5.2.6 Configuration 6 Combination of configuration 1, 2 and 3

As a first simulation of the combined successful upgrades configuration 1, 2 and 3 was assembled to get a better picture on the combined effect. Because of the negative effect of a shorter trailer and the short boat tail these were disqualified from further evaluation. The combination proved successful as it reduced drag by 24.5% at zero yaw and 47.3% at 10°yaw angle. However since no improvements had been done on the rear of the vehicle in this configuration, further improvements were likely to be achievable with a redesigned boat tail.

5.2.7 Configuration 7 Optimal package

For the final concept with the new improved boat tail the lowest drag coefficient was achieved. With a lowest Cd of 0.443 this configuration reduced the total drag by 33.8% at zero yaw and 55.1% at 10 °. Given that cardboard and duct tape was used to build the aero kits there were likely areas of miss alignments and vertices created by the joints that disturbed the flow over the body. To further enhance the results of these upgrades a new model of the vehicle would be necessary and would likely give slightly lower values of Cd. As discussed in the single concepts implementing this exact model of aero kit would not work in reality due to regulations and the necessity of higher agility of the actual vehicle. These proposed methods of lowering the drag would therefore in a real life scenario more represent guidelines and goals when designing all the subsystems of the vehicle.

5.2.8 Configuration 8 New boat tail and roof fairing

The longer boat tail was tested alone to be able to compare it to the shorter one tested in configuration 5. It proved that a more shallow angle to the side of the trailer and a longer profile extending rearwards helped keeping the flow attached and reduced the size of the rear wake. The reduction in drag compared to the baseline proved to be 7.4% at zero yaw and 17.1% at 10°yaw. Comparing with the short boat tail the longer reduced drag by 18% at zero yaw and 20% at 10°yaw. Implementing this in real life could prove implausible with current regulation however since the rear end of the boat tail would be included in the length of the vehicle, thus reducing the cargo space of the trailer and would therefore likely not attract costumers.

6 Conclusion

The current aerodynamics for a truck and trailer combination is less than ideal. The bluff body nature of the road vehicle promotes bad air flow around its edgy surfaces and gives rise to comparatively bad fuel economy. It is also important to realize the various types of air flow around the truck changes during yawing and how that affects driveability and aerodynamic performance of the truck. Therefore, something that is great for straight line stability is might not necessarily be the best for a truck that is yawing.

From this research report, the students were able to improve the aerodynamic performance of the truck and trailer configuration by attaching various cardboard pieces to the vehicle. The overall leading configuration was when all of the aerodynamic devices were added simultaneously which resulted in a drag reduction of 33.8% at zero yaw and 55.1% at 10°yaw in configuration 7.

The realization that a few students placing cardboard cut-outs on a truck which greatly reduced drag suggests that there are a lot of improvement areas to be made within the trucking industry. Simply reducing the stagnation area at the front of the truck and increasing the low pressure at the rear of the trailer would do wonders towards improving drag of the vehicle. It would not be difficult to add large side skirts as in configuration 3 to reduce the drag by 7.1%, or to add slight curvature to the front face of the truck to improve the stagnation area. It is also important, however, to realize that unfortunately the loading capacity and economical profit of the cargo is of higher value. On the other hand, it might be important to weigh the environmental benefits of introducing better aerodynamics and reduce fuel-consumption. Especially on large trucks that travel at higher speeds where aerodynamics play a larger role.

To conclude, there needs to be a shift in motivation for companies like Scania and Volvo Trucks to introduce a sleeker and more aerodynamically efficient design into their production vehicles. As of now companies have their focus on the profits of maximizing cargo capacity, however, for the sake of improving and effectivizing the all-round capabilities of trucks, a more encompassing mantra has to be adopted to further develop the trucking industry.