Follow-up Report for Philipp Sueltrop, KEA Aerospace: This report analyzes the results of different HaloVision fluid dynamics simulations compared with real wind tunnel data.

Unfortunately, soon after my induction, where Finn Mcintyre explained how to use close circuit Wind Tunnel safely and gather accurate data, the closed circuit Wind Tunnel was put into maintanance.

However, I was adamant about conducting some real-world tests, as I believe this would make the whole CFD section of the report more reputable. Finn and I decided that the best alternative was to use the smaller wind tunnel on the ground floor. Unfortunately, this made taking accurate measurements very difficult. However, it could still provide visual cues on deflection, drag, lift, lateral forces, and turbulence. It should be noted that this wind tunnel has a maximum wind velocity of approximately 70 KPH.

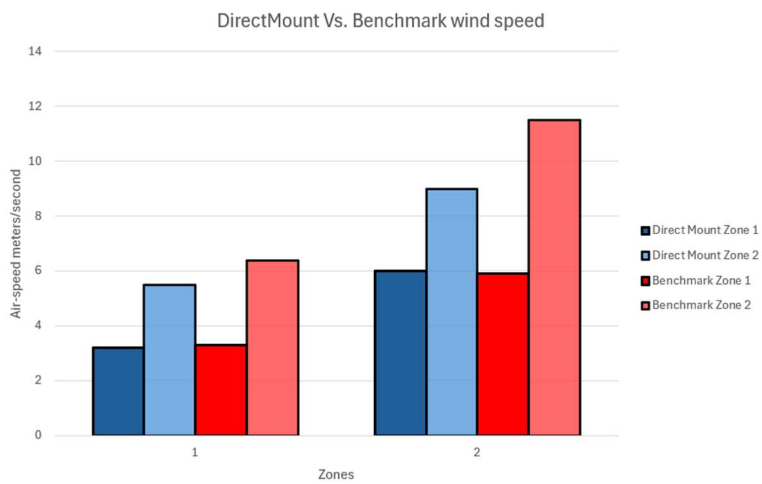
Section 1. Fluid flow analysis.

Figure 1. 'crucial air-speed' zones

Section 1.1. Windspeed results

To understand turbulence and lateral force, string was attached to the helmet at 'crucial air-speed' zones, allowing for basic flow observation. Wind speed was measured at two different points around the helmet (Zone 1 and Zone 2) using a barometer *(see Figure 1)*. This test was repeated with each design. *Figure 1* highlights the difference in speed between the two zones for the direct mount and benchmark.

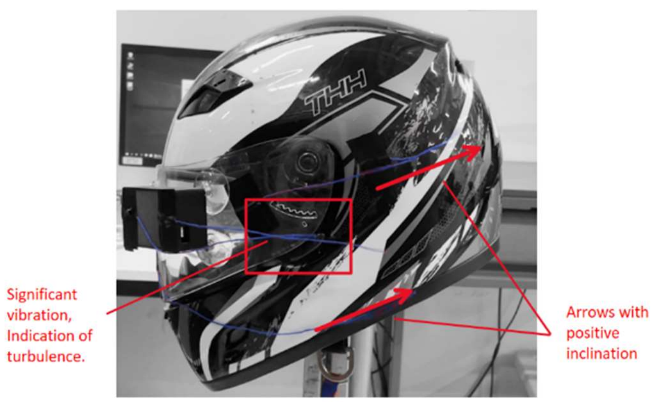
Figure 2. Air speeds of benchmark and direct mount.



The graph shows a larger drop in speed between the two zones for the direct mount compared to the benchmark. What is not clear from the graph is how much the airspeed behind the direct mount (zone 2) varied compared to the airspeed in zone 2 for the benchmark. This is a clear indication of turbulence in the design. This agrees with flow seperation of the initial report.

As well as the varying windspeed on the barometer's display, the helmet with the direct mount had a constant vibration. This vibration can be seen in the turbulence section of the video produced for this report.

Figure 3. Direct Mount flow



Section 1.2. Visual Analysis.

The best means of visually understanding the turbulence generated on the asymmetrical side of the helmet *(Figure 3)* is the video produced for this report. This video highlights the significant turbulence on the asymmetric side by the constant, rapid, and unstable movement of air around the helmet mount. The arrows drawn to highlight the direction of airflow show the air moving in a positive incline.

Figure 4. Benchmark flow.

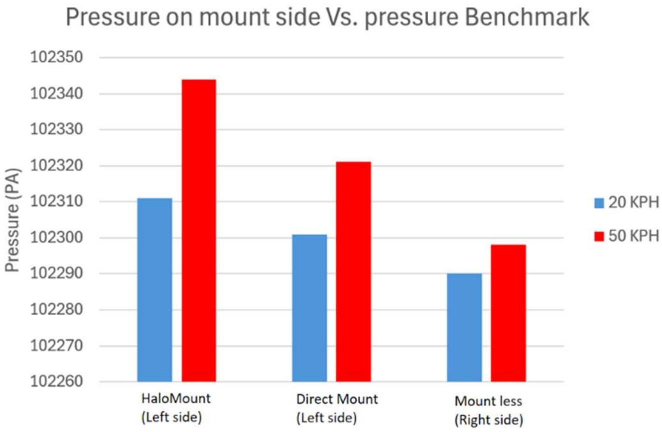
Comparing this to the symmetric side of the helmet *(Figure 4),* it is obvious that the air is significantly less interrupted and therefore moving quicker. The airflow direction of the arrows indicates a much flatter airflow, likely creating less lift.

Figure 5. Helmet tilt, lateral force indication

Figure 5 shows a side effect likely caused by the speed difference on each side of the helmet: a constant tilt towards the asymmetric side of the helmet, observed across all speeds. This indicates a significant lateral force on the mount side of the helmet.

Section 2. Pressure analysis

Figure 6. Pressure at varying speeds.

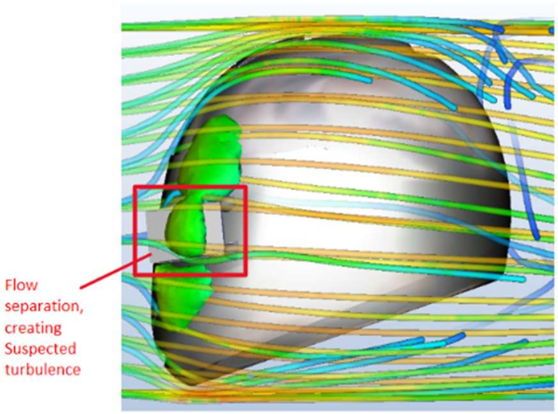


Section 2.1. Pressure at varying speeds

To attempt to understand the significant lateral force on the helmet with both mounts, pressure values using a pitot tube were taken on either side of the helmet at 20 KPH and 50 KPH. A lower pressure on the mount side of the helmet (left-hand side) indicates a lateral force towards that side. Figure 6 shows a trend that reinforces the idea that the HaloMount suffered the most, with both the highest pressure and pressure difference.

Section 3. Conclusion

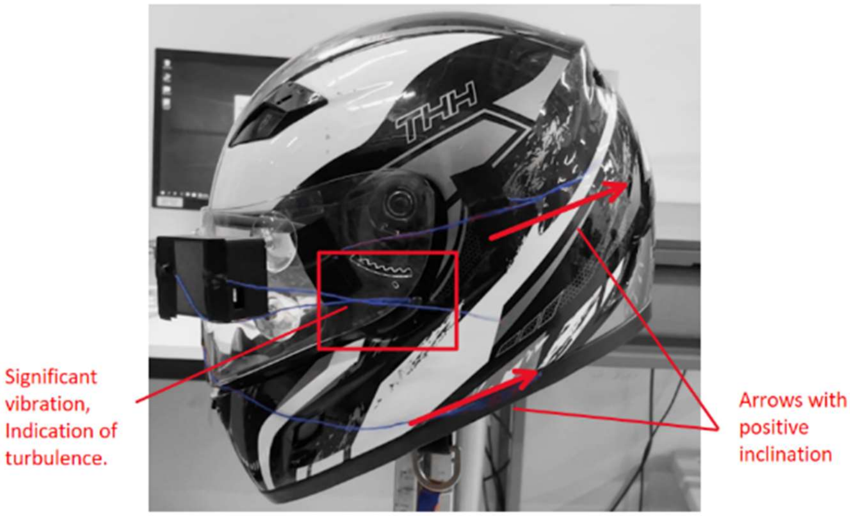
Figure 7. (Section 2.1, initial report) Direct Mount flow



Section 3.1 Flow analysis summary.

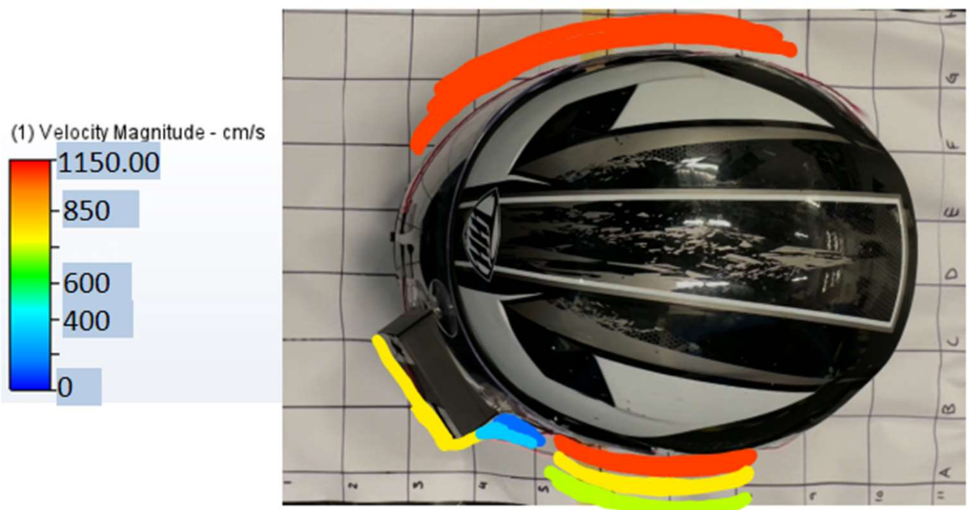
The turbulence suspected to occur on the asymmetric side of the helmet (Section 2.3 of the initial report, Figure 7 in this report) can be verified by comparing the ISO volumes from the CFD simulations to Figures 3 and 4.

Figure 4 (2). Direct Mount flow, open loop tunnel



It should be noted that the positive angle of flow inclination present in the open wind tunnel tests cannot be seen with traces on the CFD model. An improvement I mentioned in my initial report was the vertical domain size; this could be to blame for the more horizontal airflow around the helmet.

Figure 8. Pressure mapped against speed at varying speeds.



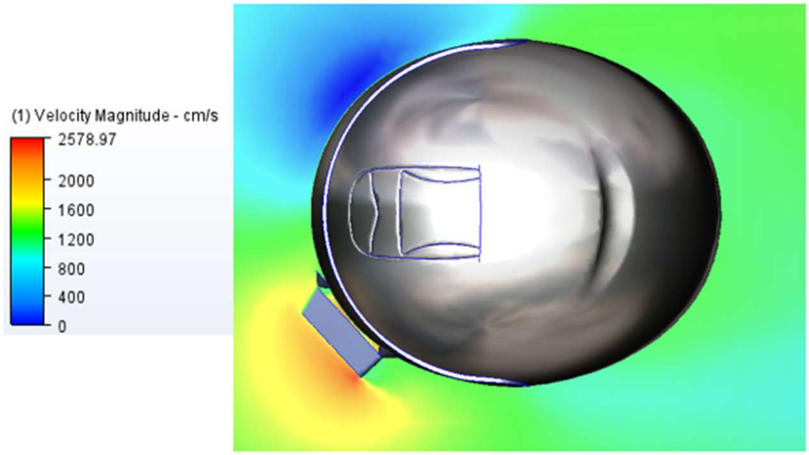
Section 3.2 Windspeed analysis summary.

The results from the wind tunnel analysis were drawn onto a top-down view of the helmet. This illustration was constructed to allow easy comparison with Section 2.1 in the initial report.

This velocity "heat map" was illustrated using data from Figure 2. The use of the same color palette as that used for the CFD velocity plane in Section 2.1 again was done for easy comparison. It should be noted that zones have been extended to make these results easier to compare visually to the CFD-generated heat map.

The illustration in Figure 8 shows some similarities to the velocity heat map from Section 2.1 in the initial report. The most noticeable similarity was the relatively high air speeds around the mount in both the illustration and the CFD-generated heat map.

Figure 6 (2). (Section 2.1, initial report) Pressure at varying speeds



The airspeed around either edge of the helmet is slower than the results from the open wind tunnel would suggest. While the legends would indicate that these helmets are being tested at different speeds, Figure 8 is simply further from the exit of the wind source. Care was not taken to ensure these were at similar distances because this section is only designed to be interpreted relative to color, rather than specific air velocity values.

Section 3.3. Summary – Was it all worth it?

The objective of this exercise was to validate the initial CFD findings. This was undertaken because of how easy it can be to make CFD results appear convincing. Despite not being able to collect data from the closed-loop wind tunnel, I would still call this an overall success. The open wind tunnel results were able to back up the lateral force CFD results and help further visualize turbulence. The difference between my CFD results and these wind tunnel results emphasized the importance of simulation settings in retrieving accurate CFD results.

Insights gained from learning how to take accurate measurements from wind tunnels are invaluable and have greatly contributed to my understanding of fluid mechanics as a whole. Additionally, I would like to say a huge thank you to Finn Mcintyre for allowing me to use this facility, as well as sharing knowledge surrounding the interpretation of some of the results. I am forever grateful.