TECHNICAL DOCUMENT

IMPROVING MOTORCYCLE AERODYNAMICS: FIND A FAIRING WITH LOW AERODYNAMIC DRAG

Fairings are an essential component of many motorcycles and designed to improve aerodynamics and stability of a bike. For a student diploma project on the aerodynamics of a motorcycle fairing, the project team, consisting of KTM employees Martin Herzog, Alexander Hladik, and Christian Fernsebner, worked closely with Altair, specifically Altair's Student Ambassador at the TU Munich, Matthias Leister. The task was to compare motorcycle fairing concepts to improve drag and aerodynamic balance. This document will describe how the design team used Altair solutions, including Altair Virtual Wind Tunnel™ and Altair ultraFluidX™, to achieve the best fairing concept, ensuring low aerodynamic drag as well as improved rider safety and handling.

Optimizing Aerodynamic Efficiency

While aerodynamics play an important part in the design of all vehicles, it is of crucial importance when designing a motor racing bike. To improve the aerodynamics and increase the efficiency and overall performance of their bikes, manufacturers often rely on motorcycle fairings, lightweight panels in various shapes and sizes that are mounted to the motorbike. Designing these fairings poses several challenges to manufacturers, from material choice and manufacturing constraints to ergonomics, rider safety, and comfort. As the primary purpose of these panels is to reduce the wind resistance and aerodynamic drag as well as to improve aerodynamic performance, a considerable number of tests must be performed. While physical wind tunnel testing is costly, wind tunnel simulations offer the advantage of using virtual simulation techniques and working with virtual prototypes, which cost a fraction of physical testing. In a three-phase study lasting six months, Altair Student Ambassador and fluid dynamics expert Matthias Leister set out to improve the overall aerodynamics of a motorbike concept.

Altair's easy-to-use solution ultraFluidX enabled fast modelling allowing to setup the simulations in a short timeframe

> The aerodynamics project showed us how easily and quickly Altair ultraFluidX enables pre-processing while providing us with high-fidelity results. The cooperation with the Altair team has been outstanding and inspired us from the beginning. Without Altair's tools and excellent support, this project would not have been feasible.
>
> Christian Fernsebner, Team Leader Fabric./Mech./Prod./3D Print Motorsports, KTM Racing GmbH

Physical prototype

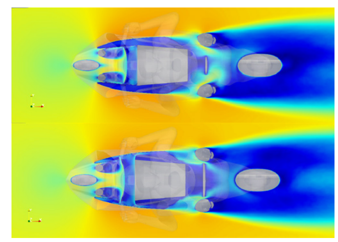
The Challenge: Finding the Best Concept

For a student diploma project that aimed to add an optimized fairing to a naked bike based on the KTM 1290 Super Duke, the diploma project team, including Christian Fernsebner, team leader Fabric./Mech./Prod./3D Print Motorsports, KTM Racing GmbH, needed both suitable software tools and expert support to perform aerodynamic studies that would enable them to evaluate motorcycle concepts and predict the aerodynamic behavior of the most promising version. In addition to an aerodynamically optimised fairing concept that would work in the real world while meeting all manufacturing requirements and budget guidelines/goals, the task was to get an attractive design that appeals to the target group. As an Altair customer using Altair simulation solutions in the area of topology optimization and strength analysis, Christian Fernsebner turned to Altair for support with aerodynamic analysis – an area that was new to the project team.

ALTAIR

Setting Up the Simulation

The starting point for the simulation was a dummy model, using a very simplified motorbike geometry, without any gaps or screws. The more detailed the simulation models are, the longer it takes to calculate – and it doesn't go up linearly, but exponentially. This means that a small refinement can have a huge influence on computing time, and engineers must find a set-up that works efficiently. By iteratively increasing the resolution of the simulation by reducing the size of the cells in which the flow is calculated, the students identified a point at which the results no longer change, for example, the drag coefficient. To prepare the geometry and the model setup, Altair® HyperWorks® CFD and Altair Virtual Wind Tunnel™ (VWT), part of the powerful design and simulation environment, the Altair HyperWorks platform, were used. For the simulation itself, Altair used the transient CFD Solver Altair ultraFluidX™, Altair's solution for ultrafast aerodynamics simulation based on the Lattice-Boltzmann Method. The study was performed in three phases:

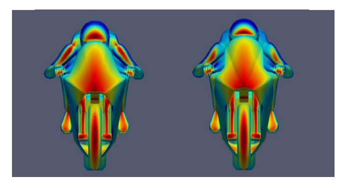


An accurate and efficient simulation setup in Altair Virtual Wind Tunnel enabled high-fidelity results in about 8 hours.

1) Comparison of the aerodynamic drag between two fairing concepts using simplified geometry
2) Validation of the aerodynamic performance of a detailed version of the selected fairing concept
3) Improvement of the aerodynamic balance and downforce using wings

1) Comparison of the Aerodynamic Drag Between Two Fairing Concepts Using Simplified Geometry

In this first phase of the study the team had to decide between two initial motorbike concepts, showing differences in length, angle and shape of the windshield, cutout at the handlebar, side tear off edge, and tail geometry. To find the design with the best performance, the team benefitted from using simplified geometries which enabled faster pre- and post-processing. The team wanted to find out which of these two motorbikes, version V4 or version V5, theoretically is the more efficient; then based on the results, find a fairing concept with low aerodynamic drag. Using a convergence study with different voxel sizes, the student developed an accurate and efficient simulation setup in Altair Virtual Wind Tunnel that enabled high fidelity results in about 8 hours. The simulation results clearly showed that V5 outperformed V4 in terms of drag coefficient. The main differences in drag were caused by lower pressure regions at the driver's shoulders and a better pressure recovery behind the driver's back. These differences result from the greater length of the windshield that leads to a better flow above the helmet and thus a smaller wake and weaker low-pressure area behind the driver. Based on these results with the simplified geometry, V5 was selected for further investigations on a more detailed model.



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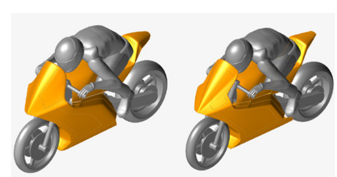
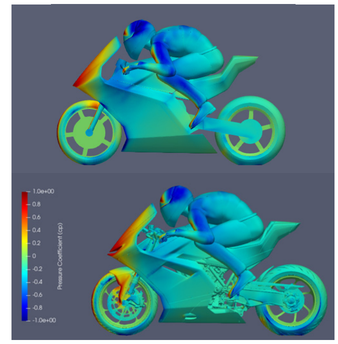


To get a detailed insight into the flow behavior and the aerodynamic features, a simulation of the detailed concept was performed.

2) Validation of the Aerodynamic Performance of a Detailed Version of the Selected Fairing Concept

To get a detailed insight into the flow behavior and the aerodynamic features, a simulation of the detailed concept was performed. In particular, the team studied the flow around additional parts and details like internal components and air vents.

To validate the similarity of the flow behavior after the changes, the team also compared the initial version (V5) to the more detailed version (V5_Detail). The results revealed a very similar aerodynamic behavior of both versions, showing that the features which made V5 the better concept, were applied to the detailed version, which considered the exact motorbike geometry, i.e., the final exhaust and engine geometry, gaps, and screws. Due to the additional parts, gaps, and surface imperfections, the aerodynamic drag was increased from 0.506 in V5 to 0.514 in V5_Detail. This difference is caused by the more open geometry inside of the motorcycle in the area around the front suspension and the handling bar, enabling airflow to escape upwards and thus reducing the pressure in front of the radiator and the mass flow through the radiator. However, while the overall drag was increased, the drag coefficient acting on the driver was reduced from 0.113 to 0.090 with less force acting on the shoulders and feet.



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3) Aerodynamic Devices: Improvement of the Aerodynamic Balance and Downforce Using Wings

In the third phase, the team focused on improving the aerodynamic balance using wing elements (winglets) for better vehicle dynamics to ensure safety and better handling. In detail, the team looked at the ratio of downforce to the road, between the front axle and the rear axle, improving the lift distribution to achieve a better aerodynamic balance. Due to a tight timeline, the study was limited to one winglet setup. By using winglets, the lift on the front axle was decreased by 20%, and the downforce on the rear axle was increased by 13%. Also, due to the aerodynamic efficiency of the winglets, the overall drag was increased by 6%. The findings include:

- The vortex generated by the winglets creates a high-pressure region at the air vent exit, inducing lift and reducing the mass flow through the radiator. A repositioning of the winglet could reverse the effect and improve the airflow through the vent and creating additional downforce.
- Most of the increase in downforce is caused by the local pressure difference on the winglets, but the wing tip vortex also causes downforce in the rear of the bike due to the low pressure in the vortex core.
- Improvements like a less aggressive angle of attack, a more optimized positioning, and utilizing airfoil profiles for the winglets could furthermore improve the aerodynamic efficiency and overall effect on the lift of the motorcycle.

	Lift [N]	Drag [N]
Wings Top	- 11.03	10.48
Wings Center	- 14.81	8.39
Wings Low	- 2.17	0.59

Despite being the biggest of the winglets, the lower one has the smallest effect on aerodynamic performance.

Altair ultraFluidX enabled quick and easy pre-processing while still providing very high-fidelity results

Matthias Leister, Technical University of Munich

High-fidelity Results with Quick and Easy Pre-Processing

Altair's easy-to-use solution ultraFluidX enabled fast modelling allowing to setup the simulations in a short timeframe, with a runtime of only seven hours. While the pre-processing was quick and easy, the software delivered high fidelity results providing accurate values for drag and lift coefficients and a detailed insight into the flow behavior around the fairings. As a result, critical areas of aerodynamic flow were identified and have been improved.