How to Gain 3 Seconds Per Lap

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Formula Student is the biggest engineering competition in the world, with over 500 universities competing worldwide. The goal for each team is to design and build an open-wheel race car. During the summer these cars are put through a series of static and dynamic events at different competitions. With the merging of Thomas More Innovation and Formula Group T, two teams joined forces as one larger team: Formula Electric Belgium (FEB). FEB became the only Belgian Formula Student (FS) team, consisting of more than 30 engineering students of KU Leuven University.

Compared to the 2013-2014 cars, the focus for the new FEB car was on a 20% overall weight reduction, improved reliability and an aerodynamic package. Major improvements, like the two self-developed permanent magnet motors, were made, to achieve the set goals. Over the past race year, the Umicore Luna saw the light: an

	Thomas More Innovation	Formula Group T	Formula Electric Belgium
Car Name	UTM-2	June	Umicore Luna
Year	2014	2014	2015
Weight [kg]	290	240	208
Acceleration 0-100 km/h [sec]	< 4	3.0	2.7
Lift coefficient	\	0.098	-1.200
Drag coefficient	\	0.456	0.545
Body	Steel tubular spaceframe with flax fiber body	Carbon-fiber-reinforced polymer (CFRP) monocoque	Carbon-fiber-reinforced polymer (CFRP) monocoque



Figure 1. Model history of Formula Student cars

electric FS race car, with a weight of 208 kg and an acceleration to 100 km/h in just 2.7 seconds!

The Umicore Luna was also set out to be the first Belgian FS car to feature a fully developed aerodynamic package, consisting of a front wing, diffuser, and rear wing. The package was to be added to the Umicore Luna to generate a higher amount of downforce with the aim of achieving higher cornering speeds on the track. The research on this topic was completed in the context of a Master's Thesis to obtain a degree in Industrial Engineering in Electromechanics. During the design of this aero package, the students were supported by Belgian design, engineering and research company, Voxdale bvba.

Voxdale specialize in automotive, medical and industrial sectors, as well as space and aerospace industries. In its design and engineering process, Voxdale uses FloEFD™ for the optimization of designs. Most recently it has been used in drag reduction of trucks and Indycar race cars, as well as for structural analyses and thermal management projects.

Together with Voxdale the students came up with a plan of action, with weekly progress meetings.

The design of the aero package for the race car started out with the search for an airfoil for the front and rear wing, suitable for the needs of the Formula Student competition. Since the average speed of a Formula Student car is relatively low, an ideal high lift and low Reynolds airfoil was chosen. As a result of the gain in downforce and overall efficiency of the wing, a two-stage wing was chosen.

The angle of attack, gap and overhang of both wing stages were simulated in 2D. A manual mesh dependency test was performed successfully for the 2D wing and showed a steady result around 1.25 million cells. Using the Automatic Refinement option in FloEFD, the number of cells dropped to 250,000, resulting in an enormous reduction of calculation time, while still obtaining correct results.

The parameter for this optimization was to obtain the highest possible square lift coefficient, while minimizing the drag coefficient (max CL^2/CD). Over 100 simulations were performed to obtain the best value.

The angle of the diffuser was simulated in the same way: different angles were simulated in 2D, while numerous diffuser lengths were observed in 3D. The pitch of

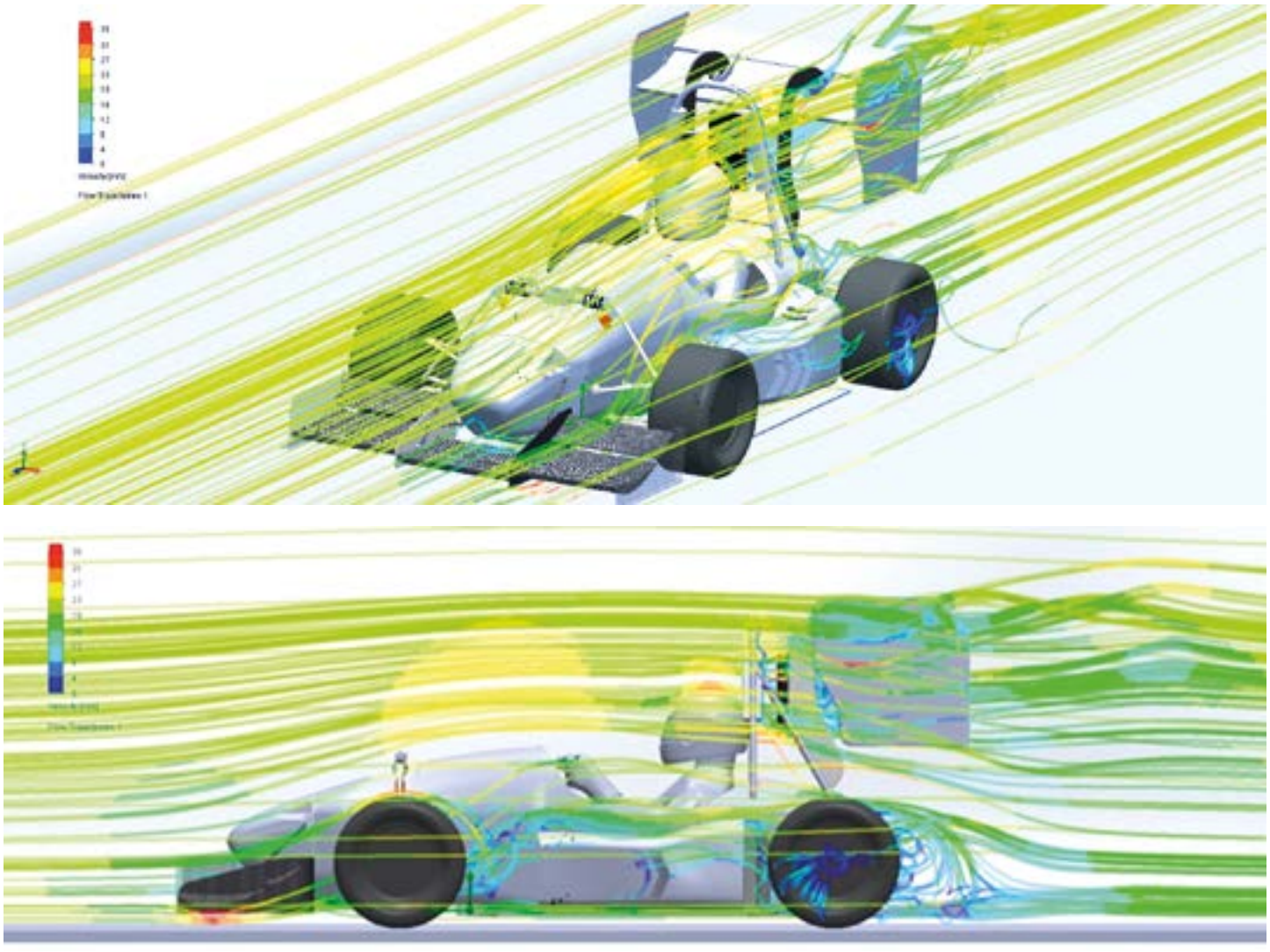

Figure 2. Flow Trajectories showing velocity over the new Umicore Luna model

the full car was also taken into account for this optimization.

After the optimization of both the diffuser and wings, a full 3D car model with aero package was simulated in CFD. The angle of attack of the rear wing was chosen to be adjustable in order to have an ideal setting for the different events at a Formula Student competition. In doing so, different settings of drag and downforce were possible and available for further validation, both on the track and in wind tunnel tests.

For the 3D simulations, a symmetry condition was used, splitting the car down the middle. This proved very useful in reducing overall calculation time. To simulate the different angles of attack of the rear wing, at first half of the car was simulated for one situation. As only the rear wing can change, EFD Zooming was performed at the rear part of the car. This again helped to reduce calculation time, which was critical to meet the deadlines of the Formula Student project.

The results of the full 3D simulations were validated in a wind tunnel using a 3D printed $^1/_8$ scale model. Here, the same overall pattern as obtained using the flow simulation software was determined.

By adding the aero package, the positive lift the car originally generated, was converted into downforce. At 80 km/h this corresponded with an amount of 400N of downforce.

With the use of a simulation program that includes, among others, available power, rolling resistance and aerodynamic values, a lap time is determined. In previous years the new car, without aerodynamics, achieved a simulated lap time of 87.23 seconds. The new car with aerodynamics achieved a lap time of 84.32 seconds, a gain of almost 3 seconds.

When all simulations were completed and conclusion drawn, the aero package was built to be used during the Formula Student events, where results of the simulations could be validated further.

After a successful start at the FSUK event in Silverstone, United Kingdom, the FSG event in Hockenheim, Germany delivered a promising 16th place out of 97 competitors. Now the Formula Electric Belgium team is preparing the Umicore Luna for the last event at the end of this summer, at the Autodrom Most circuit in the Czech Republic.

Although the 2014-15 season hasn't finished, next year's team is already preparing the design of the new car, hoping for new racing success together with Voxdale and FloEFD. The first test of the season will be a full scale wind tunnel test in the newly built Flanders' Bike Valley wind tunnel, co-founded by Voxdale.