The Peloton Project Races to a Series of Firsts and a World Record

A peloton is the main field or group of riders in a road bicycle race. While it can take different shapes, the peloton's overall purpose is to take advantage of the effects of slipstreaming, or drafting, behind other riders. Air resistance is the biggest mechanical component preventing cyclists from going faster on flat road, and slipstreaming can save up to 50 percent of their energy.

Or that was the assumption, at least.

The reality is that almost no information exists on aerodynamic resistance in cycling pelotons. Systematic computer simulations or measurements have never been reported before.

Professor Bert Blocken of Eindhoven University of Technology (Netherlands) and KU Leuven (Belgium) set out to fill the information gap.

In partnership with Cray and simulation software vendor ANSYS, Prof. Blocken conducted the first aerodynamic simulation and wind tunnel test of a full peloton of 121 cyclists and, in the process, set a world record in CFD simulation.

With almost 3 billion calculation cells, the Peloton Project simulation was the largest-ever in sports and the largest using commercial CFD software anywhere.

> "With the high-quality support of Cray and its engineering experts team, we have managed to run these very large simulations where the large number of cells were crucial towards accuracy and reliability."
>
> *- Bert Blocken, Professor of Aerodynamics & Project Leader Eindhoven University of Technology, KU Leuven*

Challenge

It's well known that aerodynamic resistance inside the peloton is far less than that at the front. It serves as a shelter from wind, a means of preserving energy, and a critical component of a racing team's strategy.

In truth, however, strong contradictions exist between what the mathematical models report about peloton aerodynamics and the firsthand experiences of professional cyclists and experts.

Prompted by the contradictory evidence and lack of supporting quantitative information, Blocken embarked on a new study to investigate the aerodynamic resistance for every cyclist in two pelotons (one dense and one sparse) of 121 riders. His goal was to understand the aerodynamic interactions within the entire peloton and identify the correspondingly best position.

Solution

Blocken and his research team focused on several key questions: exactly how low is the air resistance within a peloton, at which positions does the lowest air resistance occur, and how much air resistance do cyclists at the front or edge of the peloton actually experience?

To answer these questions they performed high-resolution CFD simulations using a Cray® XC™ supercomputer and ANSYS® Fluent® CFD software. Then they validated the simulation results against four different wind tunnel tests.

For simulation accuracy, calculations have to be performed to 0.020 millimeters from the surface of the athlete and the bicycle. For 121 cyclists, the simulation consisted of almost 3 billion cells.

In doing so, they produced the largest simulation in sports aerodynamics ever — and revealed some unexpected results.

Results

Previous studies looked at the resistance experienced by a single cyclist or a small group (up to 4) riding in a line. The last cyclist in such a row has a resistance of about 50 percent that of a lone cyclist. Thus, researchers assumed the 50 percent number also applied to those riding in a peloton. This, despite the fact that cyclists report that when situated in the belly of the peloton they hardly have to pedal to move within it.

Supported by ANSYS code and Cray supercomputing power, Blocken was able to run a simulation massive enough to capture the actual aerodynamics. They discovered that the minimum air resistance in the peloton is only 5 to 7 percent that of a solo cyclist.

Simplified mathematical models commonly assumed the resistance to be reduced to 50 or 70 percent that of an isolated rider. Those numbers are actually 10 times too high. Teams used this number to set strategy such as determining when a cyclist should try to escape the peloton. And it could explain why so few breakaways actually succeeded.

The simulations revealed additional insights:

- All cyclists, including the leading one, get an aerodynamic benefit from riding in a peloton.
- The leading rider experiences only 86 percent of the resistance of a solo cyclist.
- Cyclists at the outer edges of the "peloton spearhead" have the highest resistance.