



# Aerodynamic analysis of different cyclist hill descent positions

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## ABSTRACT

Different professional cyclists use very different hill descent positions, which indicates that prior to the present study, there was no consensus on which position is really superior, and that most cyclists did not test different positions, for example in wind tunnels, to find which position would give them the largest advantage. This paper presents an aerodynamic analysis of 15 different hill descent positions. It is assumed that the hill slope is steep enough so pedaling is not required to gain speed and that the descent does not include sharp bends necessitating changes in position. The analysis is performed by Computational Fluid Dynamics (CFD) simulations with the 3D RANS equations and the Transition SST  $k-\omega$  model. The simulations are validated wind tunnel measurements. The results are analyzed in terms of frontal area, drag area and surface pressure coefficient. It is shown that the infamous “Froome” position during the Peyresourde descent of Stage 8 of the 2016 Tour de France is not aerodynamically superior to several other positions. Other positions are up to 7.2% faster and also safer because they provide more equal distribution of body weight over both wheels. Also several positions that allow larger power generation are aerodynamically superior.

## 1. Introduction

It is well-known that the greatest potential for improvement in cycling speed is situated in its aerodynamics (Wilson, 2004). At racing speeds (about 54 km/h or 15 m/s), the aerodynamic resistance or drag is about 90% of the total resistance (Kyle and Burke, 1984; Grappe et al., 1997; Lukes et al., 2005). In hill descents however, higher speeds can be achieved, up to 110 km/h and beyond (Vanmarcke, 2017). To gain as much speed as possible in hill descents, different professional cyclists adopt very different positions, as shown in Fig. 1. This indicates that, at least prior to this research, which was first announced by means of a Linked In article on 28 April 2017, there was no consensus on which position is aerodynamically superior, and that most cyclists did not test different positions, for example in wind tunnels, to find which position would give them the largest advantage.

This study was incited by the specific hill descent position assumed by professional cyclist Chris Froome in stage 8 of the 2016 Tour de France. Fig. 2a shows the altitude profile and Fig. 2b the map of this stage. The stage ended with the descent of the Peyresourde. As shown in Fig. 2, the descent of the Peyresourde is steep and not characterized by sharp bends. At the day of the descent, the weather conditions were good and the road

surface was dry. Near the very end of this stage, just before the top of the Peyresourde, cyclist Chris Froome accelerated and broke away from the group. During part of the hill descent, he adopted the position shown in Fig. 1a and achieved speeds up to 90 kmh. Finally, he won the stage and took the prestigious yellow jersey. The question arises to what extent this particular descent position provides aerodynamic benefits that are not provided by other, more commonly adopted hill descent positions.

Aerodynamic drag in cycling can be assessed by field tests, wind tunnel measurements and numerical simulation by Computational Fluid Dynamics (CFD) (Blocken, 2014; Crouch et al., 2017). Previous aerodynamic studies in cycling have focused on cyclists in different types of race or time trial positions, either isolated or followed by other cyclists, motorcycles or cars (e.g. Kyle and Burke, 1984; Dal Monte et al., 1987; Zdravkovich et al., 1996; Grappe et al., 1997; Padilla et al., 2000; Jeukendrup and Martin, 2001; Hanna, 2002; Lukes et al., 2004; Defraeye et al., 2010a, 2010b; 2011, 2014; Blocken et al., 2013, 2016; Crouch et al., 2014; Griffith et al., 2014; Blocken and Toparlar, 2015; Fintelman et al., 2014a, 2015a; Barry et al., 2015; Beaumont et al., 2018). Recent studies have also focused on Paralympic tandem cycling (Mannion et al., 2018a, 2018b), Paralympic handcycling (Mannion et al., 2018c) and even on full cyclist pelotons (Blocken et al., 2018). However, to the best

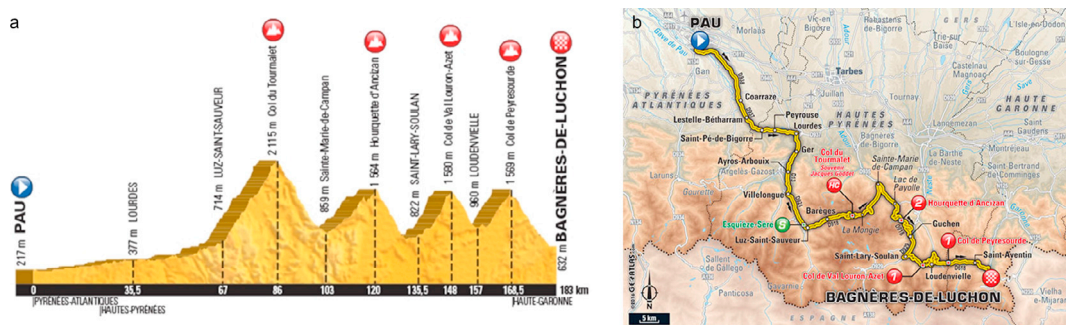
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**Fig. 1.** Hill descent positions as adopted by professional cyclists: (a) Chris Froome on front part of top tube; (b) Marco Pantani behind saddle; (c) Vincenzo Nibali on saddle in “back horizontal” position; (d) Vincenzo Nibali with forearms tucked in (“puppy paws” position); (e) Fabian Cancellara in “back up” position; (f) Peter Sagan on rear part of top tube. Source: VRT/Sporza.



**Fig. 2.** Stage 8 of the Tour de France 2016. (a) Altitude profile and (b) Map of stage. Source: touretappe.nl.

of our knowledge, no previous study focused on specific hill descent positions.

This paper therefore provides an aerodynamic analysis of different hill descent positions. Evidently, in most professional descents, the aerodynamic performance of a given position is not the sole criterion,

also the ability to provide power by pedaling (see Grappe et al., 1998; Fintelman et al., 2014b, 2015b; 2016) and steering capability in sharp bends are important. However, in the present paper, we focus on steep descents without many sharp bends, similar to the Peyresourde descent in the 2016 Tour de France.

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