J. Wind Eng. Ind. Aerodyn. 155 (2016) 1–10

Contents lists available at ScienceDirect

Journal of Wind Engineering and Industrial Aerodynamics

journal homepage: www.elsevier.com/locate/jweia

Aerodynamic benefit for a cyclist by a following motorcycle

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ARTICLE INFO

Article history:
Received 23 April 2016
Received in revised form
27 April 2016
Accepted 27 April 2016

Keywords:
Computational Fluid Dynamics
Wind tunnel
Aerodynamic cyclist drag
Cycling aerodynamics
Following motor
Motorbike
Numerical simulation

ABSTRACT

In recent years, many accidents have occurred between cyclists and in-race motorcycles, even yielding fatal injuries. The accidents and the potential aerodynamics issues have impelled the present authors to perform dedicated wind-tunnel measurements and Computational Fluid Dynamics (CFD) simulations to assess cyclist drag reduction when followed by one, two or three motorcycles. The 3D steady-state Reynolds-Averaged Navier–Stokes simulations with the standard k–ε model are validated by the wind-tunnel tests. The cyclist drag reduction goes up to 8.7% for a single trailing motorcycle and to 13.9% for three trailing motorcycles at a distance of 0.25 m behind the cyclist. This distance is not uncommon in elite races, as evidenced by the many recent accidents. The effect by a single following motorcycle at realistic short distances d=0.25 m (8.7%), d=0.5 m (6.4%) and d=1 m (3.8%) is larger than that by a following car at realistic short distance d=5 m (1.4%). Therefore it could be argued that in-race motorcycles are not only more dangerous but also aerodynamically more influential. This study reinforces the necessity for the International Cycling Union to change the rules concerning in-race motorcycles, not only to avoid accidents but also to avoid unwanted aerodynamic benefits.

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 in time trials), the aerodynamic resistance or drag is about 90% of the total resistance (Kyle and Burke, 1984, Grappe et al., 1997, Lukes et al., 2005). Aerodynamic drag can be assessed by field tests, wind-tunnel measurements and numerical simulation by Computational Fluid Dynamics (CFD). The use of CFD in wind engineering, also referred to as Computational Wind Engineering, has seen a rapid growth in the past 50 years (Murakami, 1997, Stathopoulos, 1997, Baker, 2007, Solari, 2007, Meroney and Derickson, 2014, Blocken, 2014, 2015). Indeed, also in cycling aerodynamics, several publications have reported CFD simulations (e.g. Hanna, 2002, Lukes et al., 2004, Defraeye et al., 2010a, 2010b, 2011, 2014, Blocken et al., 2013, Blocken and Toparlar, 2015, Fintelman et al., 2015). While most aerodynamic studies in cycling focused on the drag of a single (isolated) cyclist, several efforts have also been made to assess the effects of “drafting” (Kyle, 1979, McCole et al., 1990, Hagberg and McCole, 1990, Zdravkovich et al., 1996, Olds, 1998, Broker et al., 1999, Edwards and Byrnes, 2007, Iniguez-de-la-Torre and Iniguez, 2009, Blocken et al., 2013, Defraeye et al., 2014, Barry et al., 2015). Blocken et al. (2013) for the first time reported the aerodynamic effect for a leading cyclist due to a trailing cyclist based on CFD simulations and wind-tunnel measurements. Combining CFD simulations and wind-tunnel testing is clearly advocated in wind engineering for its synergistic effect (Meroney, 2016). Later, Blocken and Toparlar (2015) assessed the aerodynamic benefit for a cyclist by a trailing car, again by the combination of CFD simulations and wind-tunnel tests. This effect is not taken into account in elite cycling, as for individual time trials, the rules of the International Cycling Union UCI only specify a minimum distance between rider and car of 10 m because of safety reasons (International Cycling Union, 2015a, 2016). Furthermore, during actual races, this limit is often not kept because it is not strictly enforced. Nevertheless, during individual time trials, there is always at least one, but often more following cars, potentially influencing the drag of the cyclist (Fig. 1a, b and d). As a result, Blocken and Toparlar (2015) advised the UCI to modify their regulations for time trials and to fix the minimum distance for trailing cars at least at 30 m, which will not only avoid unwanted aerodynamic effects, but will also avoid dangerous situations for the riders. Indeed, the stopping distance of a car at 54 km/h on a wet road is much larger than 10 m.

Apart from cars, cycling races also contain a multitude of motorcycles, which can be neutral support motor cycles, commissaire

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http://dx.doi.org/10.1016/j.jweia.2016.04.008
0167-6105/

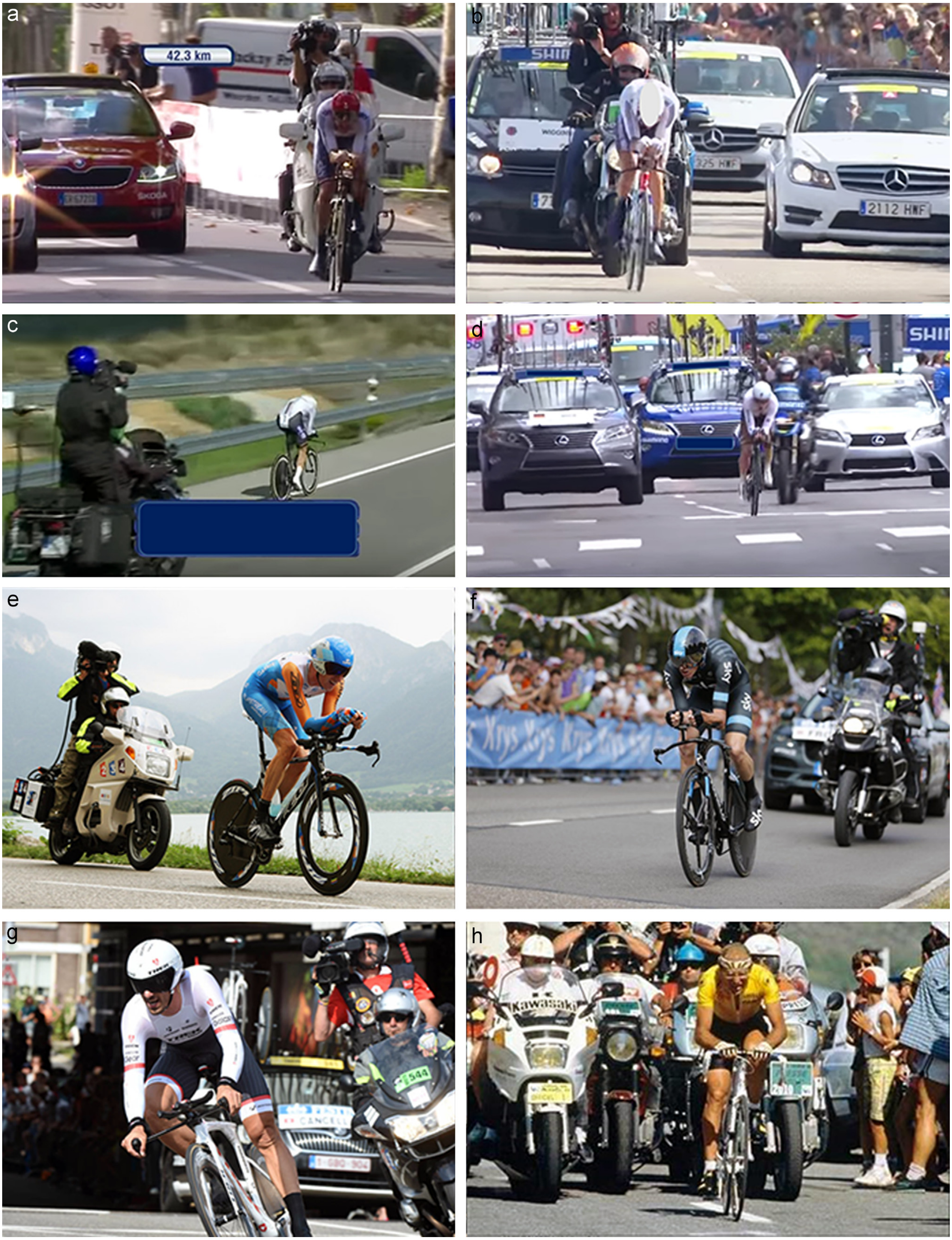

Fig. 1. Photographs from individual time trials: cyclist followed by motorcycle and/or car(s) (sources: a–d: International Cycling Union 2013, 2014, 2015b; e: www.zimbio.com; f: cyclingweekly.co.uk (Sunada); g: cyclingweekly.co.uk; h: www.hln.be).