

Multidisciplinary Optimization of an Aerobar: Aerodynamics, Biomechanics, Mass and Structure

Sébastien Terol ^{1,2,*}, Antony Costes ², Georges Soto-Romero ¹

Received: 27 March 2025

Accepted: 1 April 2025

Published: 19 November 2025

¹ LAAS-CNRS, Université de Toulouse, CNRS, INSA, Toulouse, France

² Direction de l'Innovation, ALTEN, Boulogne-Billancourt, France

Correspondence

Sébastien Terol

LAAS-CNRS, Université de Toulouse, CNRS, INSA, Toulouse, France

sterol@laas.fr

Abstract

The optimization of cycling position involves integrating two distinct analyses: individualized aerodynamic analysis and position-change power analysis. Aerodynamic analysis, conducted via Computational Fluid Dynamics (CFD) simulation or wind tunnel testing, provides the aerodynamic efficiency of each position. Power analysis quantifies the maximum power output of the cyclist for each position. By comparing these analyses, a balance between aerodynamic efficiency and power output can be achieved, estimating optimal positions for individual cyclists and given conditions. Indeed, the optimal position is specific to a particular cyclist, and depends as much on the race length and profile as on UCI or triathlon regulations. Based on the methodology of Fintelman et al., 2015, the torso angle as well as the position of the extenders allows us to precisely define a position on which to confront aerodynamic efficiency and power production. A digital twin of a professional athlete on his time trial bike was created using a 3D scan, with automatic generation of extensions based on forearm positions. This digital replica facilitates the automated design of extensions tailored to each position, enabling a comprehensive and customized approach to performance enhancement. The study aims to compare numerical study results with wind tunnel data to evaluate the algorithm's effectiveness. Subsequently, the automated aerobar design can be refined by optimizing its shape, structure, and mass, leading to a multidisciplinary optimization of the aerobars according to the cyclist's position. Solving this highly complex engineering problem would allow the fabrication of optimized aerobars tailored for a specific rider and race course.

Keywords

aerodynamic drag; power production; computational fluid dynamics; CFD; inverse kinematics; aerobars



This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>) which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.



