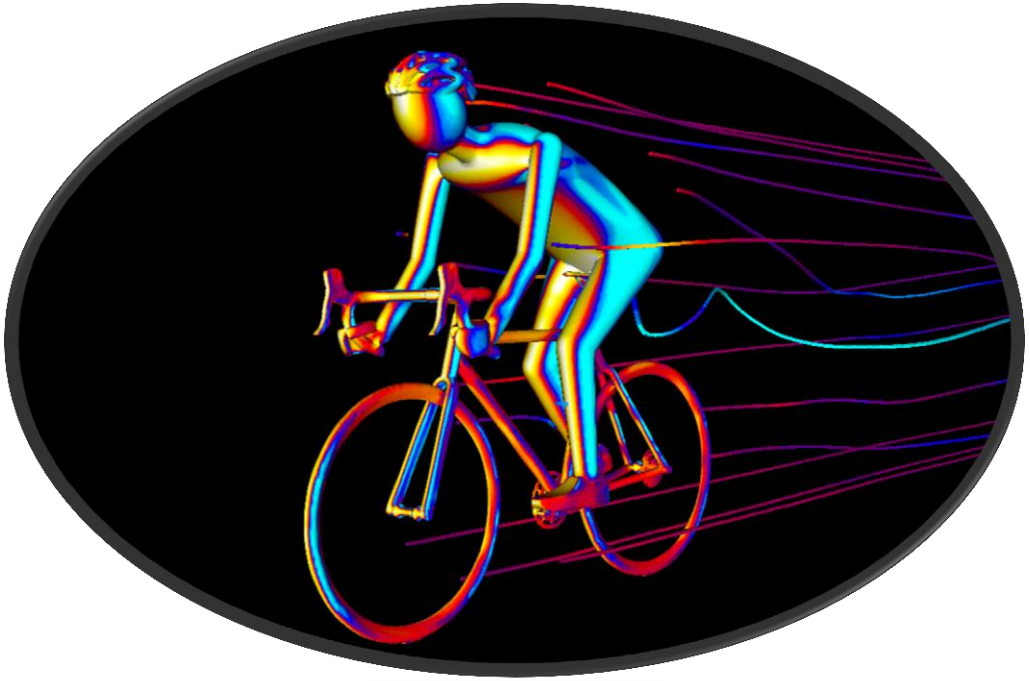
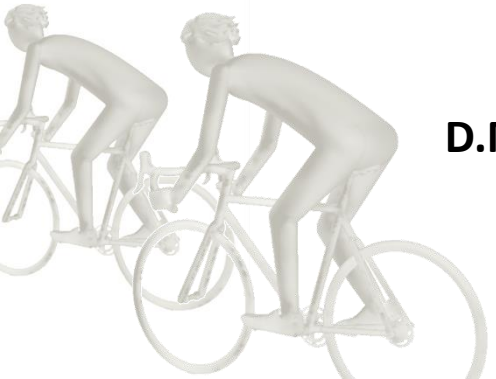
UNIVERSITY OF BIRMINGHAM

BEAR
PGR CONFERENCE 2014

The effect of cycling position on the aerodynamic responses in crosswinds





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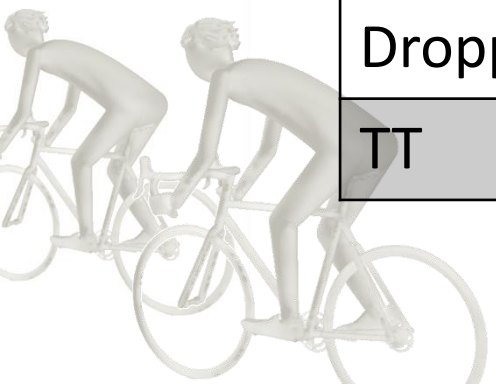
What is the effect of the riders position?

Upright

Dropped

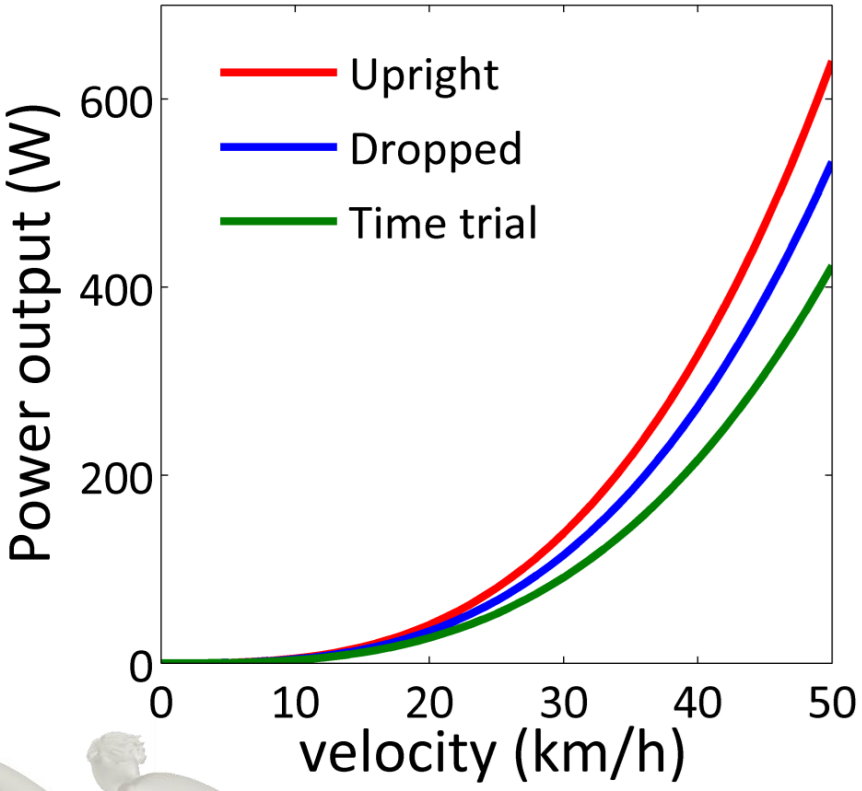
TT

	Frontal Area	**Drag reduction**
Upright	.40 m^2	0 %
Dropped	.37 m^2	≈ 20 %
TT	.33 m^2	≈ 30-35 %

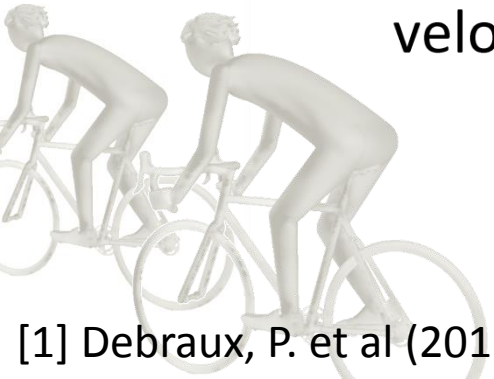


Hennekamp, W. (1990)

Power output as function of cycling velocity



Approximately **90% of power output** is used to overcome aerodynamic losses at a cycling speed of ≈ 50 km/h (31 miles/h)[1]

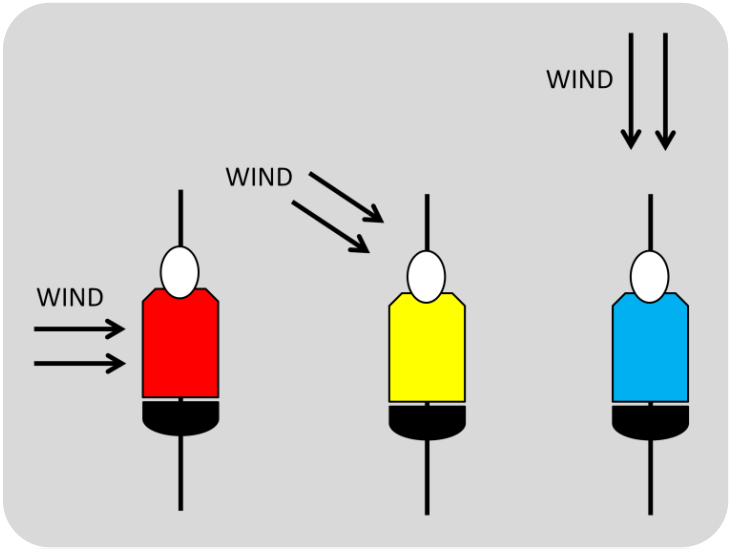


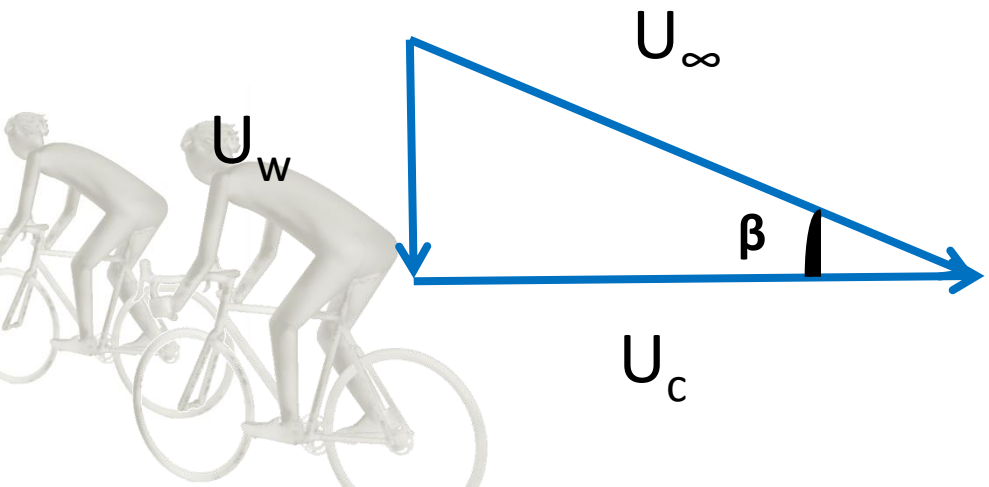
[1] Debraux, P. et al (2011).

Crosswinds in cycling

Crosswinds in cycling

- Crosswinds influences performance and safety
- Several fatal and severe crosswind incidents reported (Great Britain, Department of Transport, 2012)

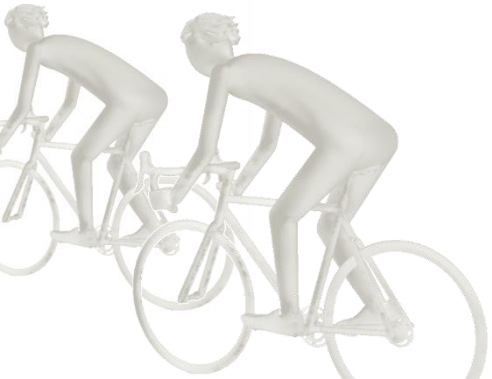




What are the aims of this study?

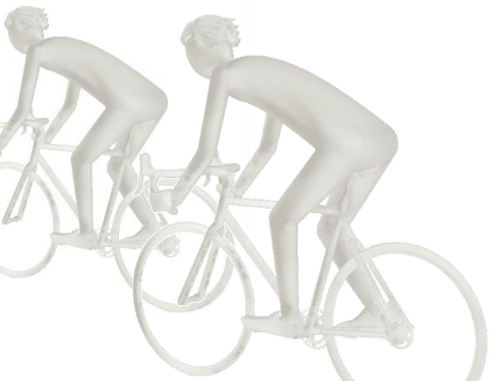
- Aims:
  - Improved understanding of the fluid flow around a cyclist in different positions
  - Investigate the effect of cycling position on the aerodynamic performance in crosswinds

- Goal: Help to improve the performance and safety of cyclists



Computational Fluid Dynamic (CFD) Simulations

- Turbulence models:
  - Reynolds-Average Navier Stokes
    - k-ε model
    - k-ω model

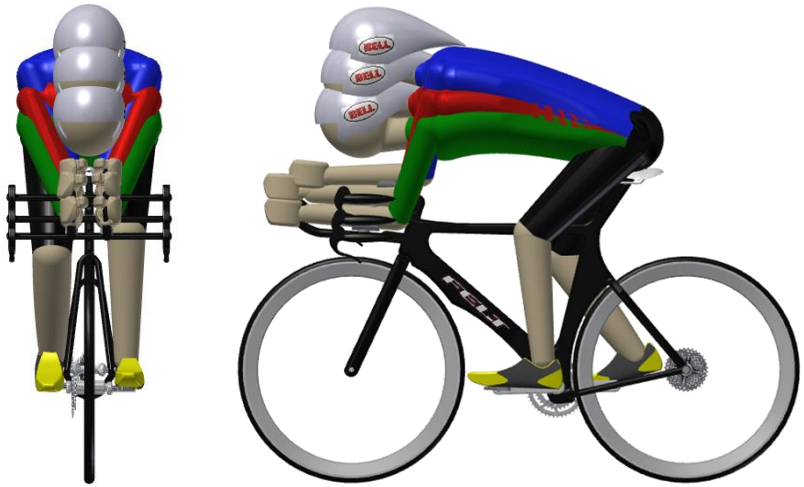


OpenFOAM

Positions analysed

- **Dropped positions**: 24° and 16° torso angle position
- **Time trial positions**: 16°, 8° and 0° torso angle position

24° and 16° dropped position

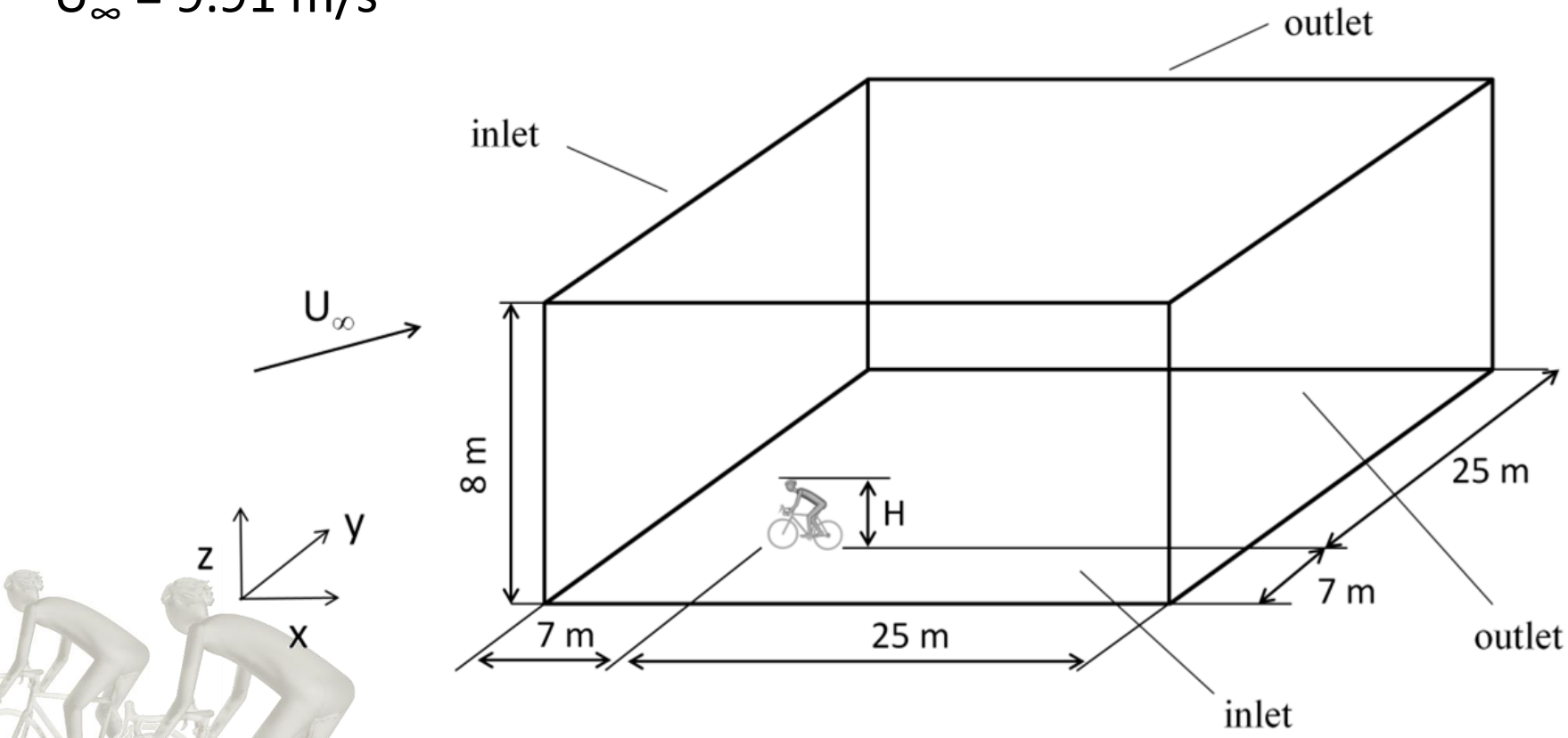


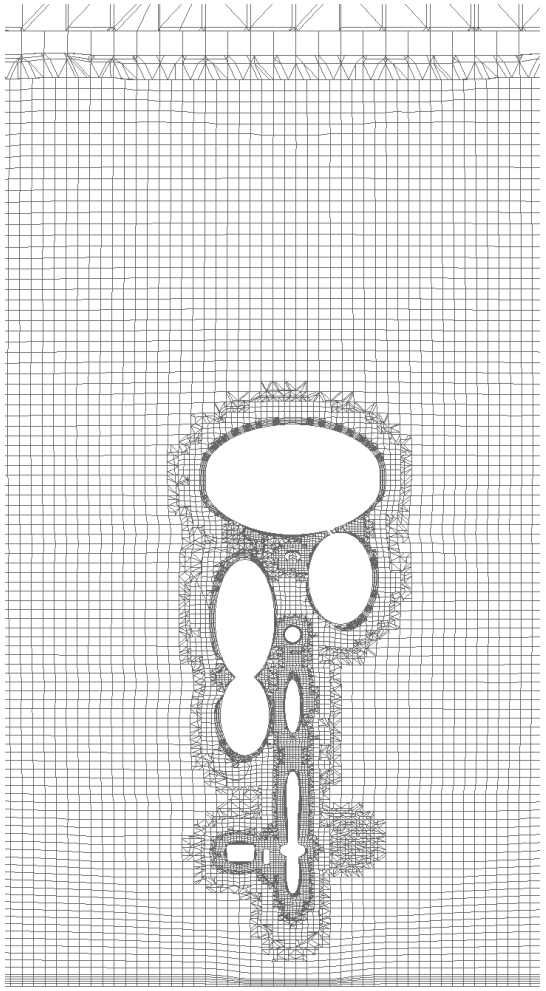
16°, 8° and 0° time trial position

Computational Mesh

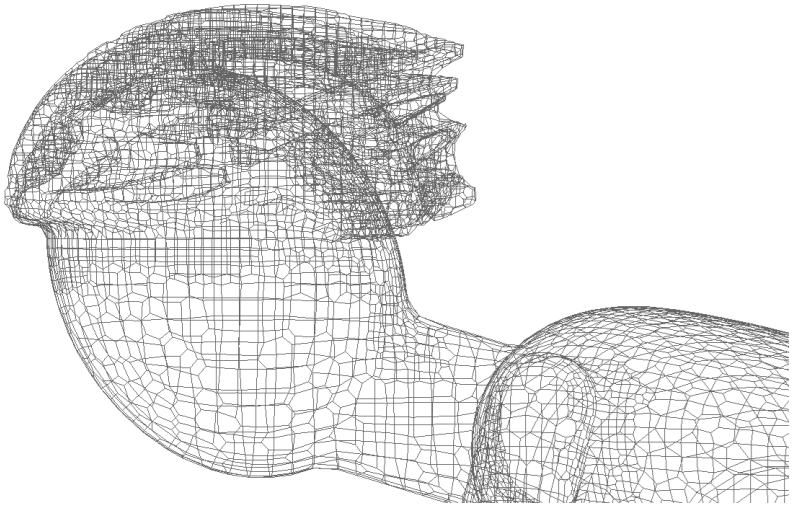
Yaw angles, β: 0°, 15°, 30° and 45°

U_∞ = 9.91 m/s

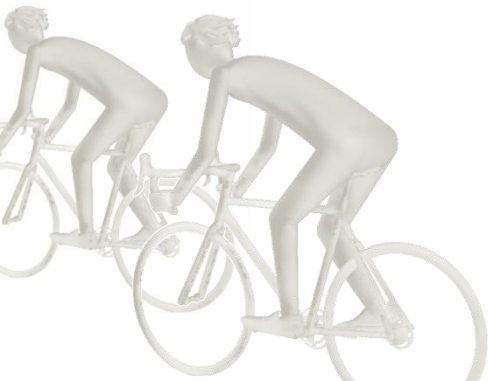




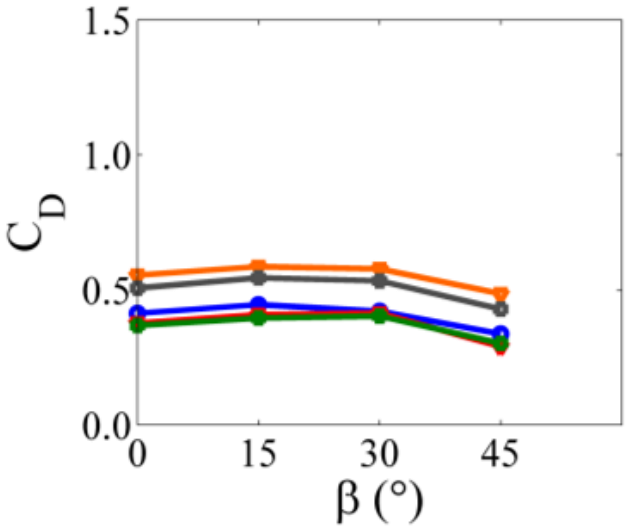
Mesh

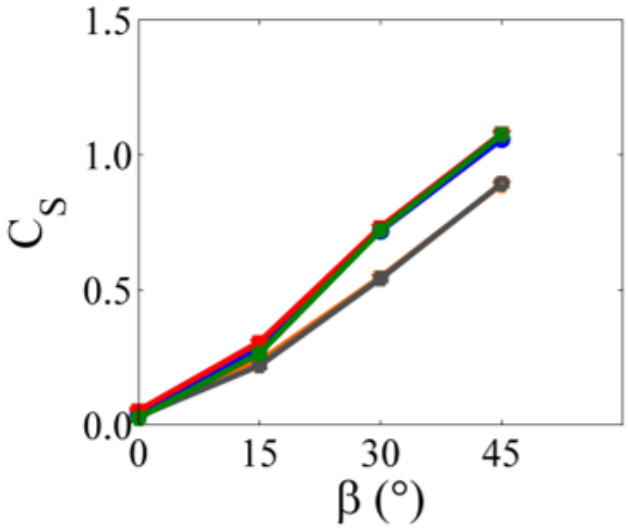


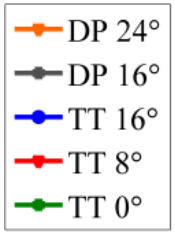
Finite volume method:
Conservation of matter, momentum, and energy must be satisfied



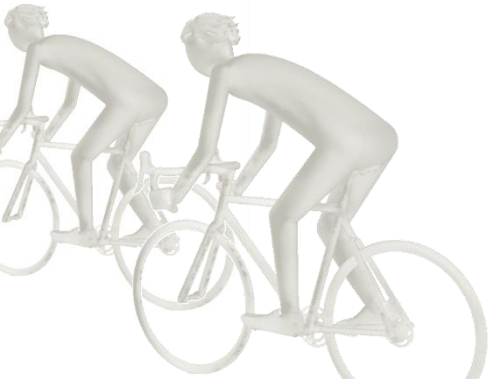
Aerodynamic coefficient results



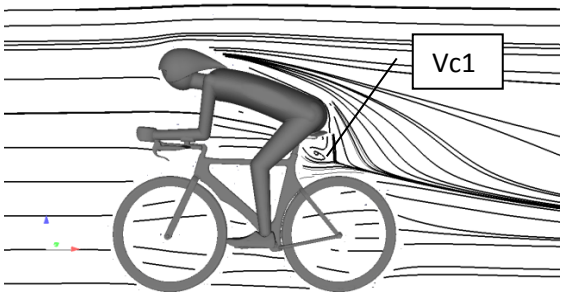




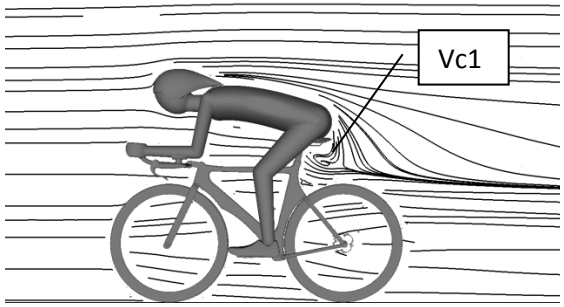
$$C_D = \frac{F_D}{0.5A\rho{U_\infty}^2}, \quad C_S = \frac{F_S}{0.5A\rho{U_\infty}^2}$$



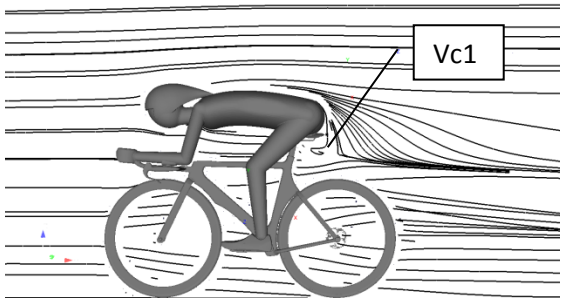
Streamlines no crosswind



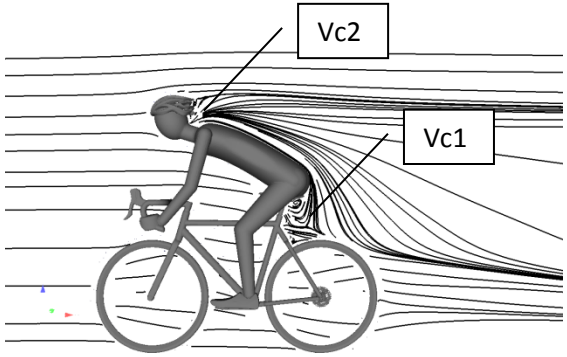
16 ° TT



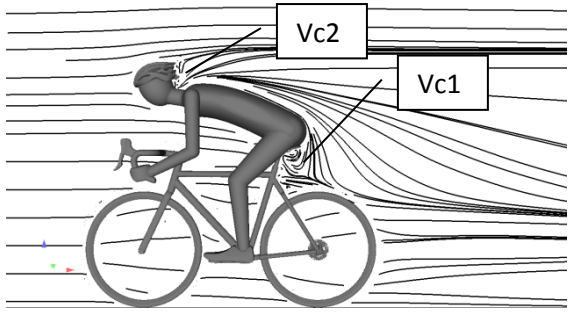
8 ° TT



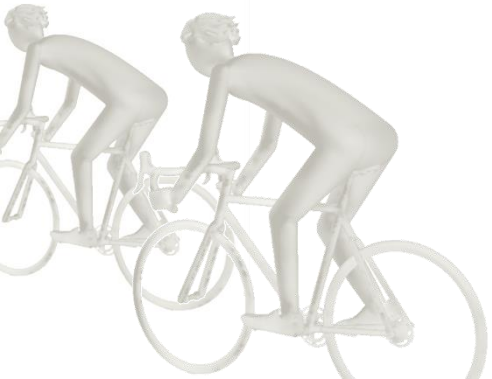
0 ° TT



24 ° DP

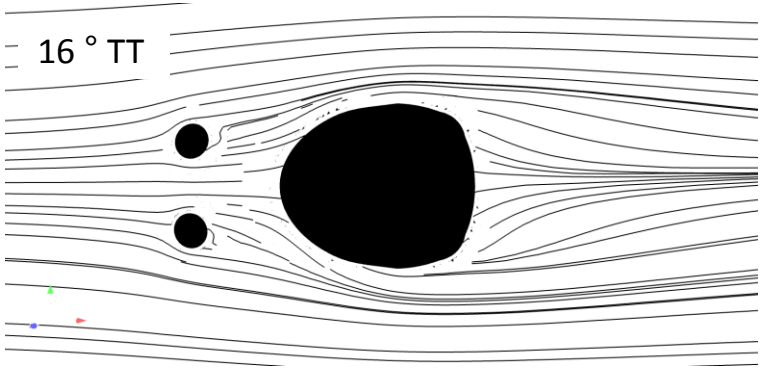


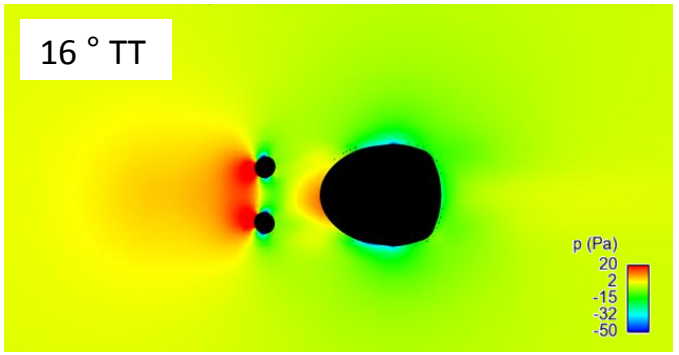
16 ° DP

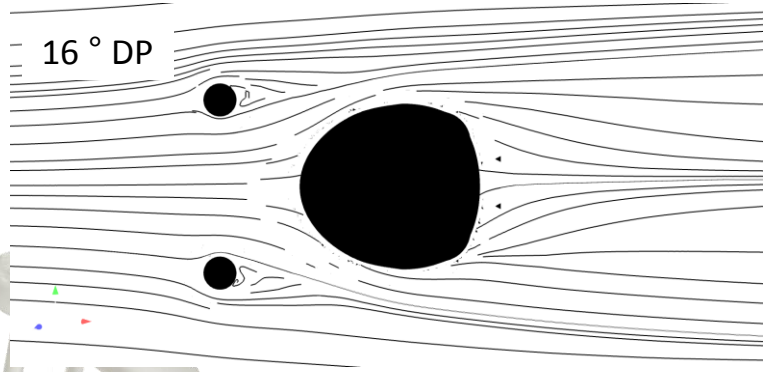


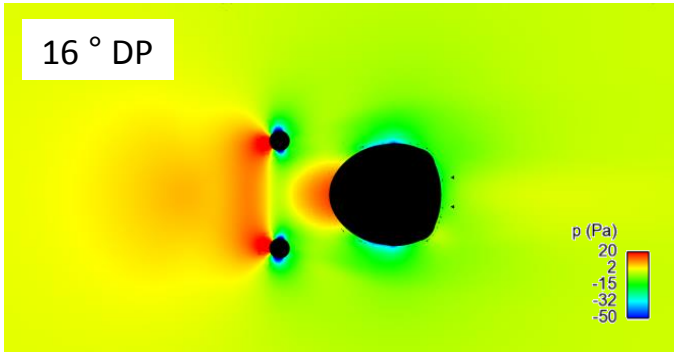
Velocity streamlines and pressure

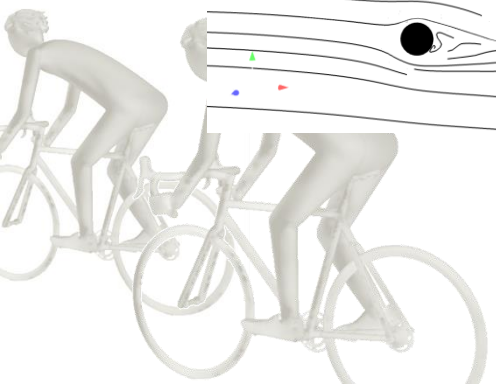
x-y plane at a height of 0.7H







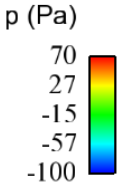


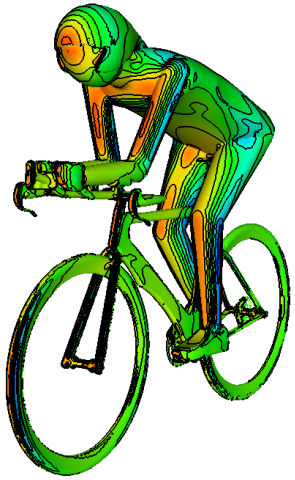


Surface pressure

16 ° DP, β = 0°

16 ° DP, β = 45°





16 ° TT, β = 0°

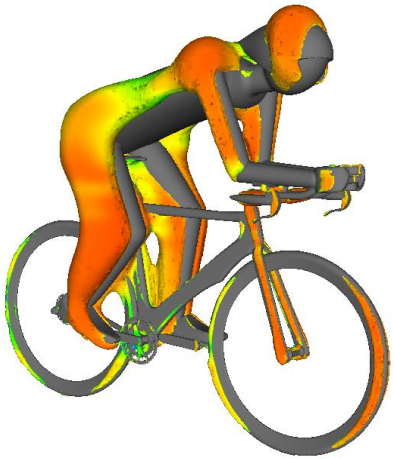
16 ° TT, β = 45°

Iso-surface pressure

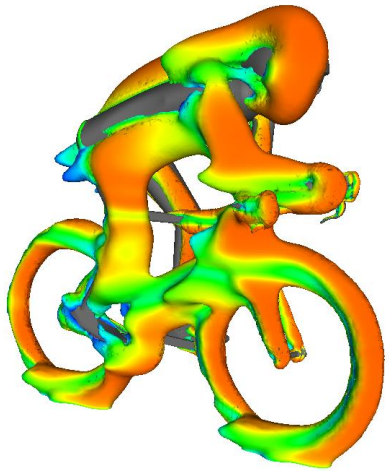
C_p = -0.240

16 ° DP, β = 0°

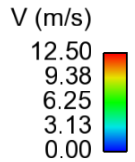
16 ° DP, β = 45°



16 ° TT, β = 0°



16 ° TT, β = 45°

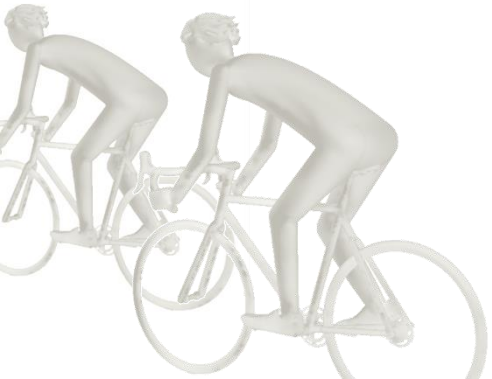


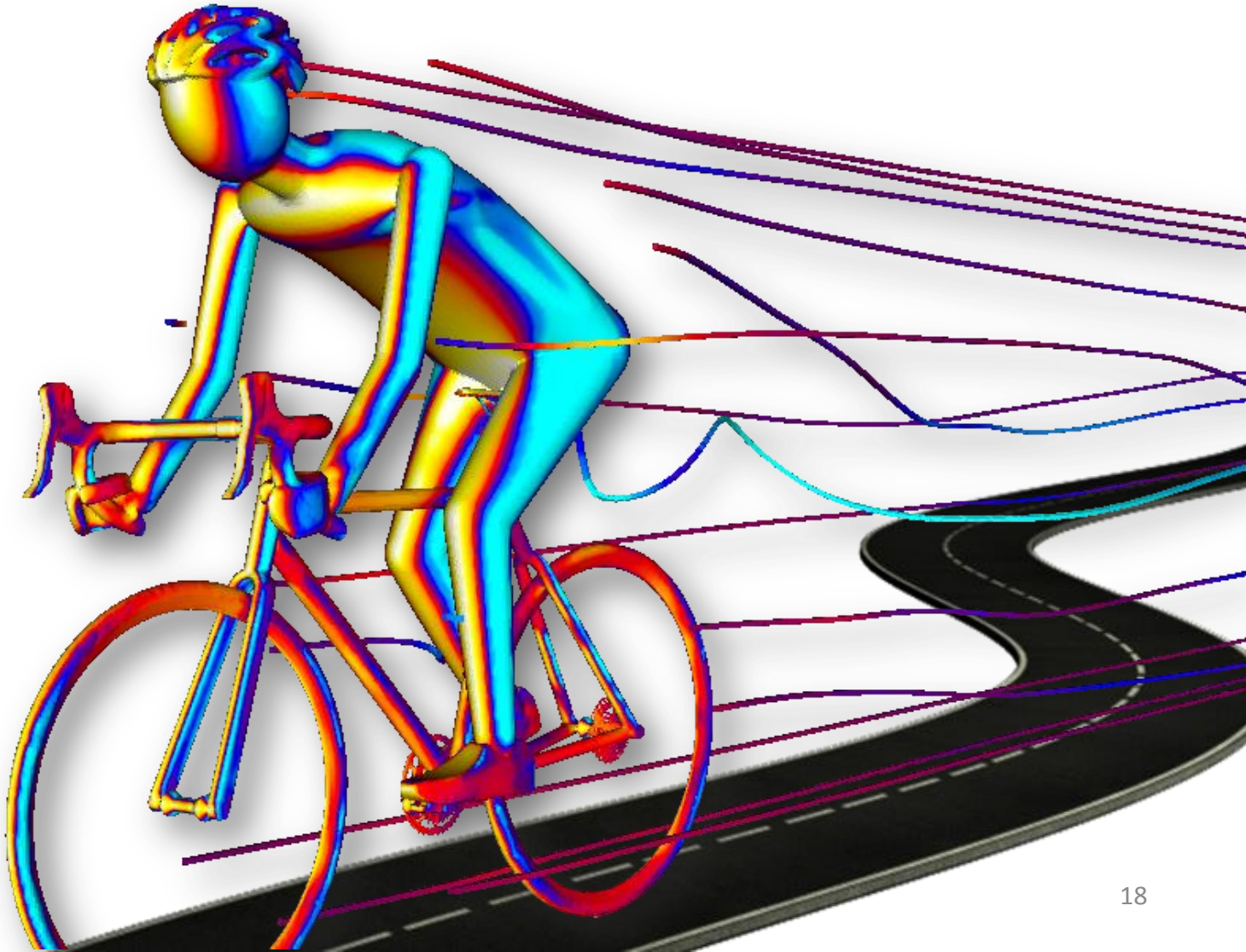
Conclusions

- Higher drag forces at no crosswinds in DP compared to TT, mainly due to differences in arm spacing and helmet geometry
- In crosswinds, significant changes in flow structures around the TT bicycle and helmet compared to DP
- Cycling equipment plays a major role in the acting side forces and rolling moments

Future work

- Investigation gust winds
- Implications on stability



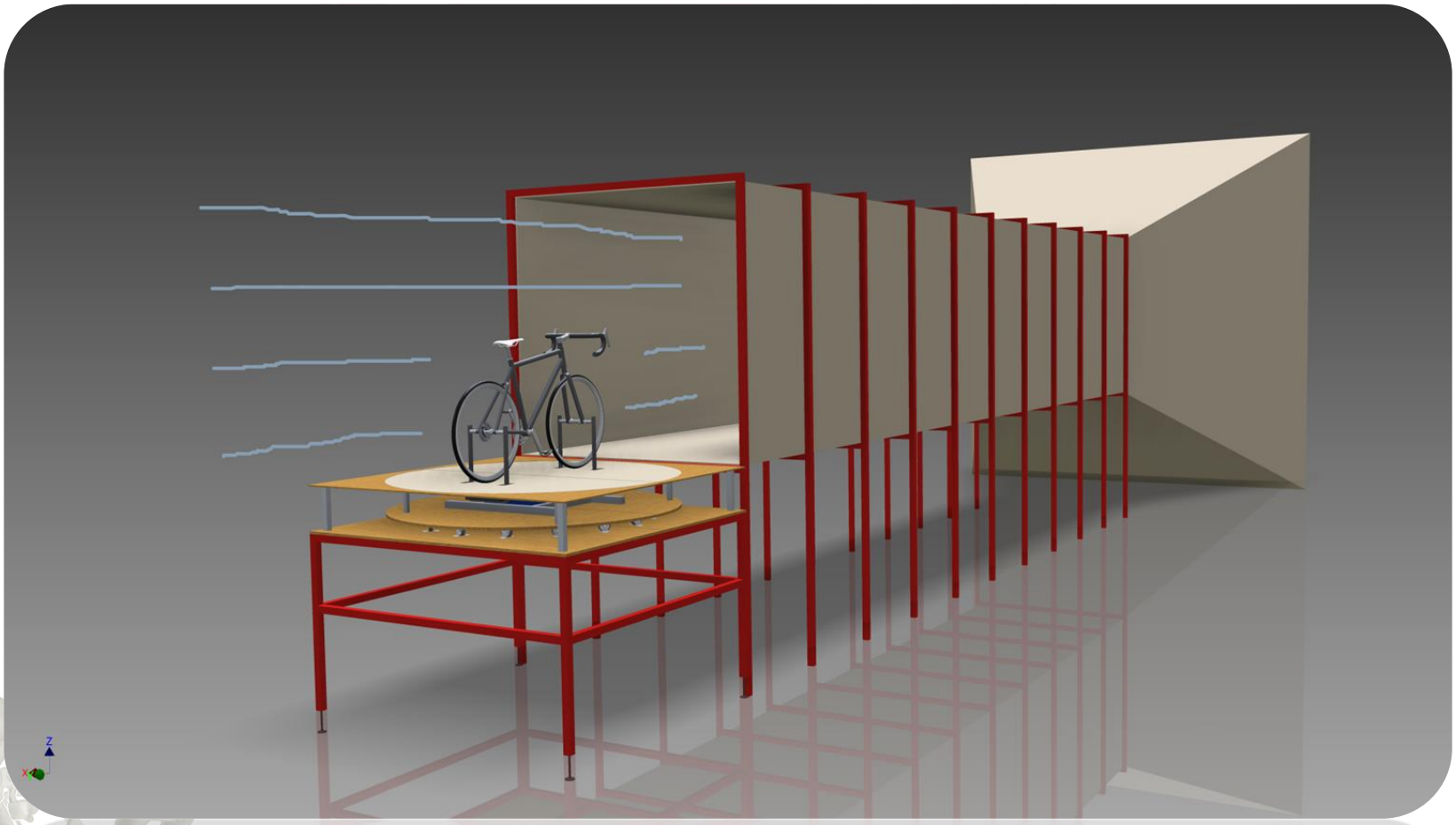


Why Fluid Dynamic Simulations?

- Adjustable wind flow (e.g. wind speed, direction)
- Better flow understanding
- Saves time and costs

Model of bicycle and mannequin developed in AutoDesk Inventor

Wind tunnel experiments



What is the setup?

Kistler force platform
on turntable