NWTF

Aerodynamic Analysis of Racing Wheelchair Athletes: Integrating Full-Scale and Scale Model Wind Tunnel Testing

Will Dixon
Loughborough University

Aerodynamic Analysis of Racing Wheelchair Athletes: Integrating Full-Scale and Scale Model Wind Tunnel Testing

Will Dixon

Gary Page

Dan Butcher

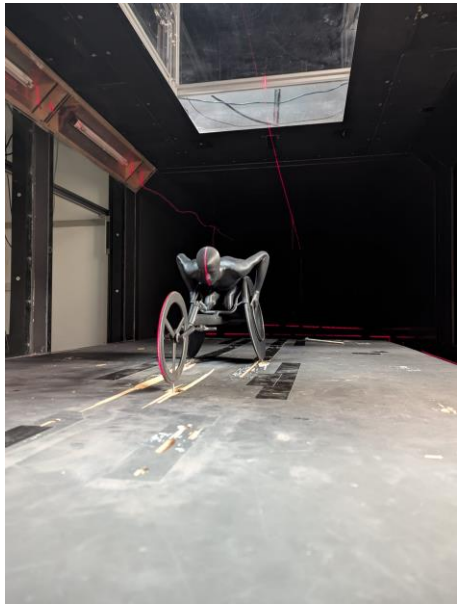
Department of Aeronautical and Automotive Engineering
Loughborough University, Leicestershire, LE11 3TU, United Kingdom

Introduction

NWTF

Scale Model Testing ⟷ **Athlete Testing**

Automotive wind tunnel at Loughborough University

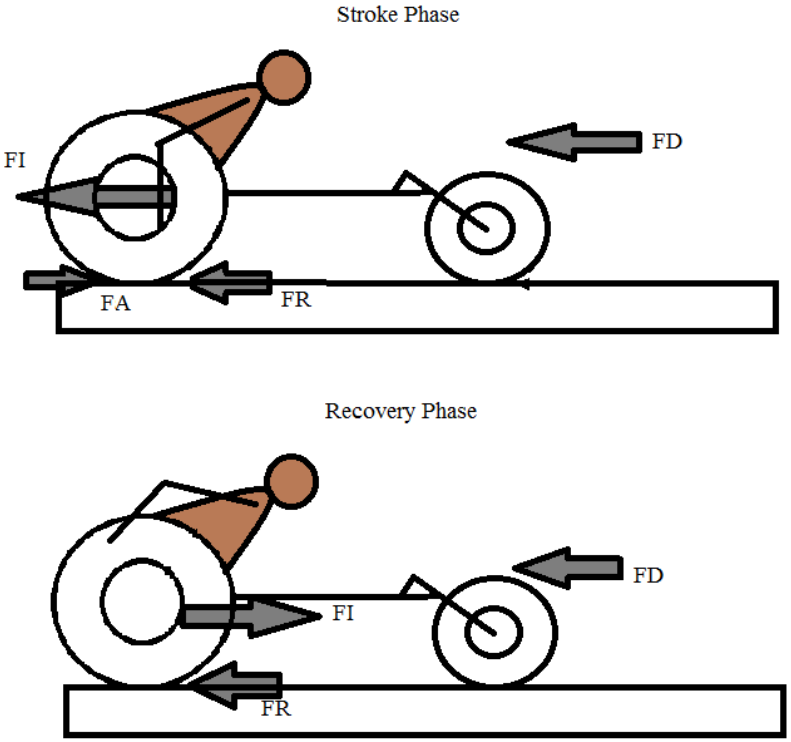


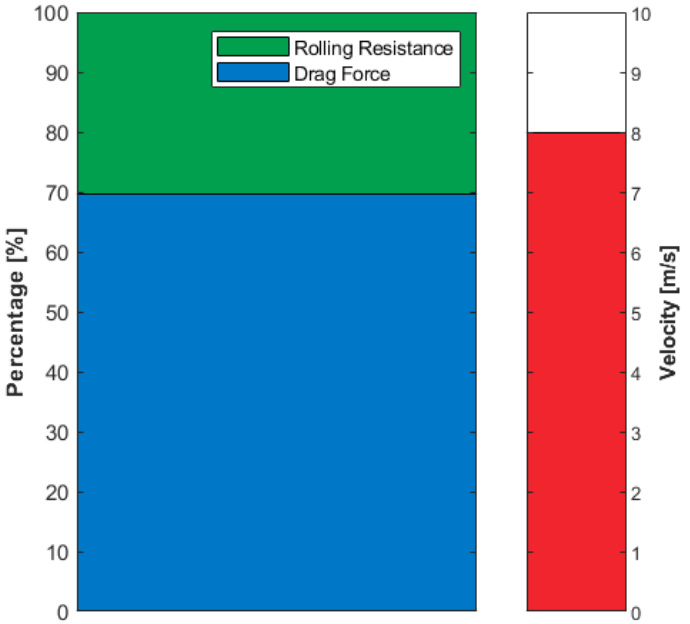
Human Flow Interactions wind tunnel at the University of Manchester

Background

Why does aerodynamics matter?

Aerodynamic drag accounts for up to 70% of resistive force





P. Forte, T. M. Barbosa, and D. A. Marinho, 'Technologic Appliance and Performance Concerns in Wheelchair Racing – Helping Paralympic Athletes to Excel', New Perspectives in Fluid Dynamics. InTech, Dec. 02, 2015. doi: 10.5772/61806.

Background

Technique of Wheelchair Racers

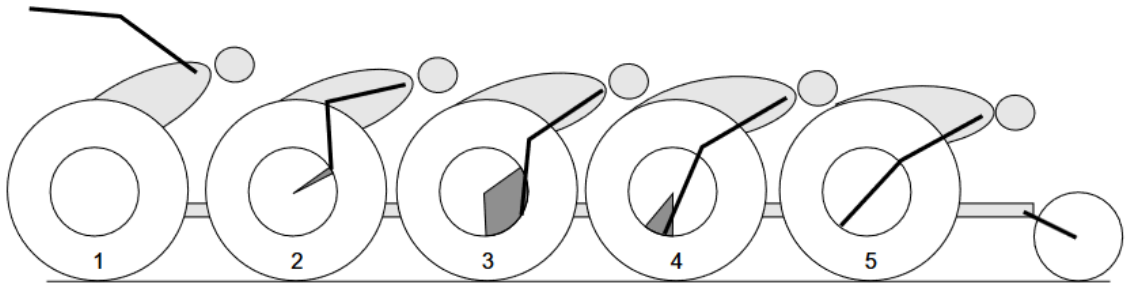


Fig. 5. Wheelchair racing propulsion technique. **1** to **2** = acceleration phase; **2** = impact energy transfer phase; **3** = drive phase; **4** = rotation force production phase; **5** = disengagement phase; **5** to **1** = back swing.

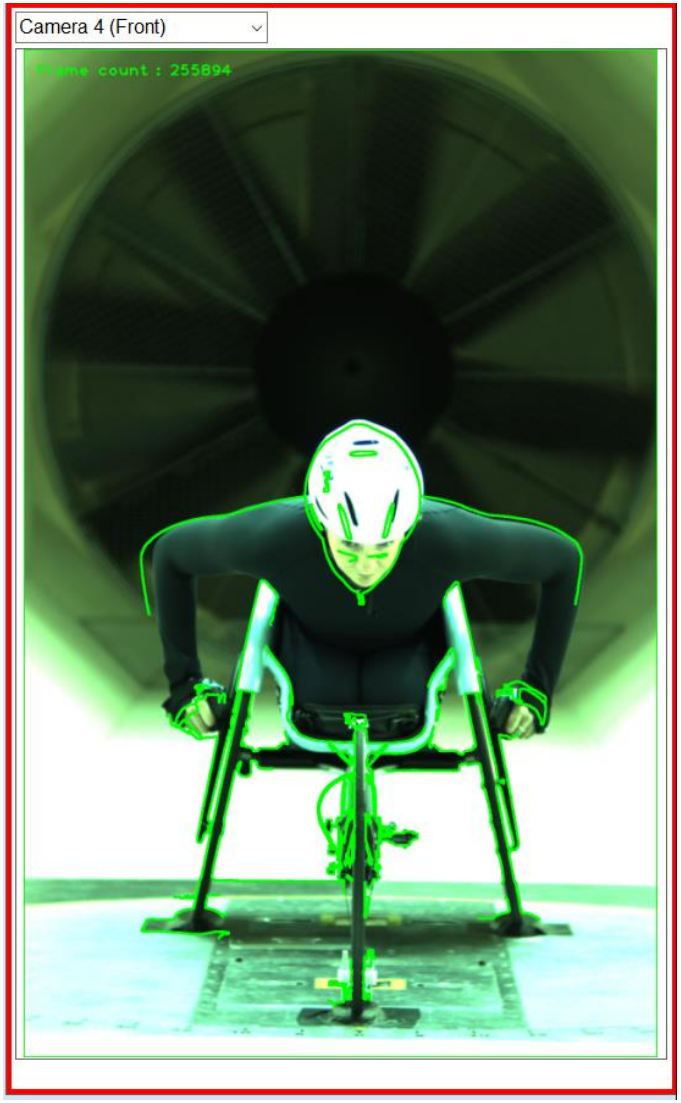
Loughborough University

PRELIMINARY FULL-SCALE TESTING

Methodology

Test Protocol

- Testing conducted with a T54 wheelchair racer
- Four representative speeds:
  - 7 m/s
  - 8 m/s
  - 9 m/s
  - 10 m/s
- Athlete was asked to hold three static positions
- 30 second runs

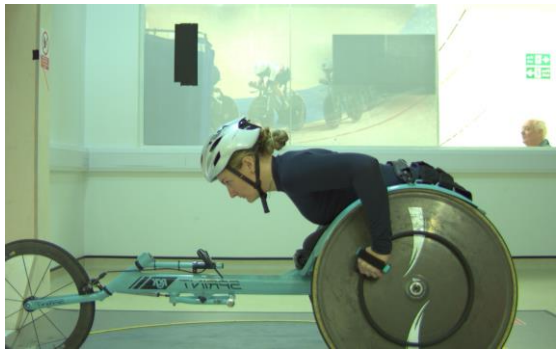


Methodology

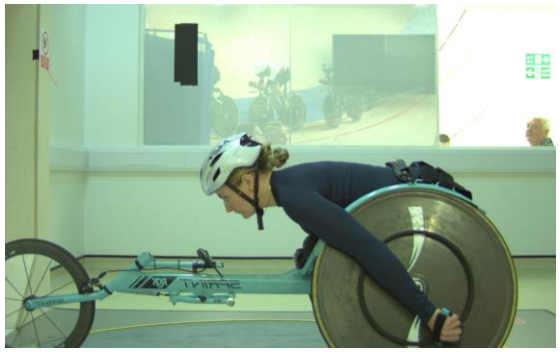
Positions

Loughborough University

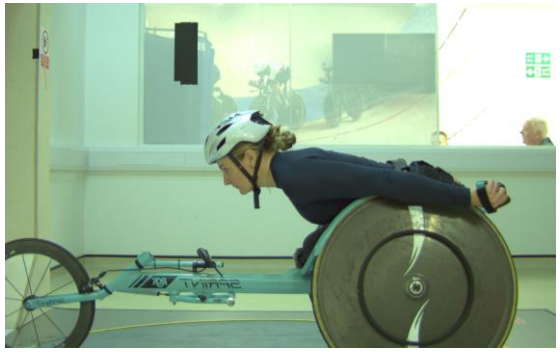
Catch



Release



Recovery



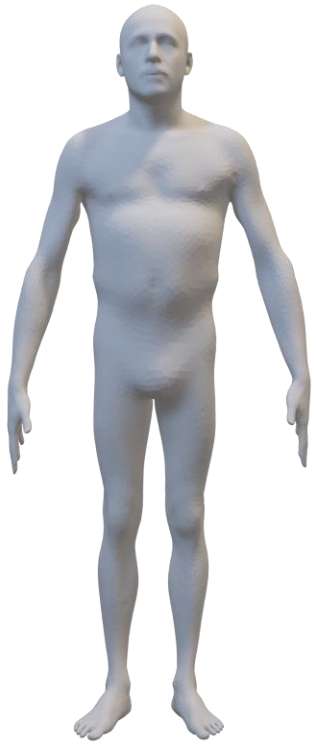
Loughborough University

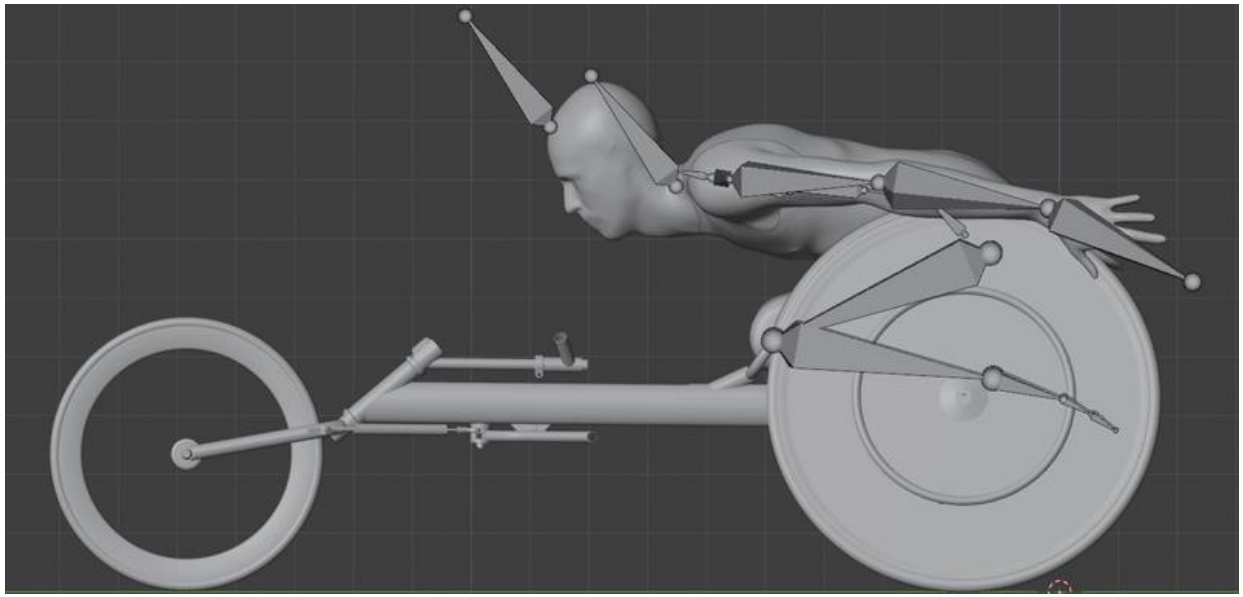
SCALE MODEL TESTING

Methodology

Geometry Selection

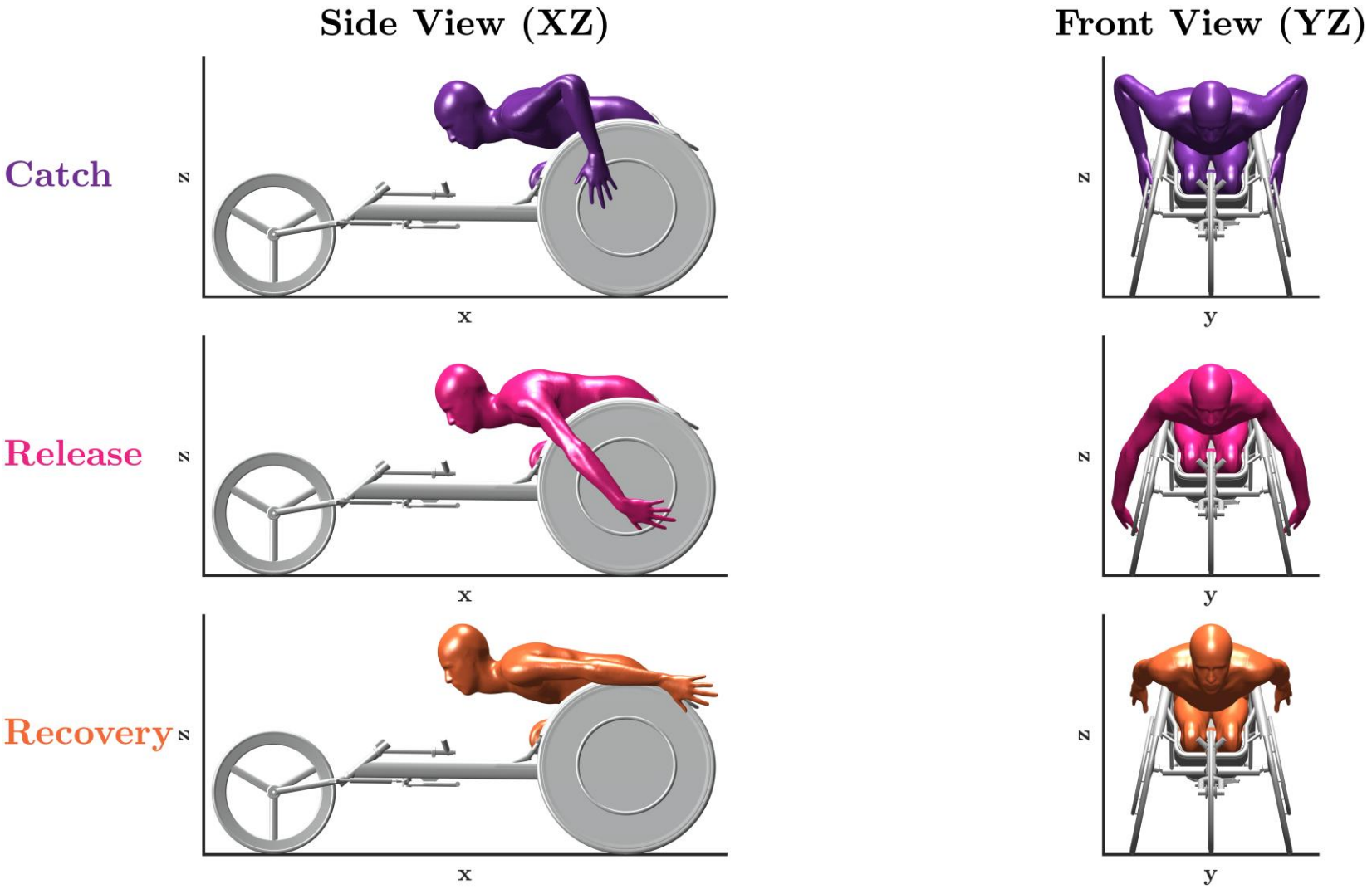
Generic athlete geometry generated from anthropometric database → Geometry rigged using a virtual skeleton → Geometry can then be manipulated into position





Methodology

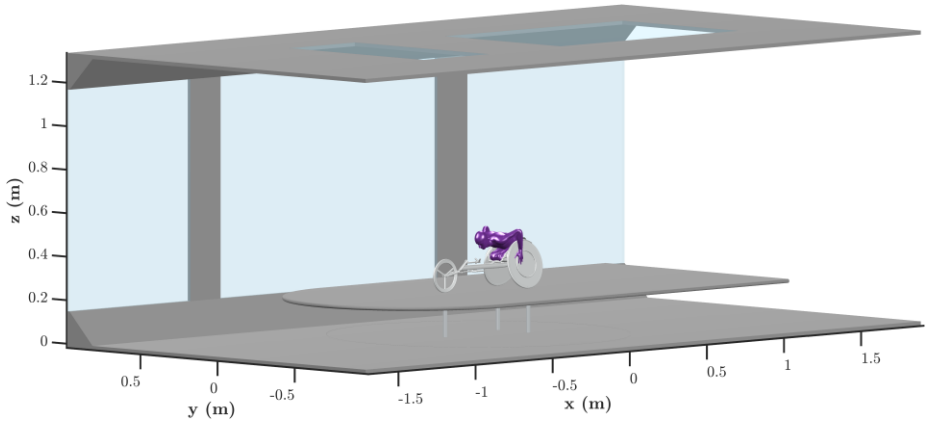
Positions



Methodology

Testing Protocol

- Model
  - 1/3 Scale
  - 3D printed
- Set up
  - Blockage < 5%
  - False Floor
  - Attached to Balance
- Data Collection
  - Reynolds sweep between 5 m/s and 40 m/s
  - Balance data sampled at 100 Hz

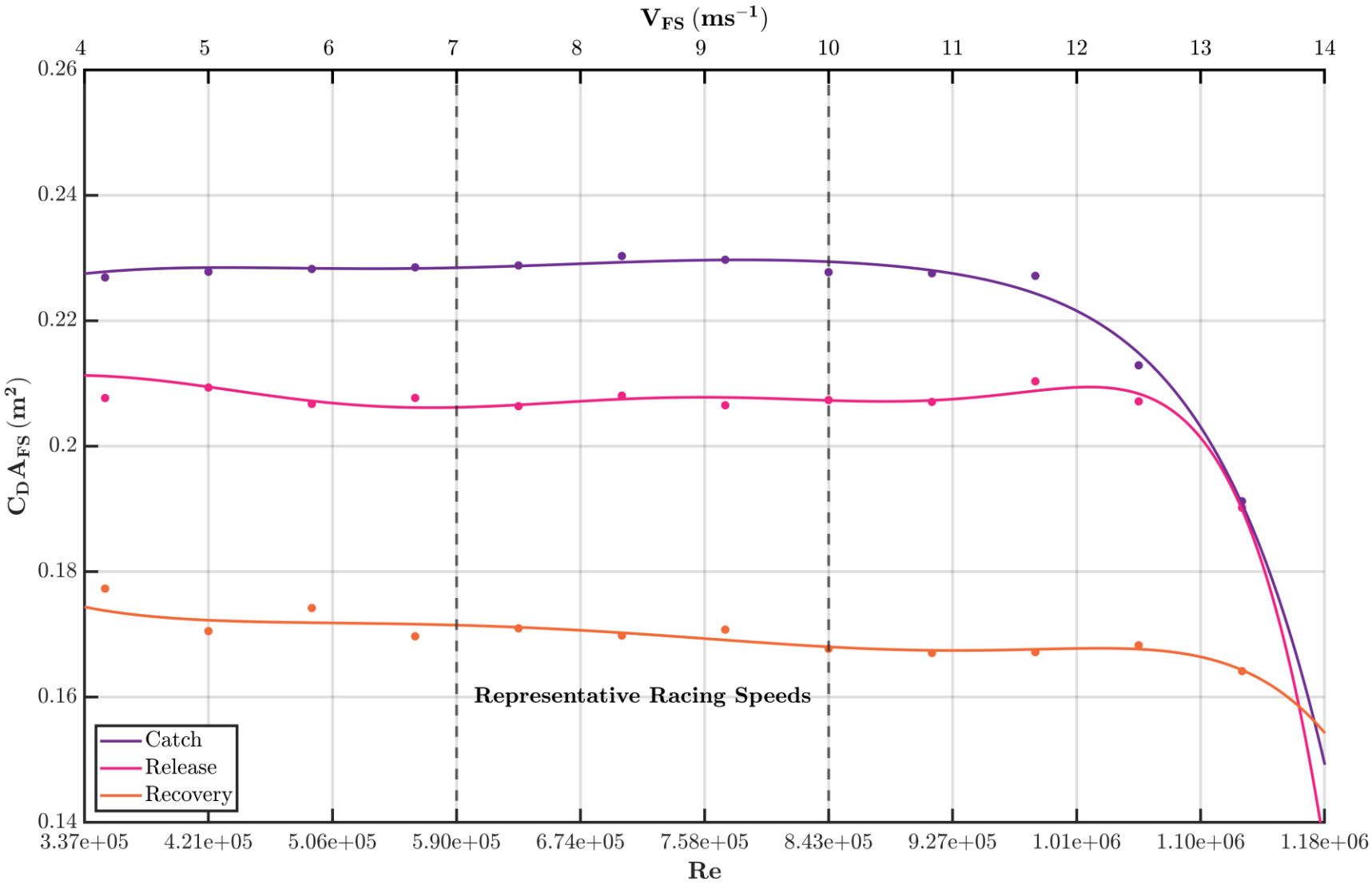


Loughborough University

RESULTS

Results

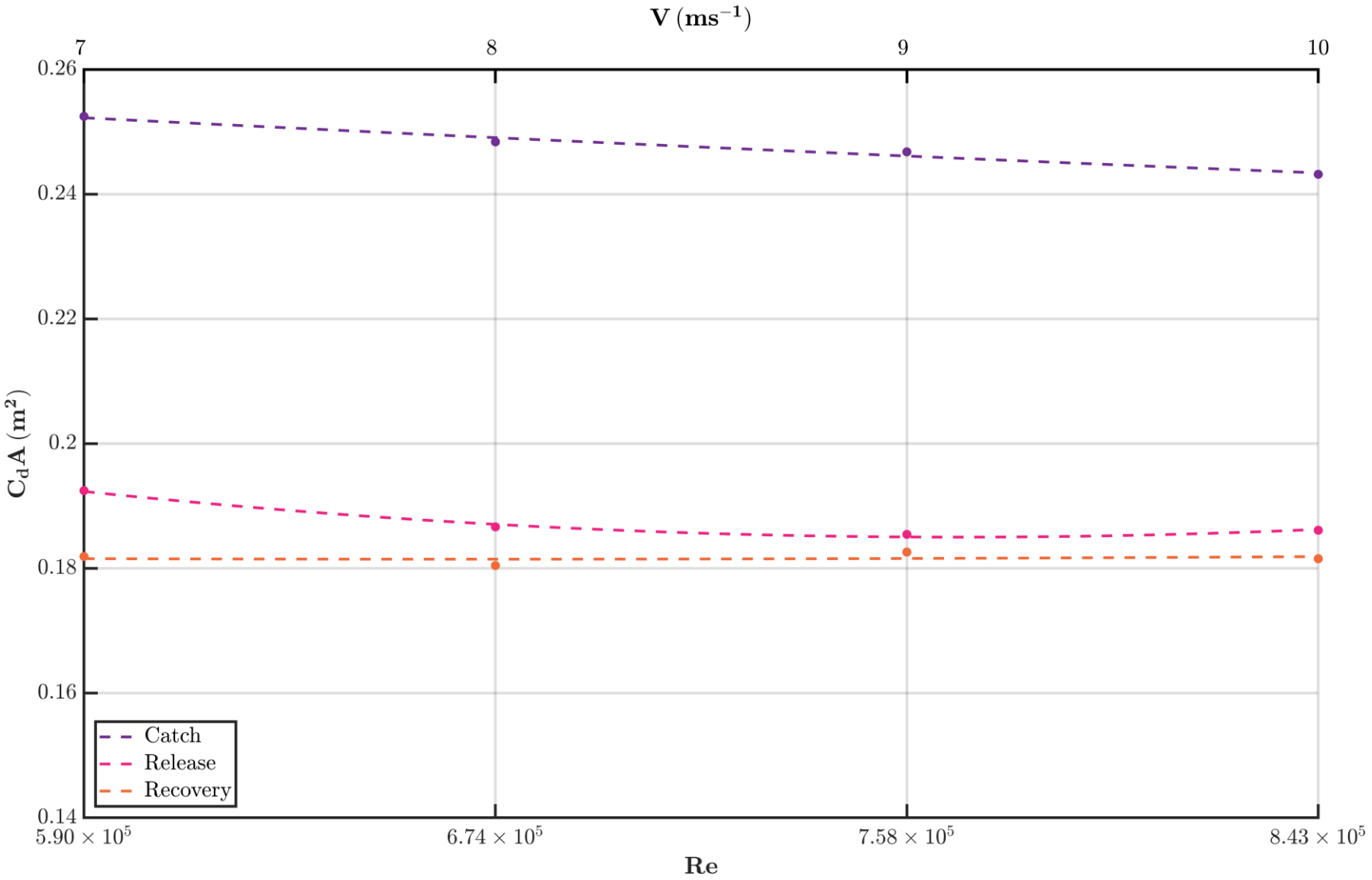
Scale Model Testing



Scale Model Reynolds Sweep (Generic Model)

Results

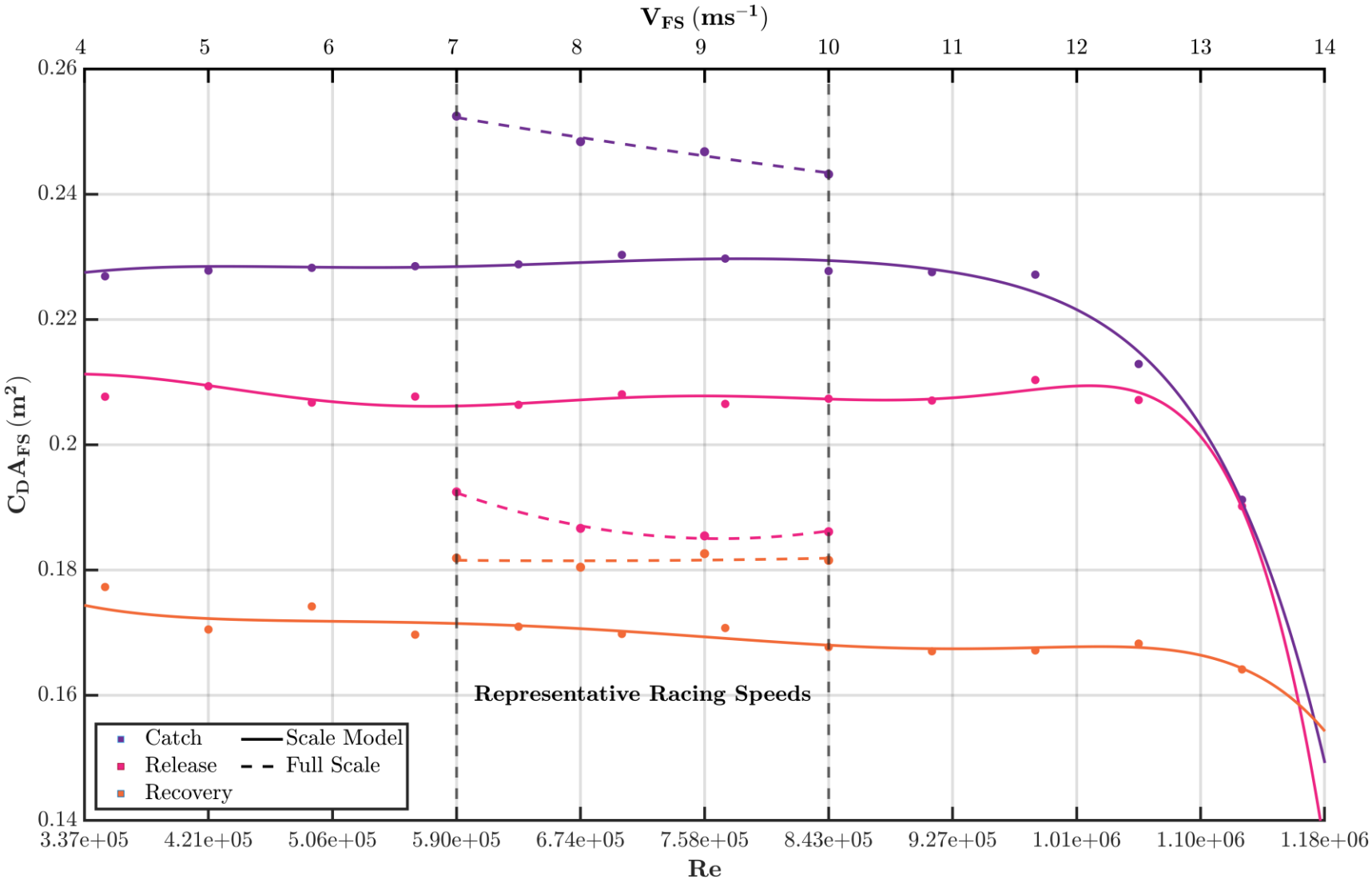
Full Scale Testing



Full Scale Reynolds Sweep (Athlete)

Results

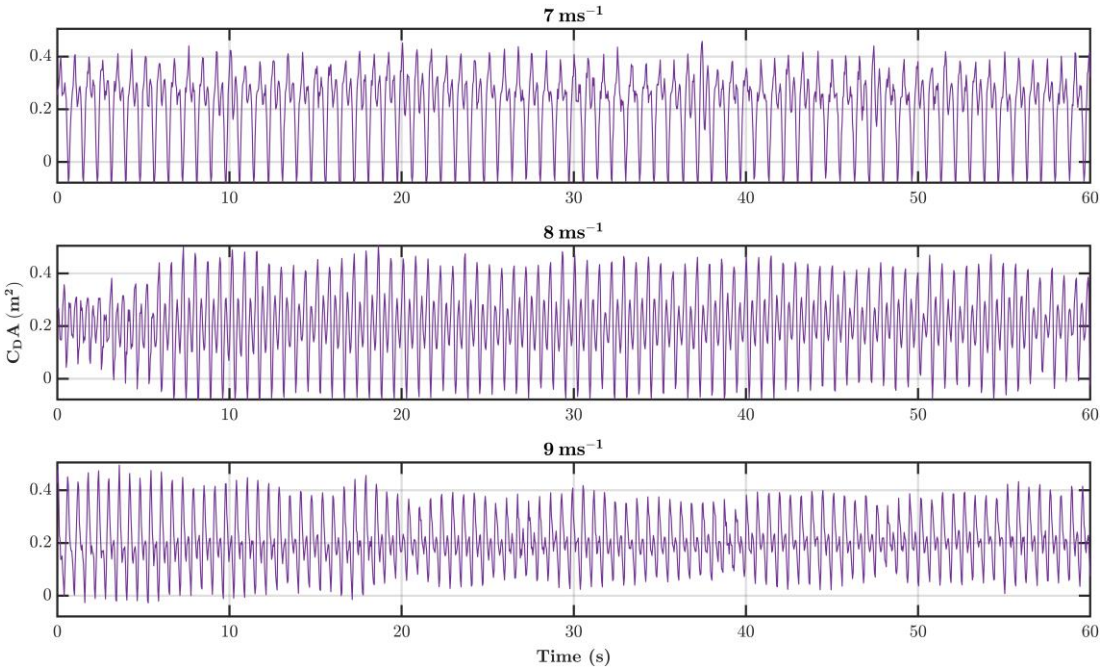
Combined

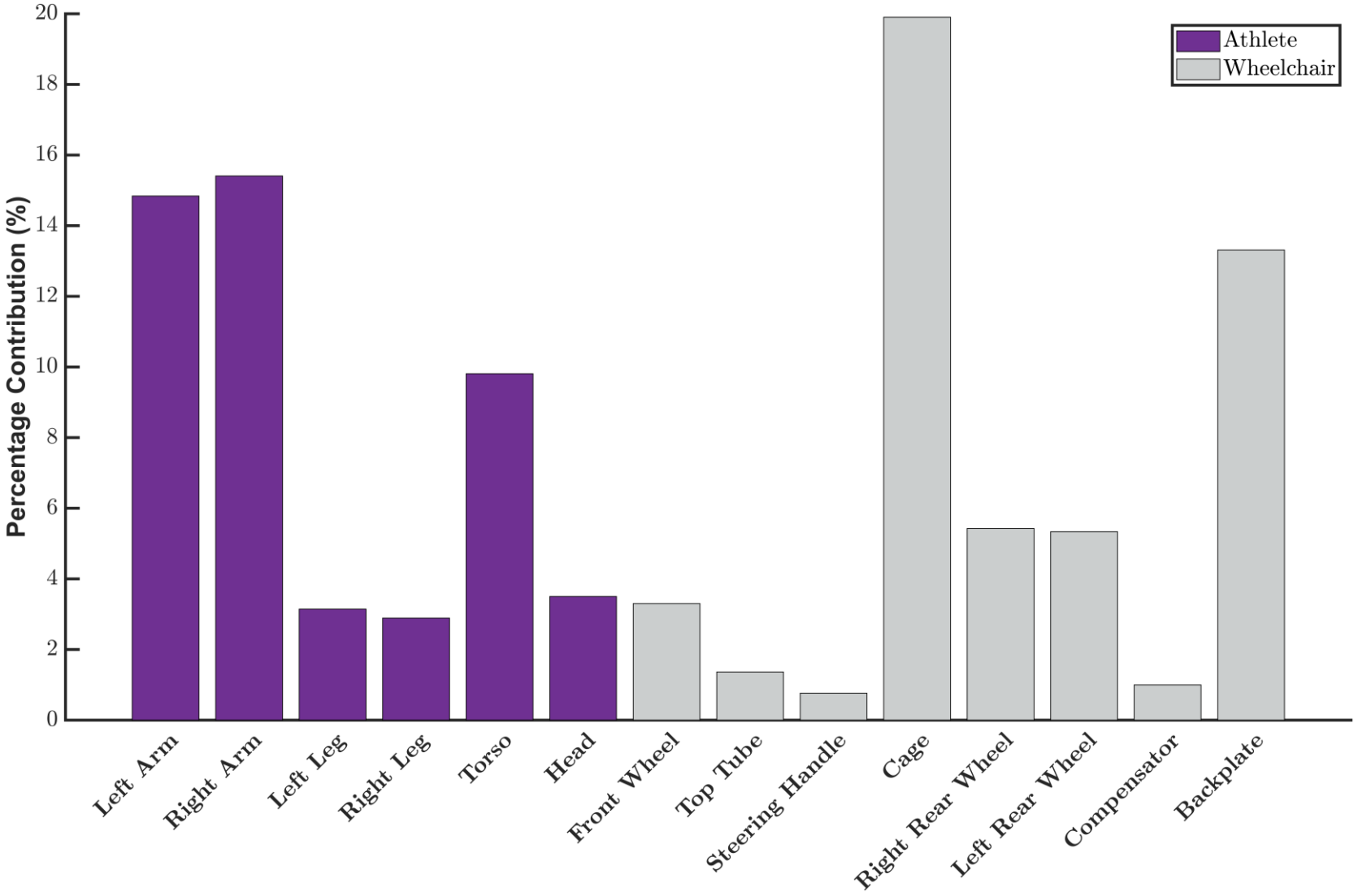


Comparison between scale model and full-scale testing

Results

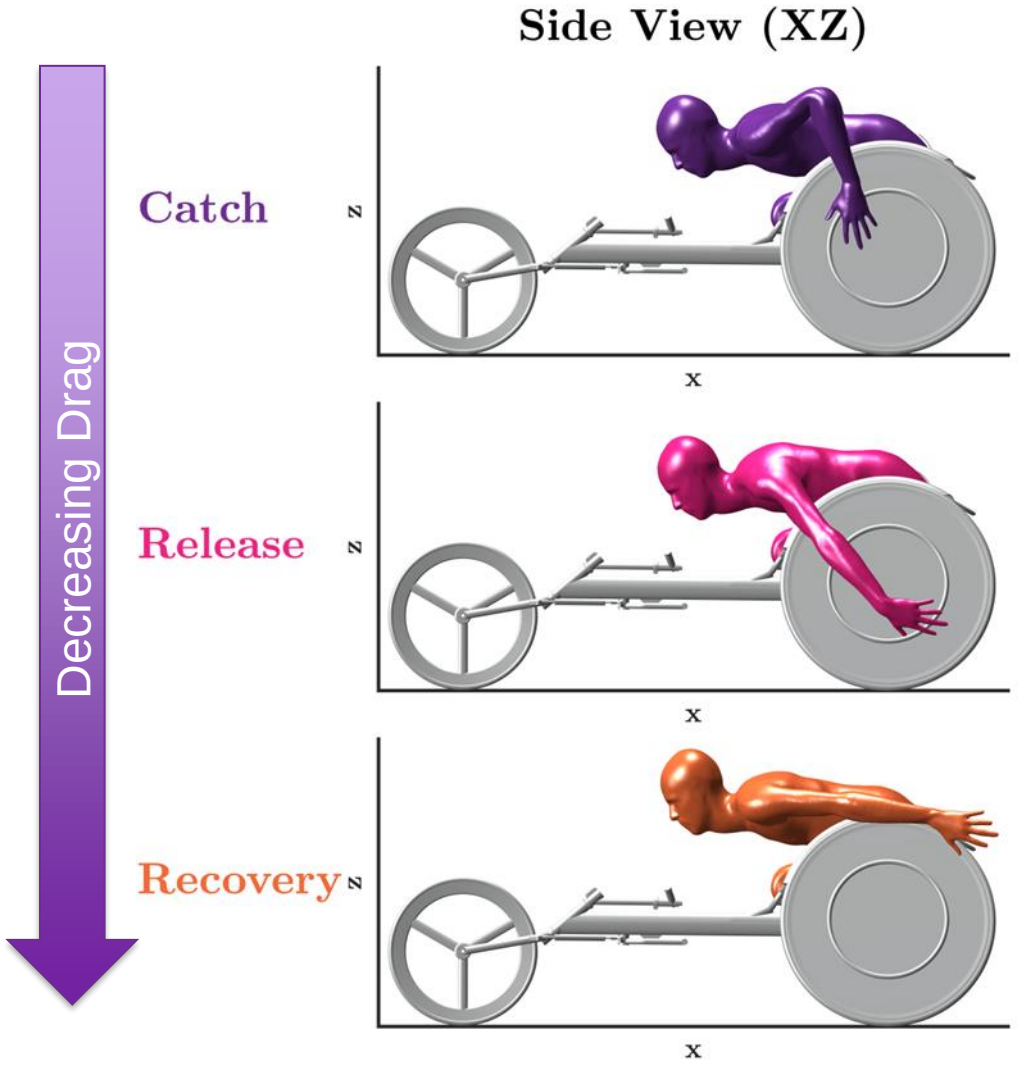
Dynamic Testing




Percentage Contribution (%)
0
2
4
6
8
10
12
14
16
18
20
Athlete
Wheelchair
Left Arm
Right Arm
Left Leg
Right Leg
Torso
Head
Front Wheel
Top Tube
Steering Handle
Cage
Right Rear Wheel
Left Rear Wheel
Compensator
Backplate

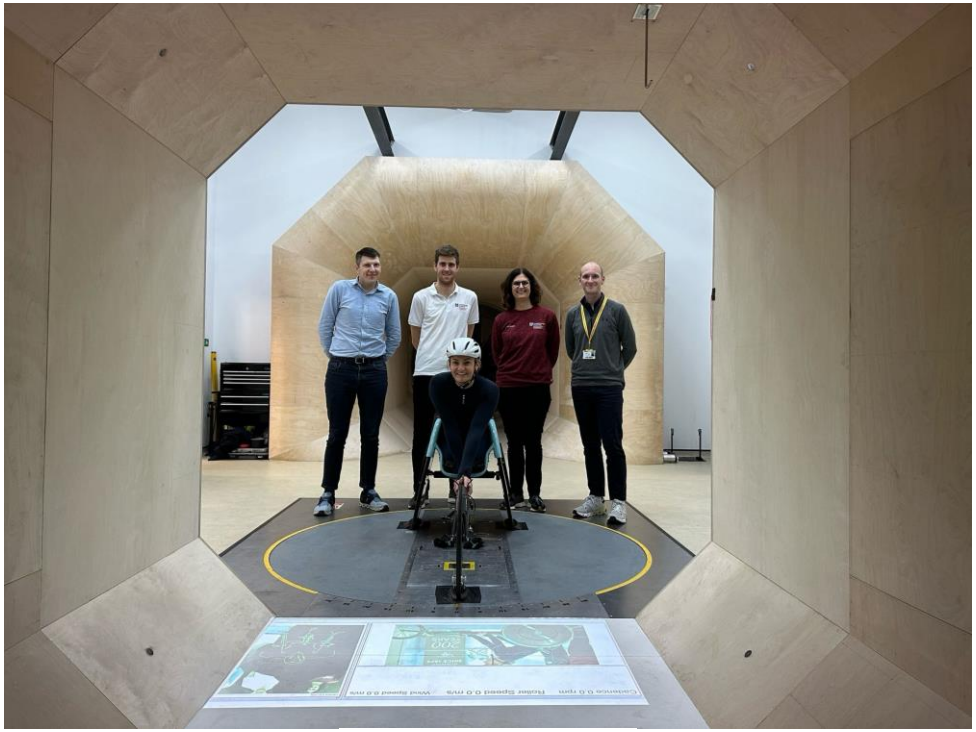
Conclusions & Next Steps

- Summary of key findings:
  - Same order from both tunnels
  - Expected differences due to athlete geometry
- Next steps
  - CFD
  - PIV
- Future Work:
  - Positional changes
  - Equipment changes
  - On track testing



Thanks

NWTF



The University of Manchester

BBC Click

Any Questions?

W.R.Dixon@lboro.ac.uk

Loughborough University