Para-cycling prostheses development:
Reflections & benefits of a holistic approach.

Dr Bryce T.J. Dyer BA (Hons), MSc, PhD, CTPD, SFHEA, MIED
Bournemouth University, UK

Background

Introduction

'There is currently limited information and guidance to help inform NGB's as to how to develop the high performance technology of elite athletes who possess limb absence'. (Dyer, 2018).

Dyer, B., 2018. Development of high performance parasport prosthetic limbs: A proposed framework and case study. *Assistive Technology*, pp.1-8.

Introduction

'The potential grounds exist for assistive technology to provide a measurable mechanical ergogenic effect'. (Dyer & Disley, 2019)

Dyer, B. and Disley, B.X., 2019. The aerodynamic impact of a range of prostheses designs when cycling with a trans-tibial amputation. *Disability and Rehabilitation: Assistive Technology*, pp.1-5.

London 2012 Project

Cycling Prosthesis Project

2012 Brief: *To create a lower limb cycling prosthesis:*

1) For an elite level athlete

2) For the demands of two very different events

3) With extremely tight development time (6 weeks)

Mixed Race Objectives –

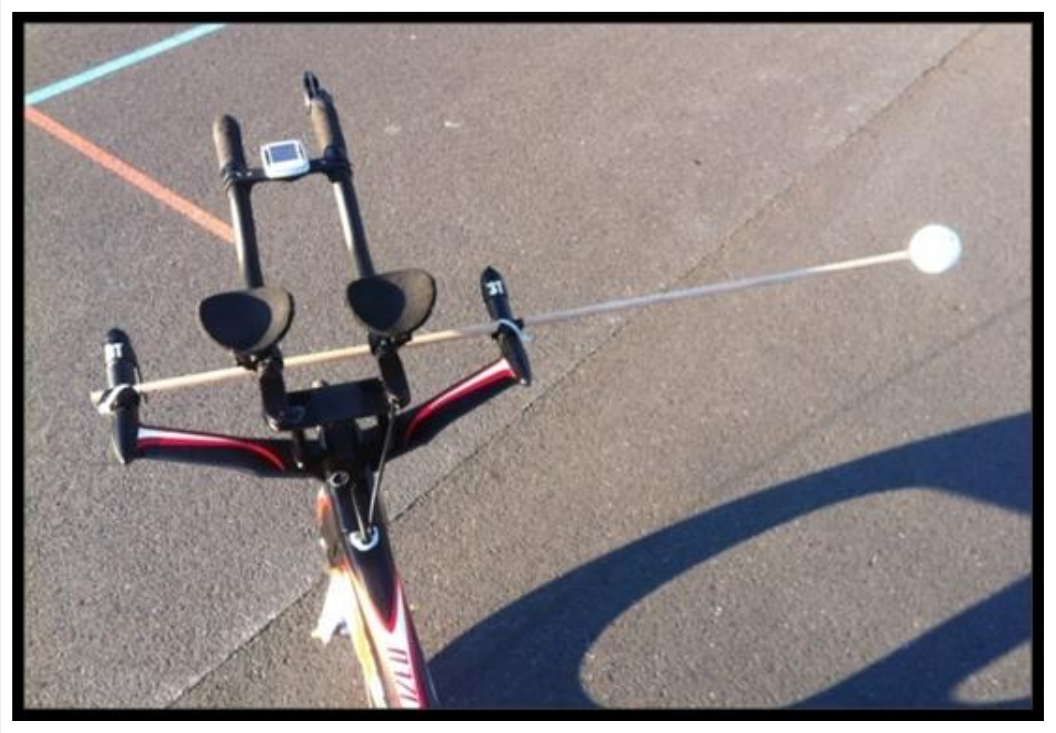
- ***Track 1km TT:***
- An event requiring an aggressive start and high power output for ~60 seconds @ ~600w

- ***Individual Time Trial:***
- An endurance event of ~20km. Aerodynamic efficiency is critical. Effort = ~300-400w

Project Constraints

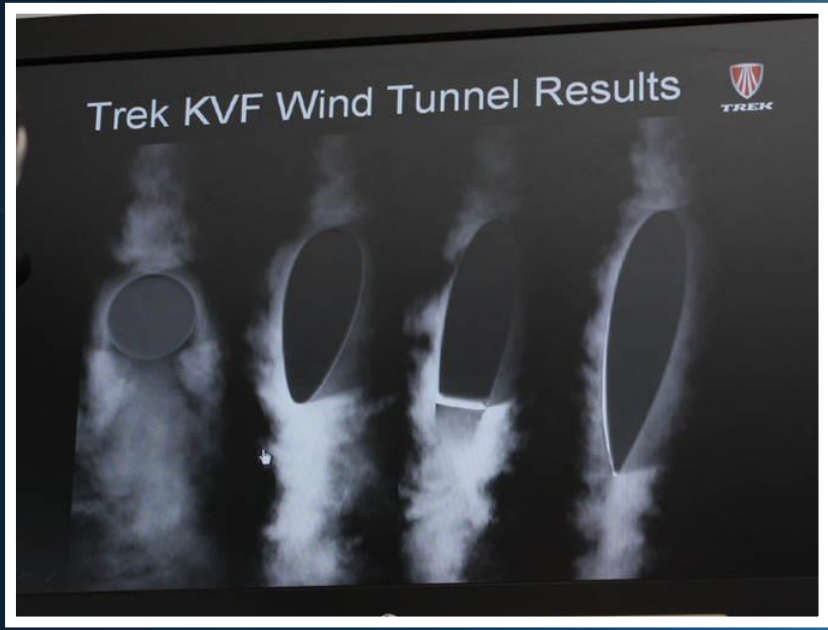
- *Lack of expertise…… so had to be found.*
- *Lack of knowledge ……...so had to be discovered.*
- *Lack of development time….. so had to be shortcut.*
- *Lack of resources ….. so had to be theoretical.*

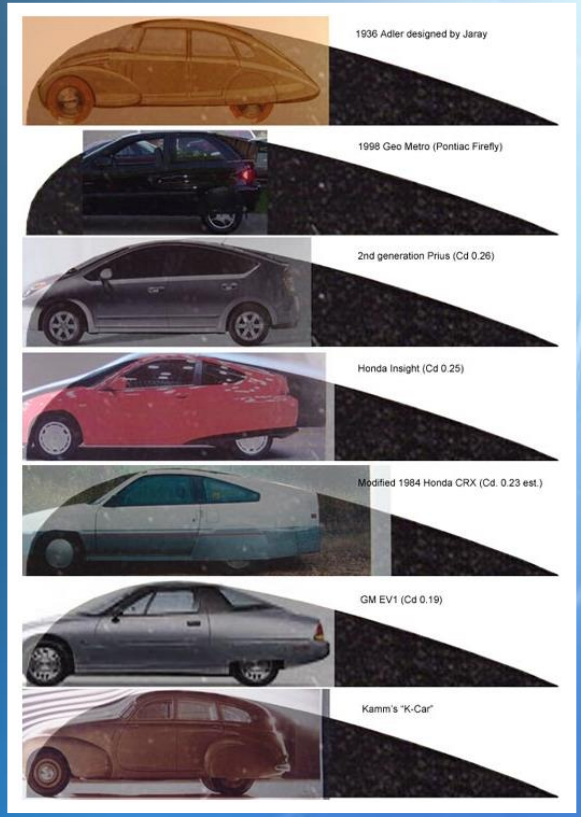
'When it comes to prosthetic-level components, aerodynamics matter' (Dyer 2015)



Dyer, B., 2015. The importance of aerodynamics for prosthetic limb design used by competitive cyclists with an amputation: an introduction. *Prosthetics and orthotics international*, *39*(3), pp.232-237.

The Concept: The Kamm Tail





- A profile that utilises aerodynamic efficiency
- Is stiff laterally

Prototyping / Development Models

Iteration as a tool of development in both fit and function prior to final finishing.

Design Realisation

Design Justification

- Reduced Weight – increased acceleration of athlete.
- Increased stiffness – efficient power transfer.
- Improved aerodynamic efficiency – reduced drag.
- Does not infringe current bicycle technology legislation.

Rio 2016 & Invictus Games Projects

Cycling Prosthesis Project

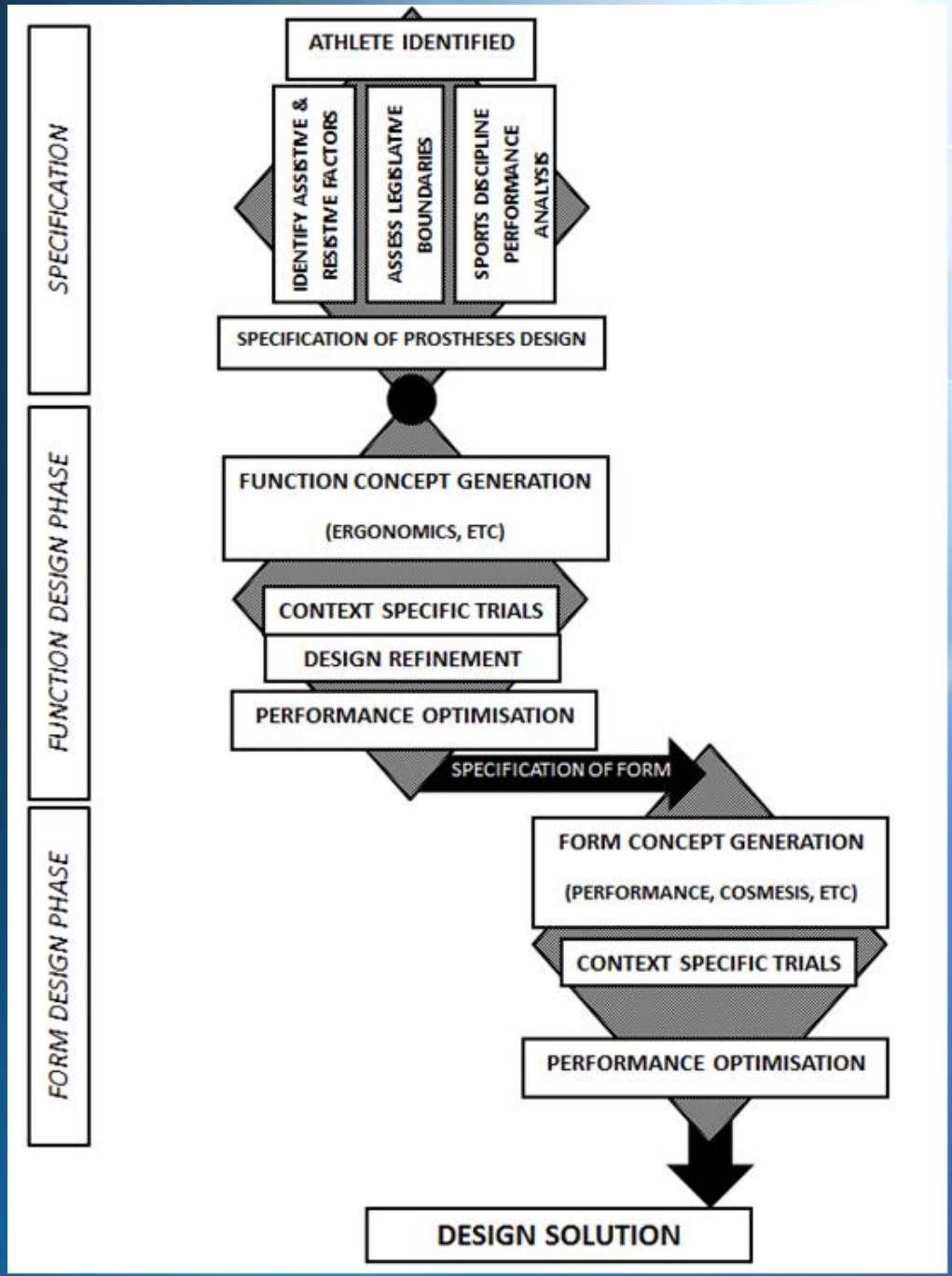
2016 Brief: *To refine and quantify performance enhancement for an evolved design of lower limb cycling prosthesis:*

1) For an elite level athlete going to Rio 2016 (and another at the Invictus Games).

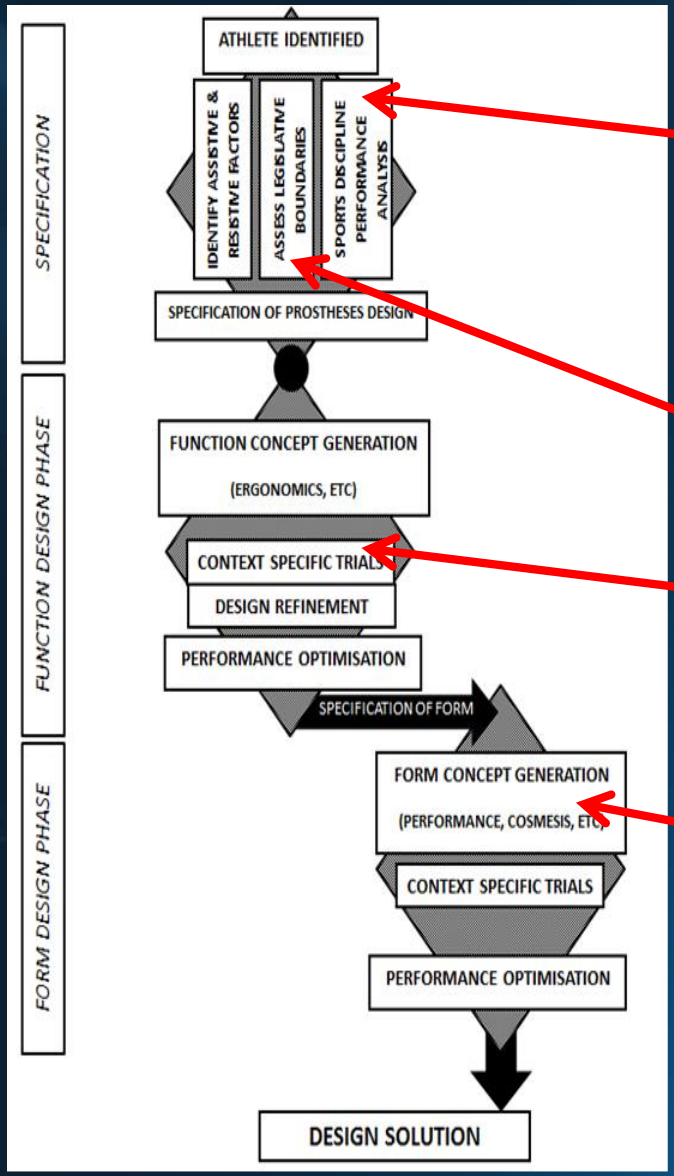
2) For the demands of 3 very different events:

- *1km track TT.*
- *Road race.*
- *Individual time trial.*

A New Model

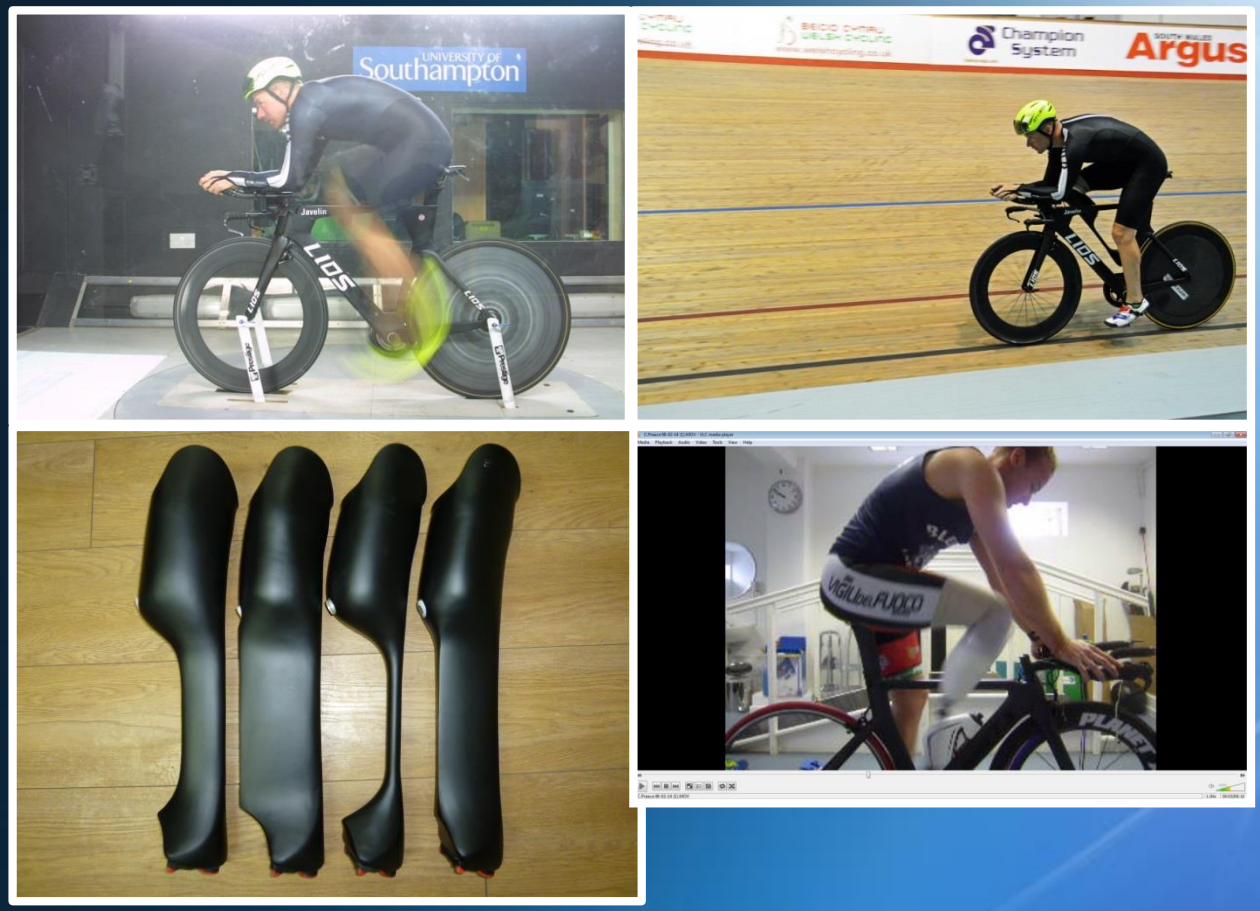

SPECIFICATION
FUNCTION DESIGN PHASE
FORM DESIGN PHASE
ATHLETE IDENTIFIED
IDENTIFY ASSISTIVE & RESISTIVE FACTORS
ASSESS LEGISLATIVE BOUNDARIES
SPORTS DISCIPLINE PERFORMANCE ANALYSIS
SPECIFICATION OF PROSTHESES DESIGN
FUNCTION CONCEPT GENERATION
(ERGONOMICS, ETC)
CONTEXT SPECIFIC TRIALS
DESIGN REFINEMENT
PERFORMANCE OPTIMISATION
SPECIFICATION OF FORM
FORM CONCEPT GENERATION
(PERFORMANCE, COSMESIS, ETC)
CONTEXT SPECIFIC TRIALS
PERFORMANCE OPTIMISATION
DESIGN SOLUTION

Hanging Diamond Process: 2016 Key Outcomes



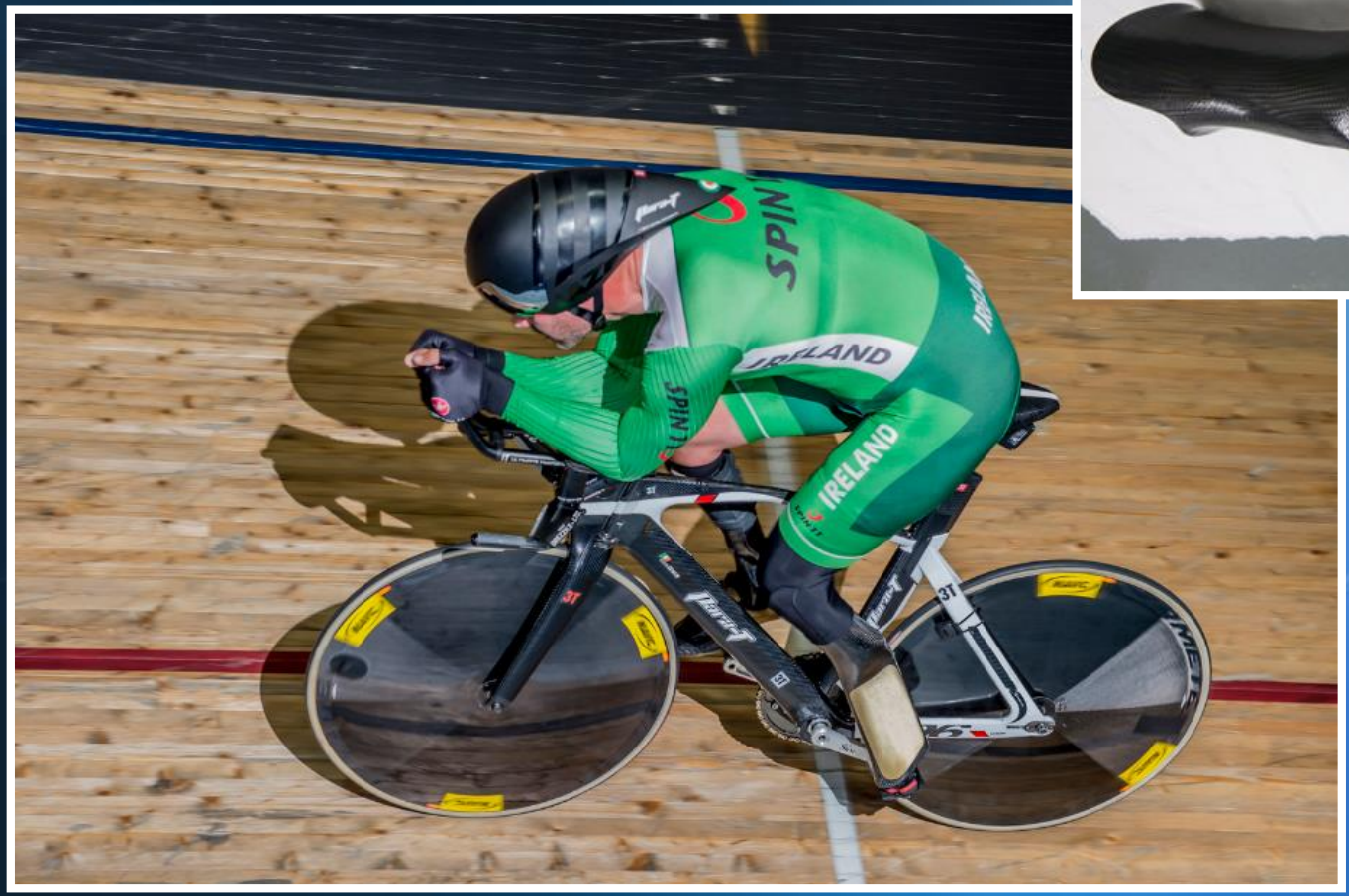
- Statistical analysis of event results revealed that the athlete classification were dominated by those using a prosthetic limb. Best scope for investment and medal success !
- Legislative rules analysis revealed loose/vague criteria and therefore allowed plenty of scope.
- Aerodynamic testing of a technology (never before evaluated) defined the best concept and a quantifiable performance enhancement.
- Personalised customisation of prosthetics builds a potential athlete-product positive relationship.

2016 Design Realisation 1*



*Dyer, B. and Disley, B.X., 2017. Validation of the virtual elevation field test method when assessing the aerodynamics of para-cyclists with a uni-lateral trans-tibial amputation. Disability and Rehabilitation: Assistive Technology, 13 (2), 107-111.

2016 Design Realisation (2)



What about the future of Paracycling technology ?

(it may not be in engineering & technology at all !)

Where else can we look for performance enhancement ?

Is emotional design a solution ?*

Method: 5 elite paracyclists were surveyed using a modified 31 question product attachment survey.

Results:

- The basis of an emotional product relationship was highly polarized.
- That an ‘appearance follows performance’ approach may be of value.
- The prostheses decorative personalisation is desirable in some cases.

*Dyer, B., 2019. An investigation into the relationship between paracycling athletes and their prosthetics technology: a proposed design framework. *Disability and Rehabilitation: Assistive Technology*, pp.1-7.


HONDA