

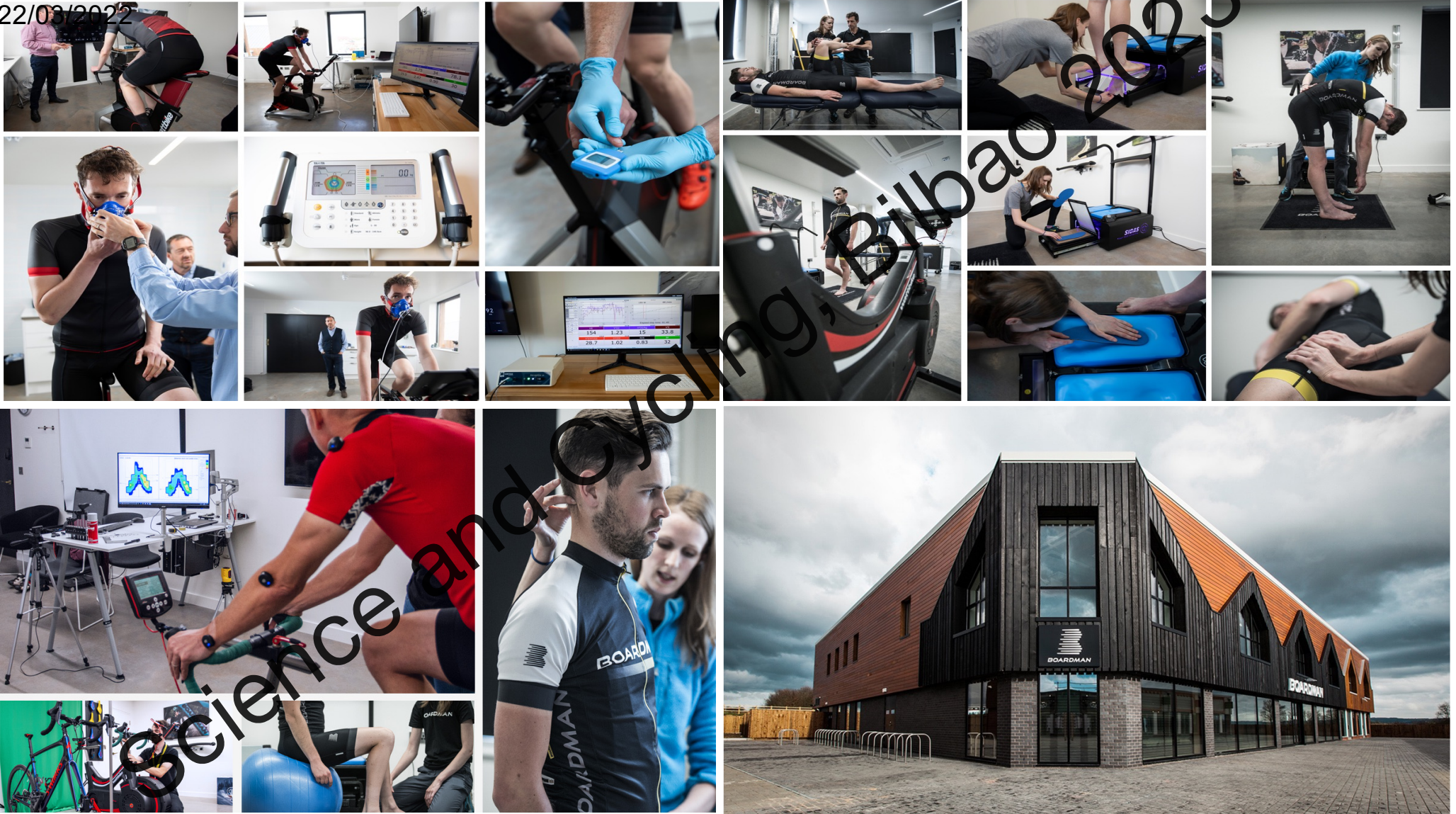


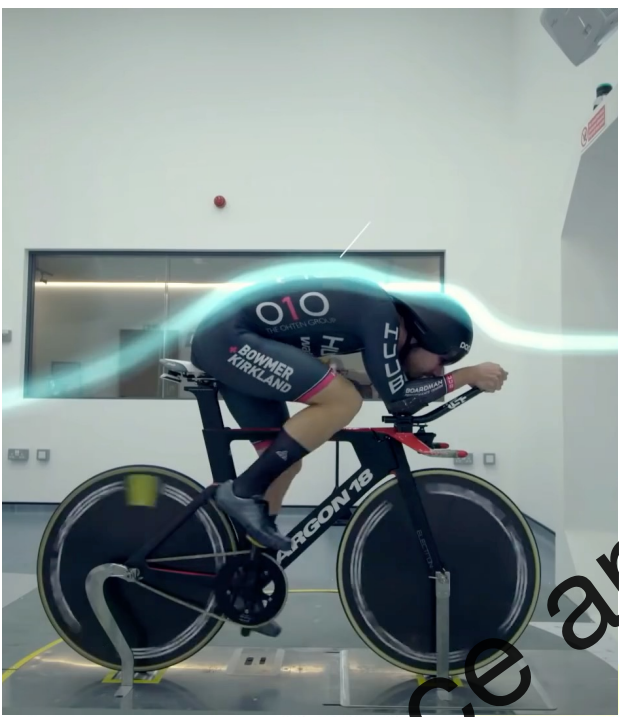
# Ergonomics of Aerodynamics

Jamie Pringle



22/03/2022

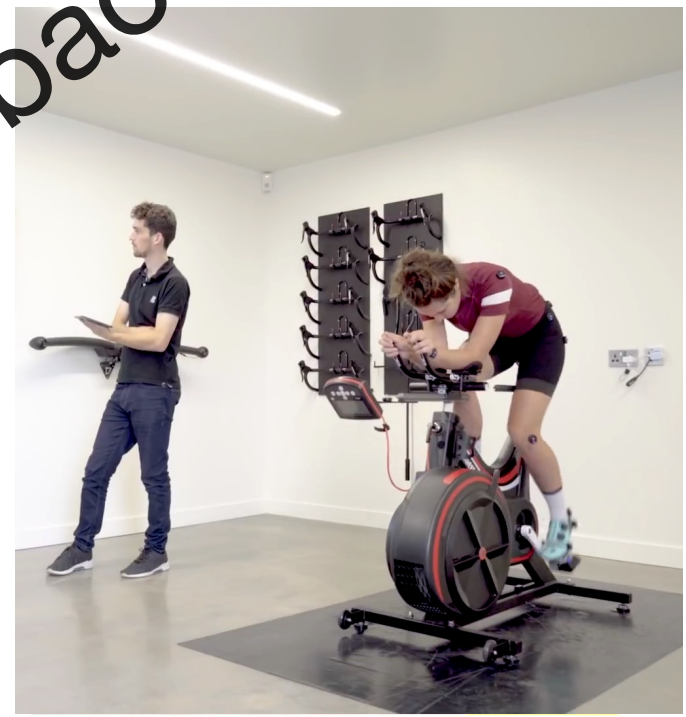




AERODYNAMIC SERVICES



HEALTH & FITNESS SERVICES



POSITION & TECHNIQUE SERVICES

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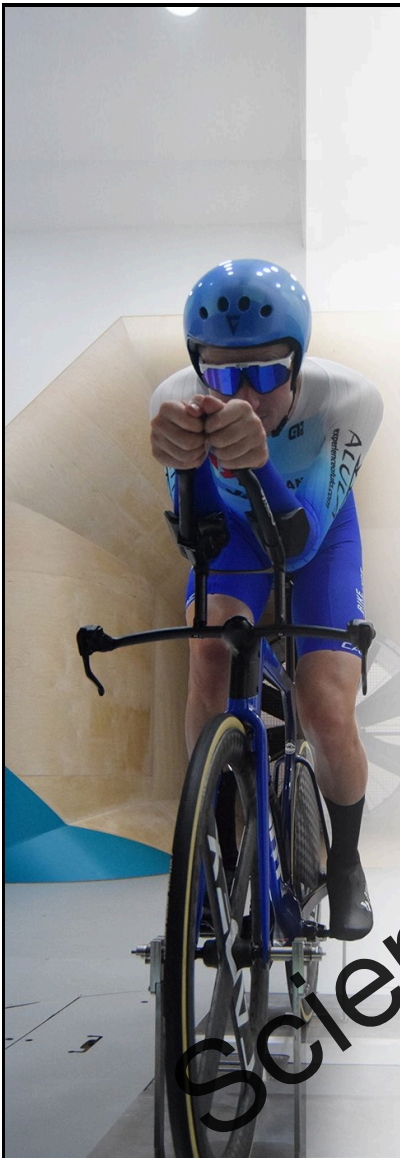
22/03/2022

VORTEX



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# AERO POWER

WITH TEAM BIKEEXCHANGE-JAYCO

*Because we wanted to improve our time trial performances, so we partnered with one of the best companies in the world when it comes down to positioning.*

**MARCO PINOTTI**  
PERFORMANCE DIRECTOR

**VORTEQ** | HUMAN PERFORMANCE

**BIKE EXCHANGE Jayco**  
TECHNICAL SUPPLIER



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**GIANT**

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# Ergonomics of Aerodynamics

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## A definition

“Ergonomics is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design in order to optimize human well-being and overall system performance.”

The International Ergonomics Association

# A model of practice

Theory, principles, data & methods leading to optimization



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Method

Outcomes

Data

Realities



DEFINE



DISCOVER



DEVELOP



DESIGN



DELIVER

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# Defining the challenge

What it takes to win; what it takes to lose ....really make a pig's ear of it



DEFINE



DISCOVER



DEVELOP



DESIGN



DELIVER

# Define and focus

Needs, history, and constraints



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- **NEEDS:** event (what it takes to win)
- **HISTORY:** what's worked; what hasn't
- **CONSTRAINTS:** resource; time; obligations

DEFINE

# Discover

Range, risk, potential – the functional window



DEFINE



DISCOVER



DEVELOP



DESIGN



DELIVER

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# Discover

A systematic and whole-body approach to establish direction and potential, range and risk



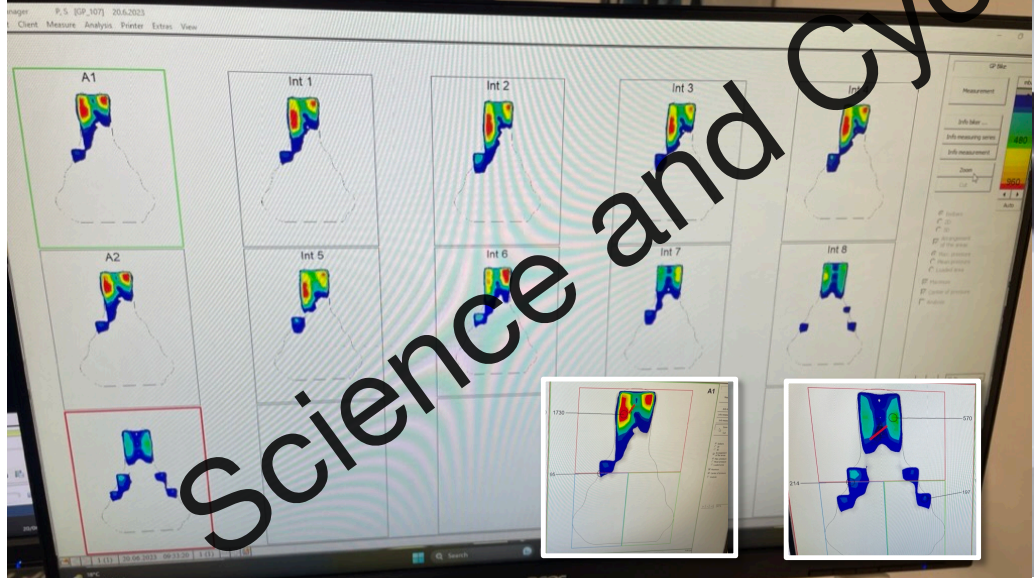
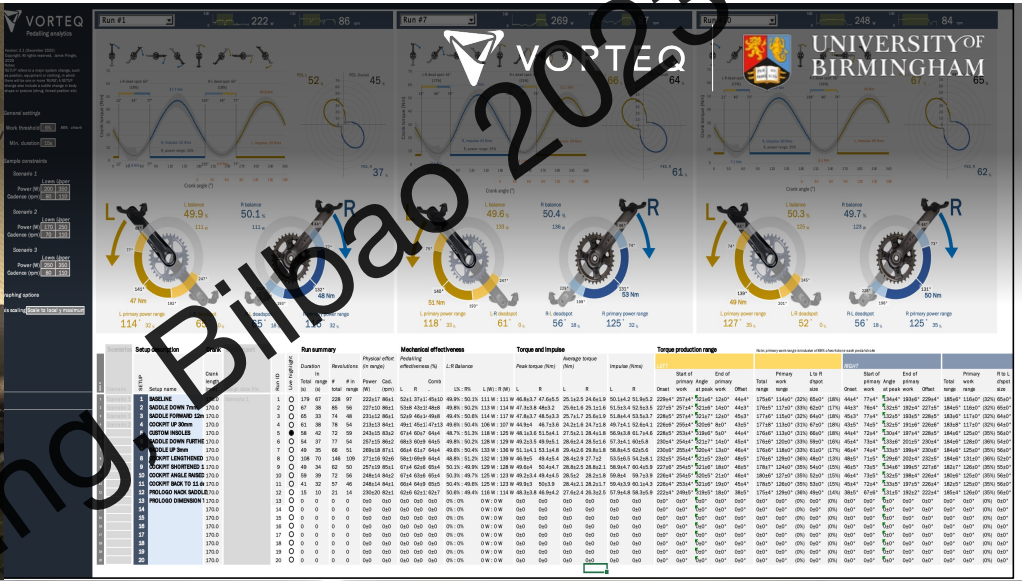
DISCOVER

- **SYSTEMATIC:** nothing in isolation
- **TRAJECTORY:** proof of concept & direction
- **RANGE:** 'Functional window'; edge of risk

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# Function and outcome is everything

Bike-fitting without sight of the outcome at the pedal (and saddle) is flying blind



Science and Cycling

# Development

Data-driven and evidence-based decision-making



DEFINE



DISCOVER



DEVELOP



DESIGN



DELIVER

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# Proof of concept

Heading in the right direction is as important as the destination



DEVELOP

- **PRIORITY:** big ticket items first
- **BALANCE:** power versus aero? Wrong fight to pick
- **PERSPECTIVE:** short and long-term

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# Wind tunnel: sport specific

Precise engineering meets variable human performer



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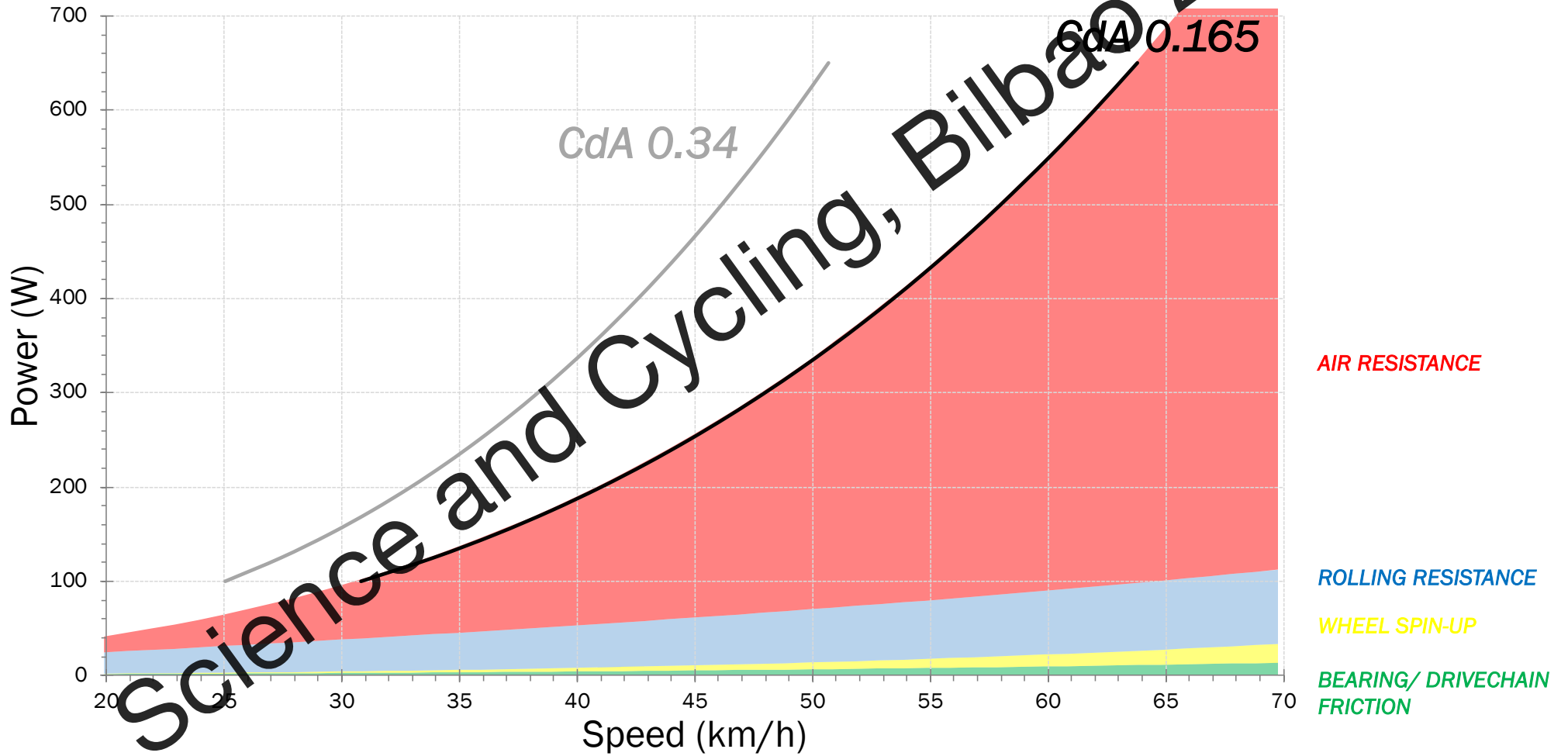
Sports Aero  
Solutions 

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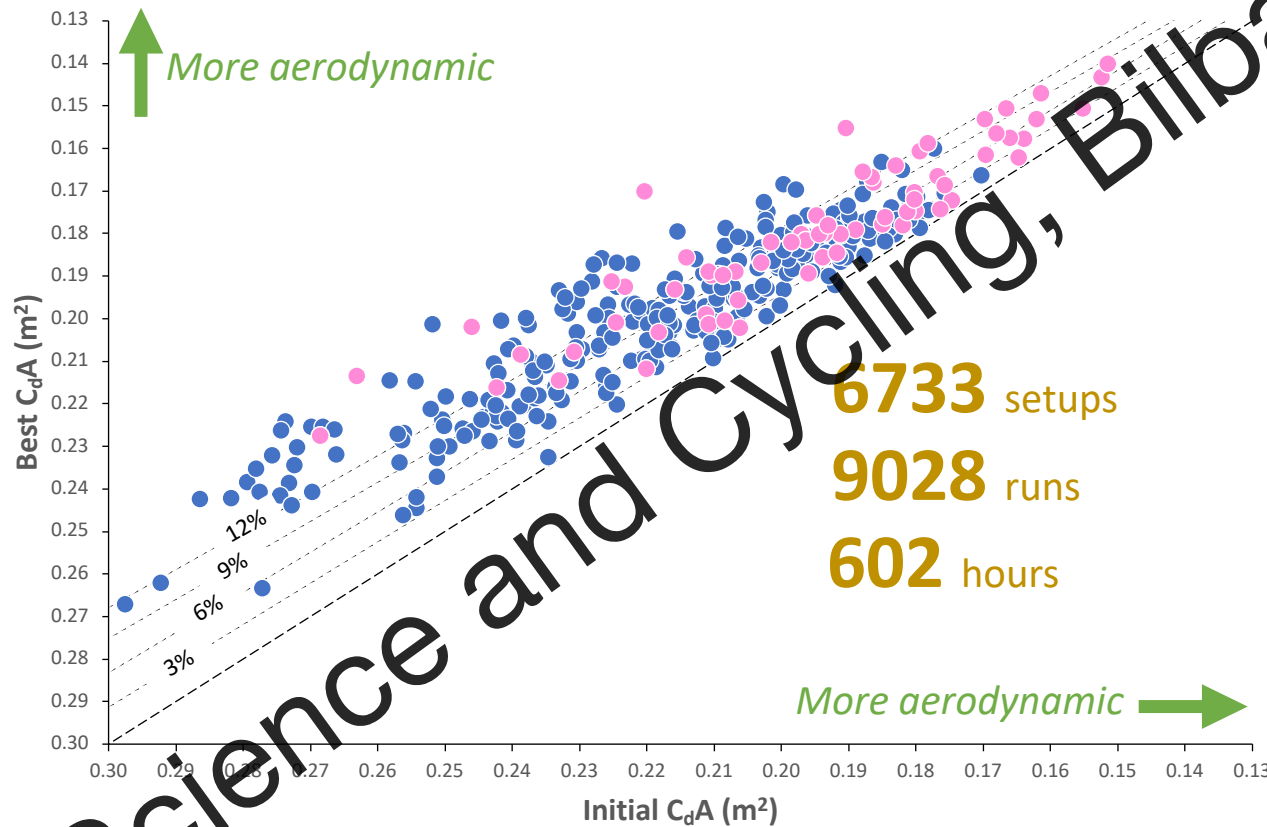
# Aerodynamics is (almost) everything

Aerodynamics, good or bad, determine performance



# Aerodynamics is (almost) everything

Aerodynamics, good or bad, determine performance



**389** sessions

**287** individuals

**71** females

**6733** setups

**9028** runs

**602** hours

**17** avg. # setups per session

**168** combined aero & biomex

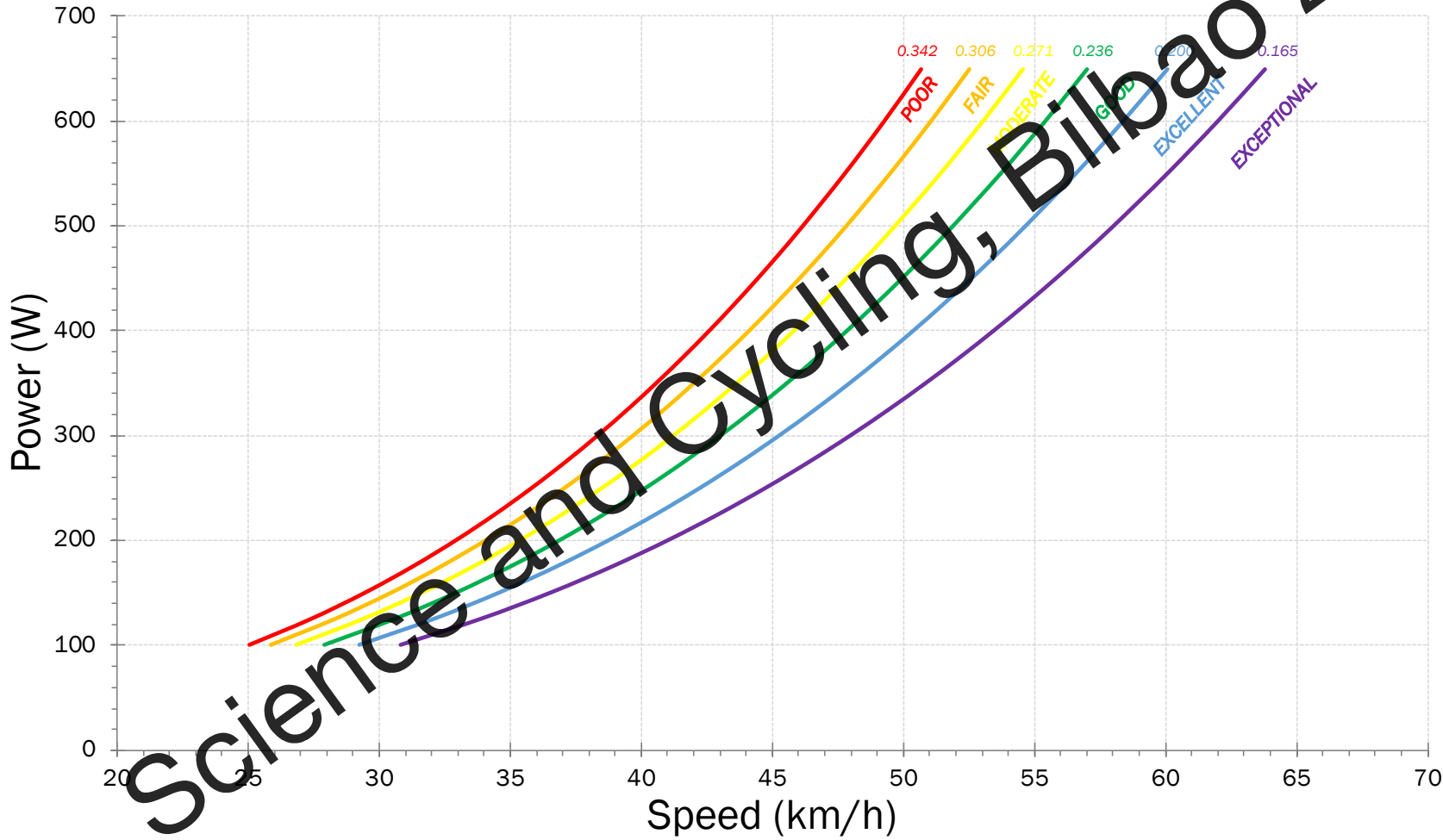
**TT** and pursuit position focus

**Note:** Coefficient of Drag Area ( $C_dA$ ) corrected for 'stanchion tares'

# Aerodynamics is (almost) everything

Aerodynamics, good or bad, determine performance

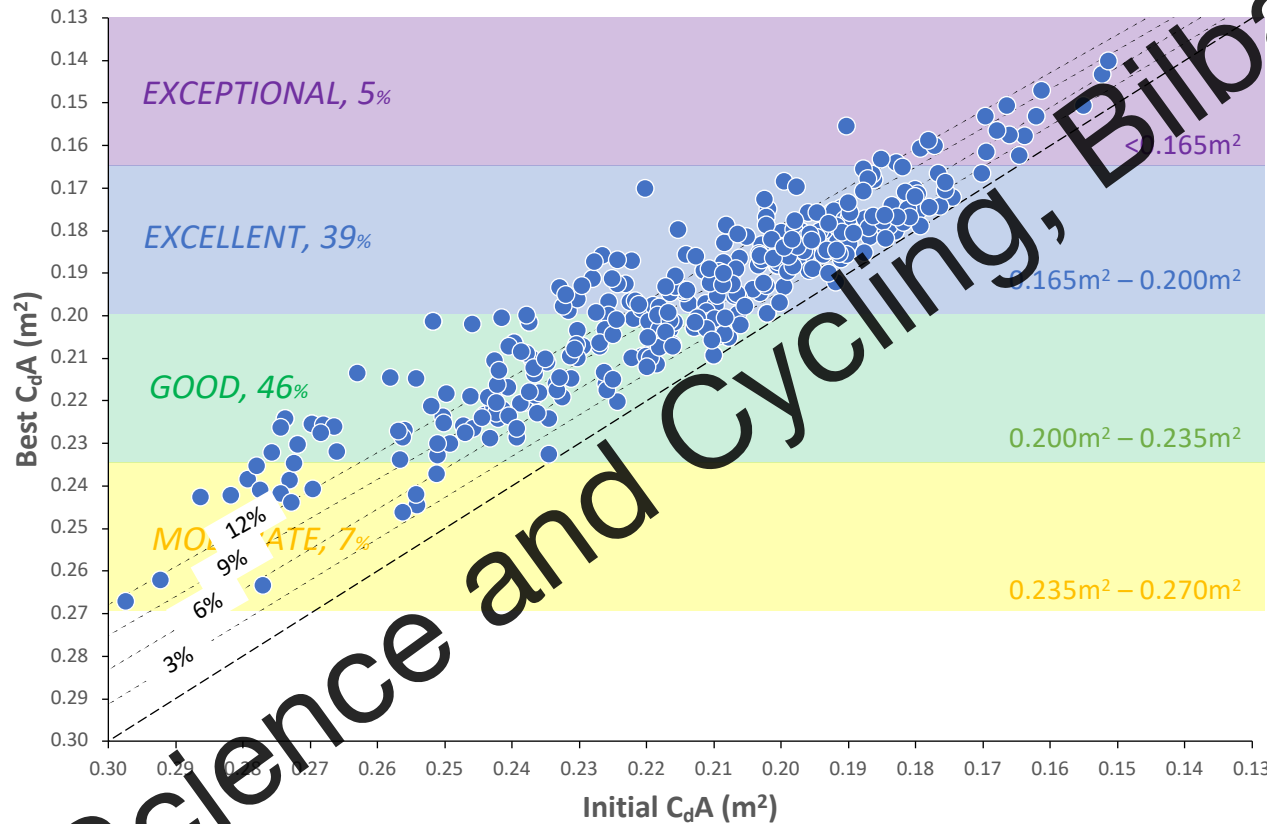
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# Aerodynamics is (almost) everything

Aerodynamics, good or bad, determine performance

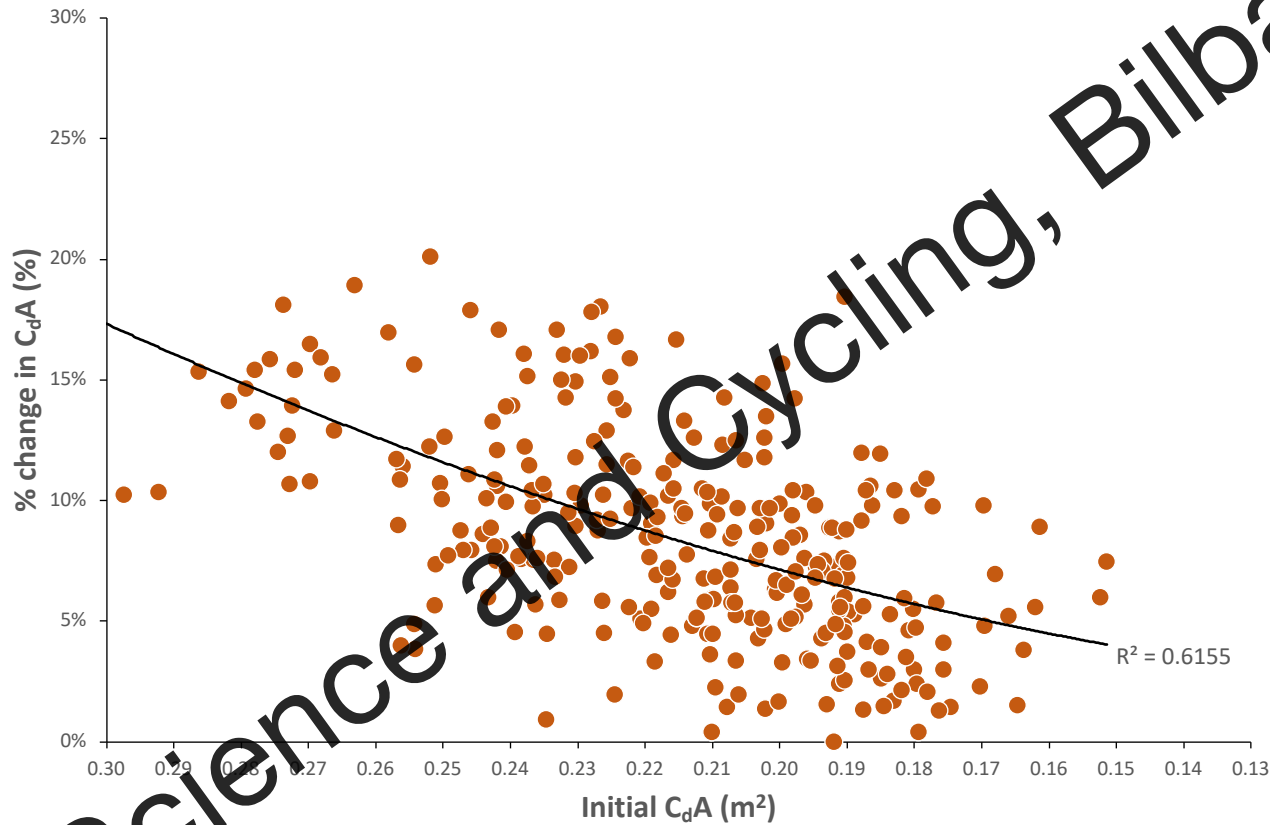


**389** sessions  
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# Aerodynamics is (almost) everything

Aerodynamics, good or bad, determine performance



**8.9%** average change in C<sub>d</sub>A

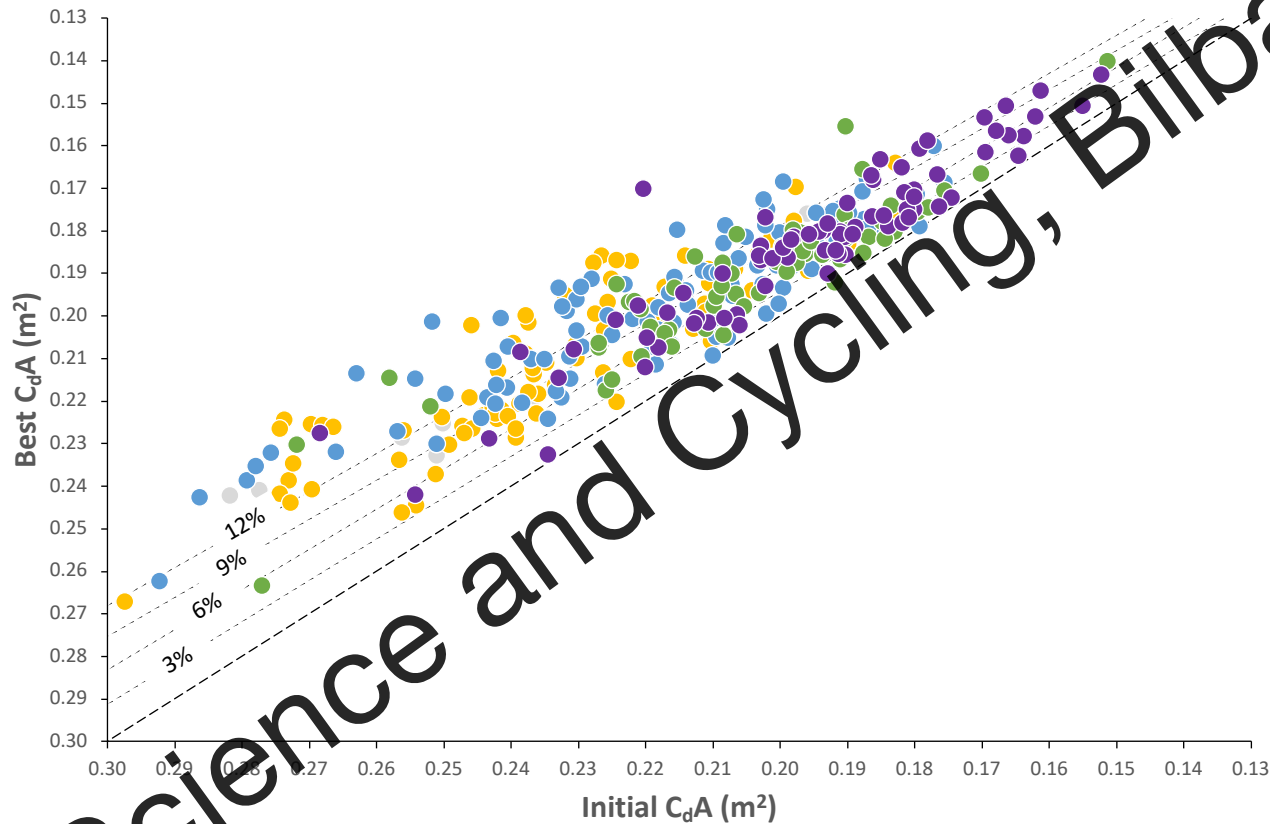
**26 W** saving in power

**1.45 km/h** gain in speed

**Note:** Coefficient of Drag Area (C<sub>d</sub>A) corrected for 'stanchion tares'

# Coefficient of Drag Area ( $C_dA$ )

8.9% average improvement across all groups



**World Tour Pro (77)**

6.6% change in  $C_dA$  | 25 W saving

**Conti/Dom Pro (62)**

6.9% change in  $C_dA$  | 21 W saving

**Top amateur (105)**

9.9% change in  $C_dA$  | 29 W saving

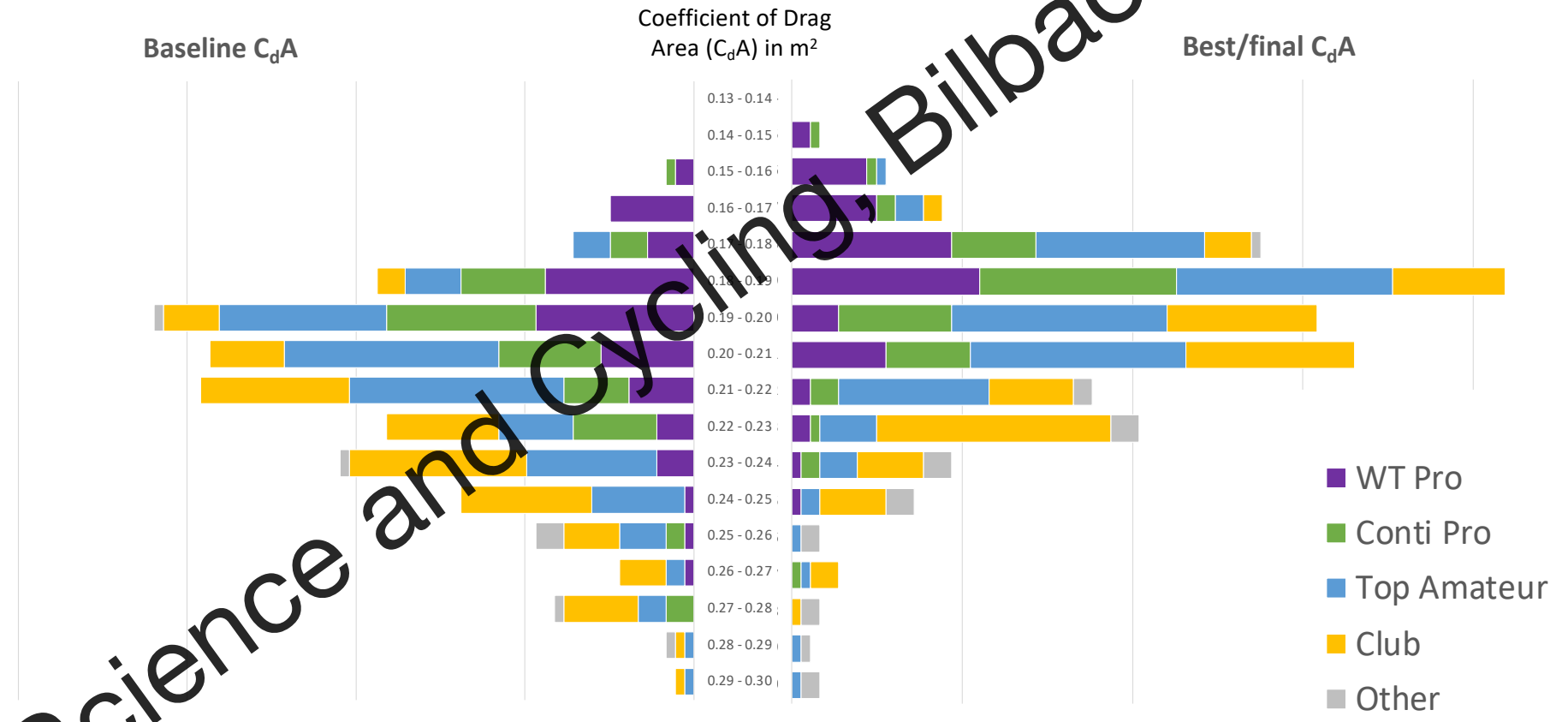
**Club level (123)**

10.7% change in  $C_dA$  | 27 W saving

**Note:** Coefficient of Drag Area ( $C_dA$ ) corrected for 'stanchion tares'

# Coefficient of Drag Area ( $C_dA$ )

8.9% average improvement across all groups



**Note:** Coefficient of Drag Area ( $C_dA$ ) corrected for 'stanchion tares'

# Designing the solution

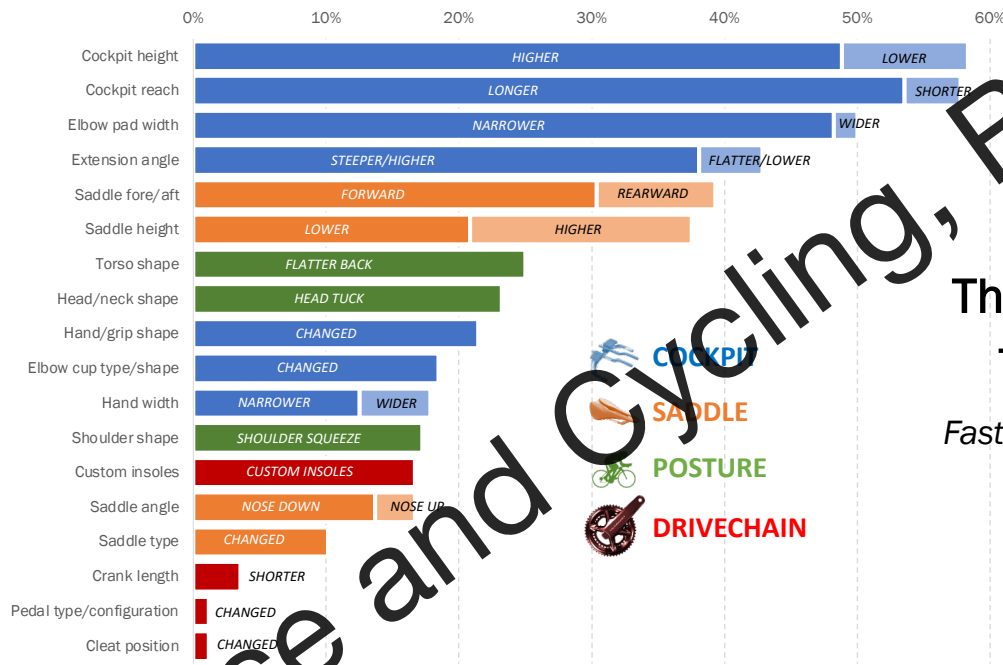
Consistent and reliable method allows for more confident decisions





# Ergonomic changes or cues

Where an ergonomic change has resulted in better function and better aerodynamics



The importance of having solutions that work in multiple scenarios

*Faster, for more of the time, for more events, for more circumstances, for more people*



- **HEADROOM:** breadth of function not singular solution
- **PRAGMATIC:** simple, achievable, flexible
- **ROBUST:** risk reduced; pressure checked

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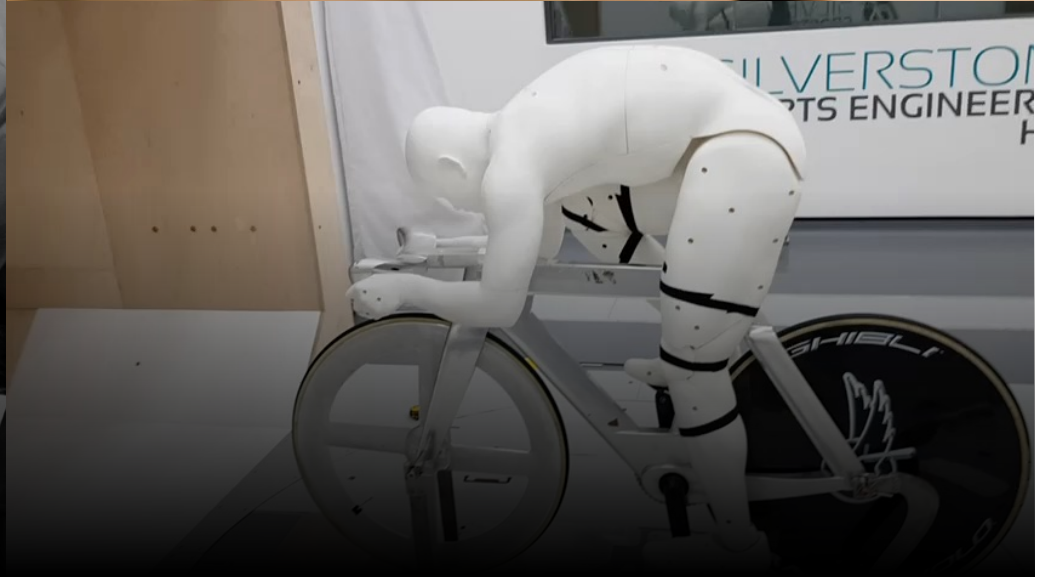
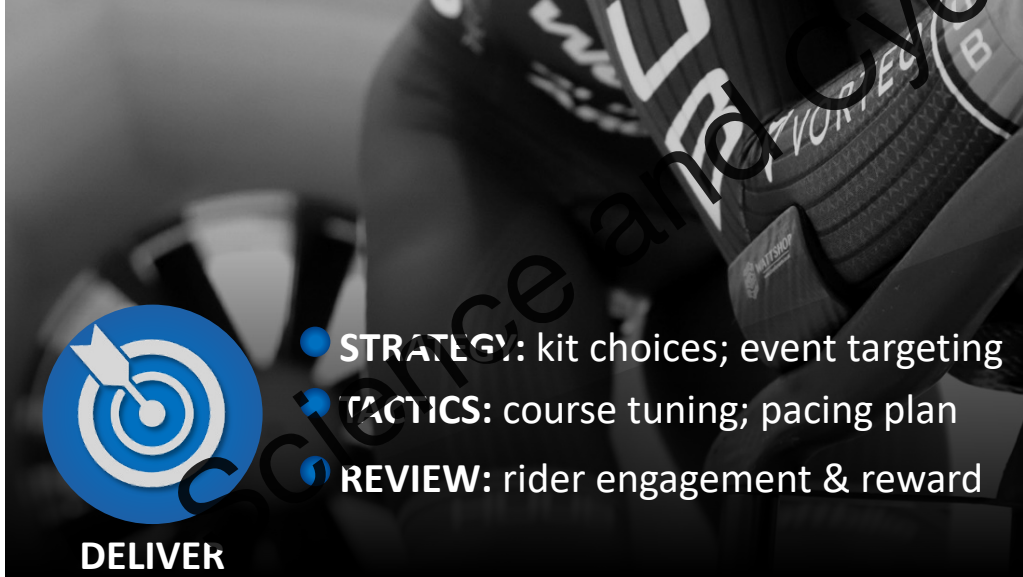
# Delivery

Consistent and reliable method allows for better decisions



# Position optimization

Confidence that the position works



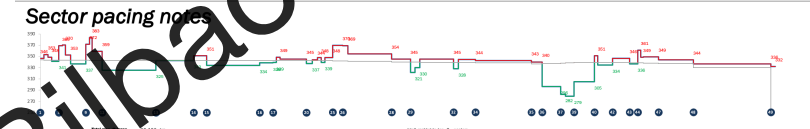
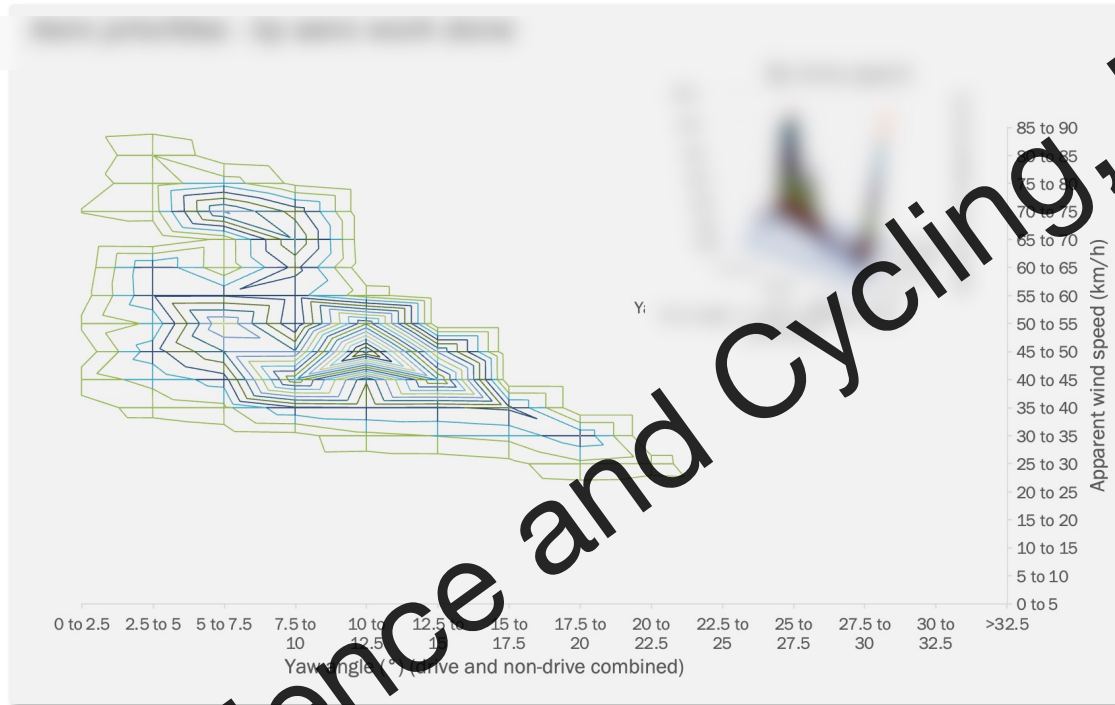
DELIVER

- STRATEGY: kit choices; event targeting
- TACTICS: course tuning; pacing plan
- REVIEW: rider engagement & reward

# Delivery: performance modelling

Physics and physiology: aero, yaw and speed, and critical power

VORTEQ 2023



Sector	Sector distance (km)			Terrain			Sector time (mins)			Physical				Sector average speed (km/h)	Pacing notes	
	Start	End	Distance	Avg. grade	Slope	Elevation gain (m)	Start	End	Duration	Sector power (W)	Power delivery for attack (%)	Rank importance	Rank for recovery			Time savings/losses
1	0.000	0.166	0.166	1%	---	2	0	00000	00:16	346	0%	---	---	---	36.7	
2	0.166	0.376	0.210	1%	---	2	0	00016	00:37	353	1%	---	---	---	36.7	
3	0.376	0.557	0.181	0%	---	0	1	00037	00:52	348	1%	---	---	---	43.4	
4	0.557	0.912	0.355	1%	---	5	0	00052	01:16	341	1%	---	---	---	51.0	
5	0.912	1.078	0.166	0%	---	8	0	00116	01:32	369	2%	---	---	---	38.1	
6	1.078	1.237	0.159	3%	---	5	0	00132	01:47	370	1%	---	---	---	37.8	
7	1.237	1.484	0.246	0%	---	1	1	00147	02:07	353	2%	---	---	---	46.3	
8	1.484	2.236	0.753	0%	---	2	3	00207	02:57	337	1%	---	---	---	54.0	
9	2.236	2.424	0.188	8%	---	15	0	00257	03:15	372	6%	---	---	---	37.6	Higher variance in power either side of target - according to terrain and/or wind
10	2.424	2.547	0.123	7%	---	8	0	00315	03:33	383	4%	5	---	---	24.6	Small variance in power either side of target - according to terrain and/or wind
11	2.547	3.047	0.499	3%	---	15	0	00333	04:22	359	1%	7	---	---	37.5	
Checkpoint 1	3.370									0:04.44				0:44.4		
12	3.047	5.695	2.649	1%	---	5	38	00421	06:57	325	3%	---	---	---	61.0	Small variance in power either side of target - according to terrain and/or wind
13	5.695	7.548	1.853	1%	---	14	1	00557	09:07	343	1%	---	---	---	51.1	
14	7.548	8.192	0.644	2%	---	12	0	00707	09:56	351	1%	---	---	---	47.3	
Checkpoint 2	8.400									0:10.50				0:26.6		
15	8.192	10.804	2.612	0%	---	8	18	00956	12:47	334	3%	---	---	---	55.2	
16	10.804	11.463	0.659	0%	---	1	4	01247	13:33	338	1%	---	---	---	53.9	
17	11.463	11.615	0.152	1%	---	1	0	01338	13:43	339	0%	---	---	---	52.6	
18	11.615	11.803	0.188	2%	---	3	0	01343	13:58	349	1%	---	---	---	45.1	
19	11.803	13.105	1.303	1%	---	10	3	01398	15:38	345	1%	---	---	---	47.3	
20	13.105	13.380	0.275	0%	---	2	1	01508	15:56	337	1%	---	---	---	54.0	
21	13.380	13.648	0.268	2%	---	4	0	01596	16:15	344	1%	---	---	---	51.2	
22	13.648	13.829	0.181	0%	---	1	1	01615	16:28	348	1%	---	---	---	49.0	
23	13.829	14.010	0.181	0%	---	1	1	01628	16:40	339	0%	---	---	---	52.9	
24	14.010	14.394	0.384	1%	---	4	0	01640	17:11	348	1%	---	---	---	44.4	
Checkpoint 3	14.400									0:17.13				0:30.6		
25	14.394	14.878	0.485	5%	---	24	0	01713	18:04	370	2%	4	---	---	33.1	
26	14.878	15.146	0.268	4%	---	12	0	01804	18:35	369	0%	6	---	---	30.9	
Checkpoint 4	15.200									0:18.44				0:38.0		
27	15.146	17.295	2.149	3%	---	75	1	01876	22:36	354	2%	1	---	---	32.1	
Checkpoint 5	18.300									0:24.04				0:30.0		
28	17.295	18.222	0.926	1%	---	20	9	02236	24:06	345	1%	---	---	---	37.0	
29	18.222	18.439	0.217	2%	---	0	5	02406	24:20	321	0%	---	---	---	54.9	
30	18.439	18.678	0.239	1%	---	1	3	02426	24:37	330	1%	---	---	---	50.8	
31	18.678	20.342	1.664	2%	---	34	4	02437	27:05	345	1%	---	---	---	40.5	
32	20.342	20.588	0.246	0%	---	4	4	02705	27:20	328	1%	---	---	---	58.3	
Checkpoint 6	21.000									0:31.43				0:40.0		
33	20.588	21.038	0.450	4%	---	31	1	02720	28:45	344	0%	---	---	---	35.5	
34	21.038	24.177	3.139	3%	---	76	4	02845	33:39	343	1%	8	---	---	33.8	
Checkpoint 7	24.700									0:34.48				0:50.4		
35	24.177	24.706	0.529	3%	---	25	0	03039	34:48	340	3%	---	---	---	27.4	
36	24.706	26.610	1.904	7%	---	0	61	03146	35:36	346	2%	---	---	---	70.2	
37	25.610	25.849	0.239	6%	---	0	14	03536	36:48	313	2%	---	---	---	63.7	Small variance in power either side of target - according to terrain and/or wind
38	25.849	26.283	0.434	0%	---	0	22	03548	36:13	302	4%	---	---	---	63.3	Small variance in power either side of target - according to terrain and/or wind
Checkpoint 8	27.000									0:35.43				0:50.0		
39	26.283	27.275	0.991	3%	---	8	37	03613	37:09	355	4%	---	---	---	63.4	Small variance in power either side of target - according to terrain and/or wind
40	27.275	27.448	0.174	4%	---	6	0	03706	37:24	351	1%	---	---	---	40.6	
41	27.448	28.172	0.724	0%	---	3	5	03724	38:13	334	1%	---	---	---	53.5	
42	28.172	29.012	0.840	2%	---	16	1	03813	38:57	346	1%	---	---	---	47.4	
43	29.012	29.410	0.398	1%	---	7	2	03917	39:43	327	2%	---	---	---	54.0	
44	29.410	29.569	0.159	6%	---	10	0	03943	40:00	361	1%	---	---	---	34.0	
45	29.569	29.688	0.118	3%	---	0	3	04000	40:10	349	2%	---	---	---	41.3	
Checkpoint 9	30.000									0:36.00				0:50.0		
46	29.688	30.437	0.749	3%	---	26	1	04010	41:09	349	2%	---	---	---	39.3	
47	30.437	32.145	1.708	0%	---	153	1	04110	46:55	354	2%	3	---	---	18.3	
Checkpoint 10	32.200									0:47.02				0:52.0		
48	32.145	36.569	4.424	6%	---	301	3	04605	53:57	338	1%	2	---	---	18.3	
49	36.569	36.583	0.014	13%	---	29	0	05017	1:00:29	332	1%	---	---	---	11.2	
FINISH	36.583									1:00:29				1:32.7		



VORTEQ



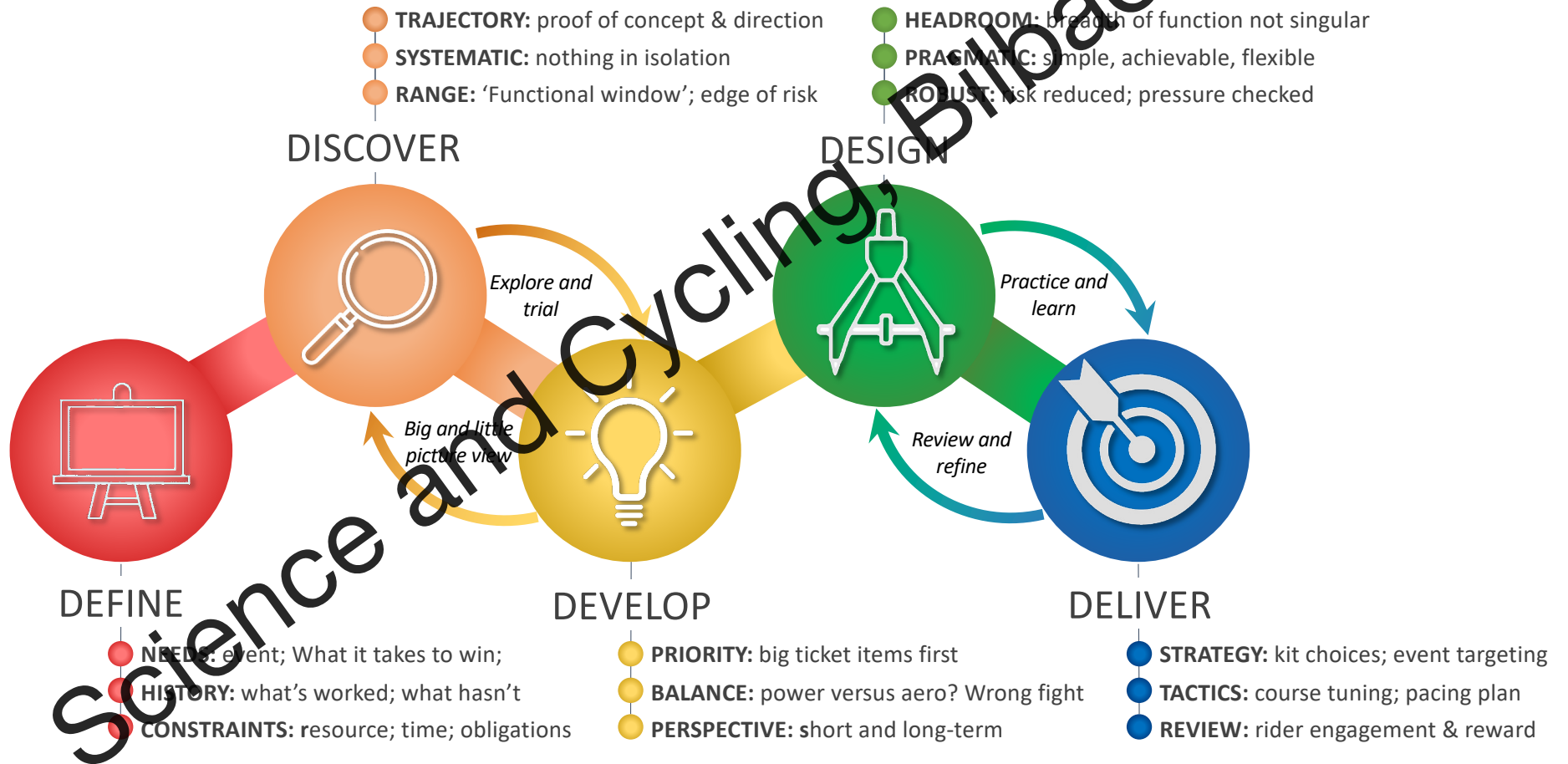
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CATESBY  
TUNNEL

# Trust the method

Systematic and logical; confidence in outcomes





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