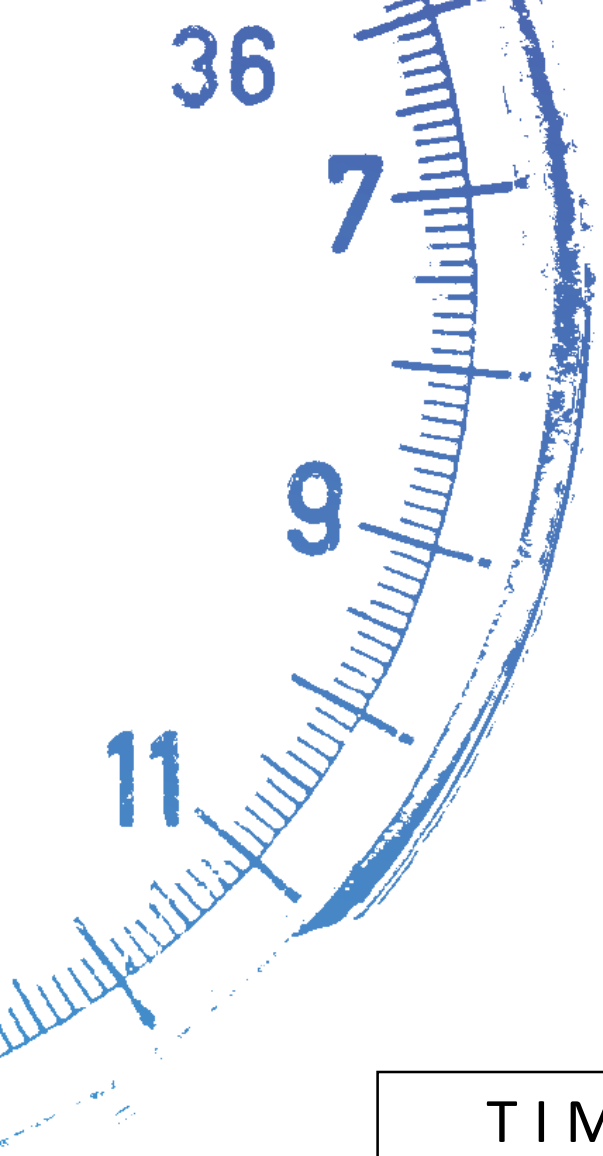


SCIENCE IN CYCLING
CONFERENCE - JULY 4TH

KRONOS

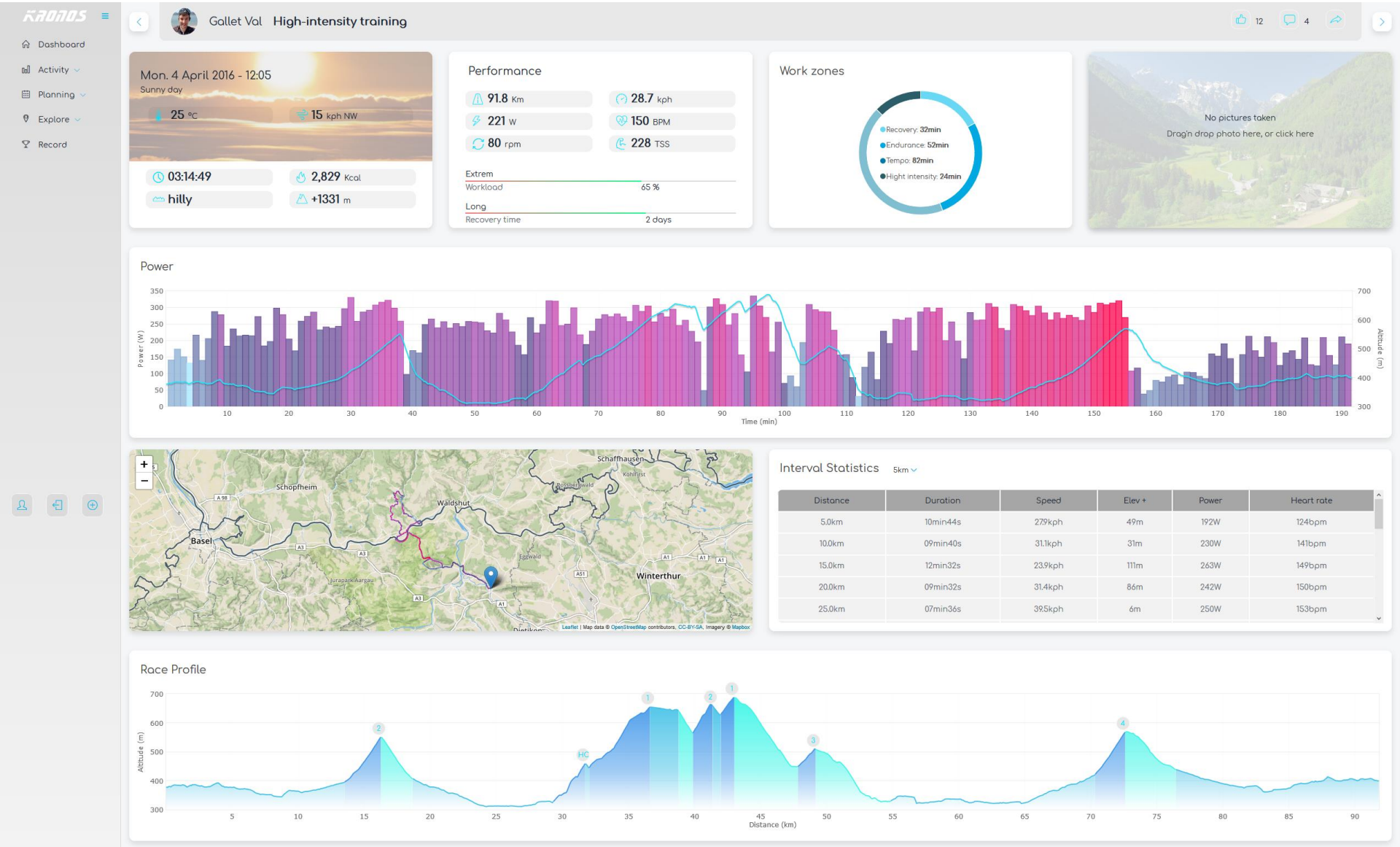
www.kronos-sport.com

TIME TRIAL MODELLING

Valentin.gallet@kronos-analytics.com

DATA ANALYSIS

OUR SOLUTION: EVERYTHING ON A SINGLE WEBSITE

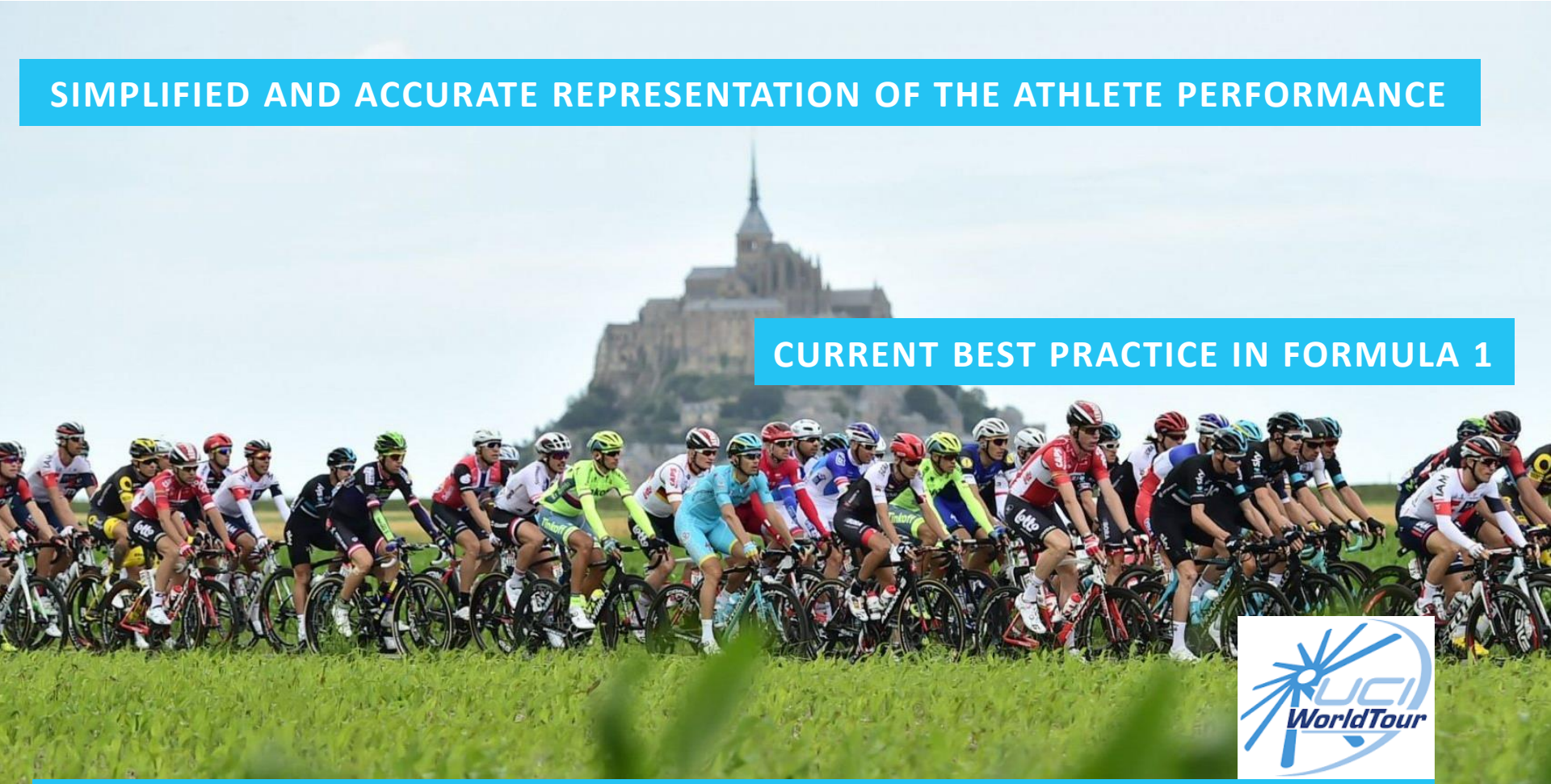


MODELLING APPLIED TO CYCLING

WHY IS IT THAT INTERESTING?

SIMPLIFIED AND ACCURATE REPRESENTATION OF THE ATHLETE PERFORMANCE

CURRENT BEST PRACTICE IN FORMULA 1



TT MODELS WERE DEVELOPPED WITH AND TESTED BY A WORLD TOUR TEAM

INDIVIDUAL TIME TRIAL

INTRODUCTION

AN OPTIMAL POWER-VARIABLE STRATEGY ALLOWS SAVING SIGNIFICANT TIME VS CONSTANT POWER STRATEGY*

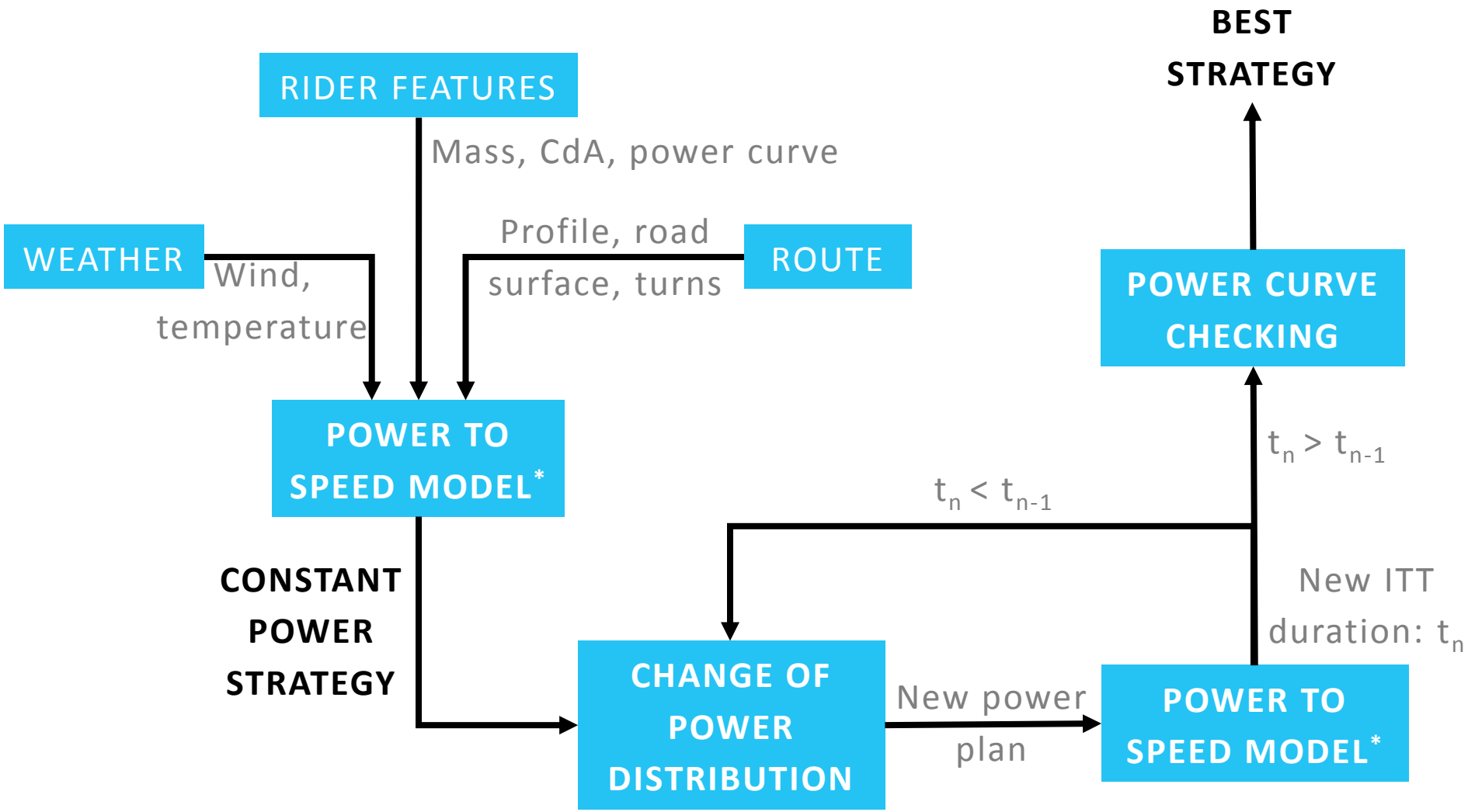
USE TO CHOOSE THE OPTIMAL EQUIPMENT (FRAME, WHEELS, SUITS…)

TO DETERMINE WHETHER IT IS WORTH CHANGING BIKE DURING THE TT

* **Distribution of Power Output During Cycling,** *G. Atkinson et al,* Sports Medicine 2007

INDIVIDUAL TIME TRIAL

HOW IT WORKS



* **Validation of a Mathematical Model for Road Cycling Power**, J.Martin et al, J. of App. Biomechanics 1998

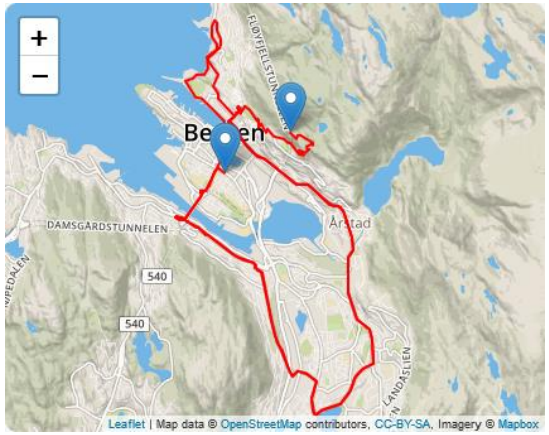
INDIVIDUAL TIME TRIAL

SIMULATION PARAMETERS

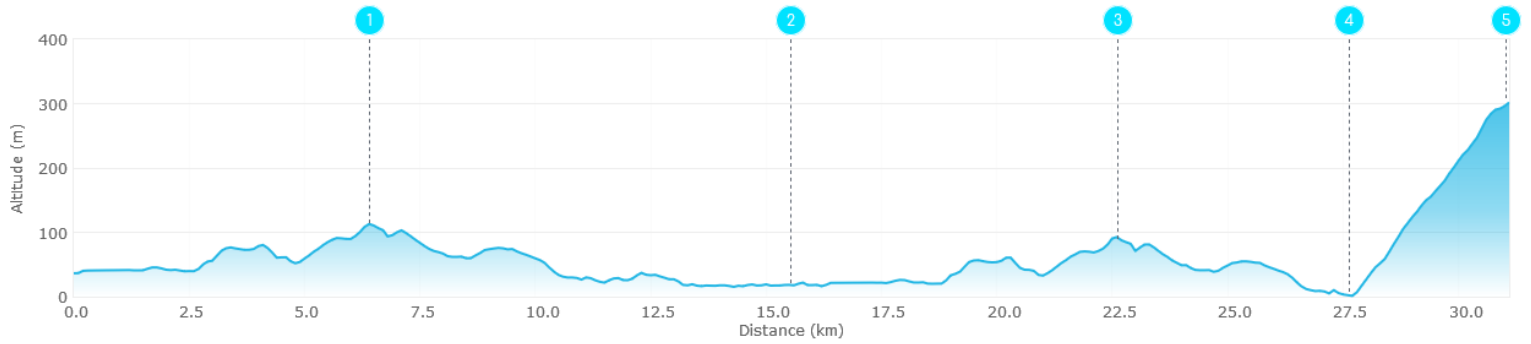
3 VIRTUAL PRO RIDERS

Name	Mass	CdA (m^2)	Max power (40 min)
Rider 1	73 kg	0.225	475 W
Rider 2	78 kg	0.234	470 W
Rider 3	75 kg	0.227	412 W

2017 WORLD ITT (BERGEN)



Rank	Rider	Time	Gap	Average Speed	Average Power
1	Rider 1	41:35		44.94kph	473W
2	Rider 2	42:54	+01'18"	43.57kph	466W
3	Rider 3	45:19	+03'44"	41.24kph	406W



INDIVIDUAL TIME TRIAL

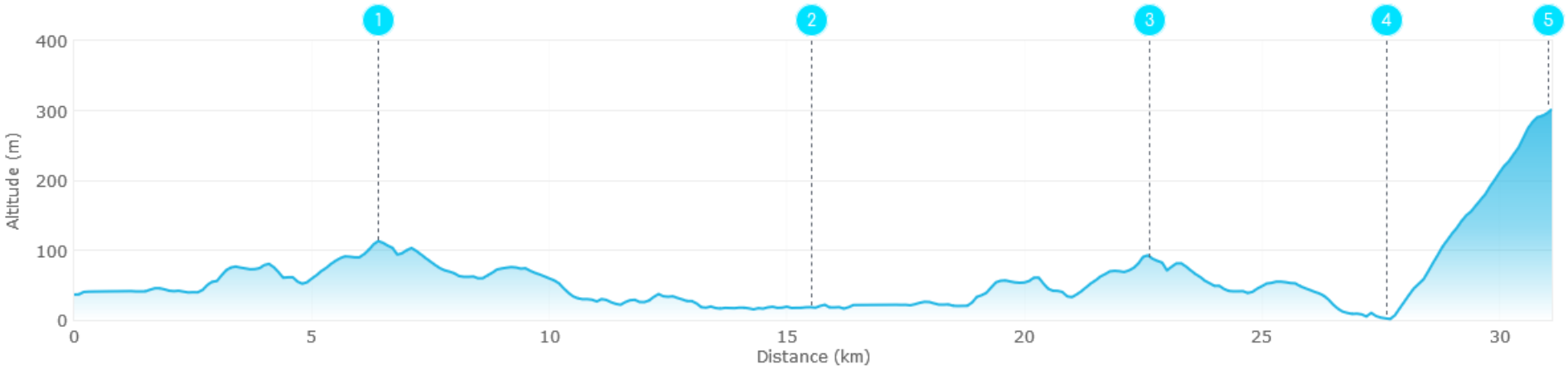
SIMULATION RESULTS

59S SAVED OVER 31KM VS CONSTANT-POWER STRATEGY!!

Power | Energy

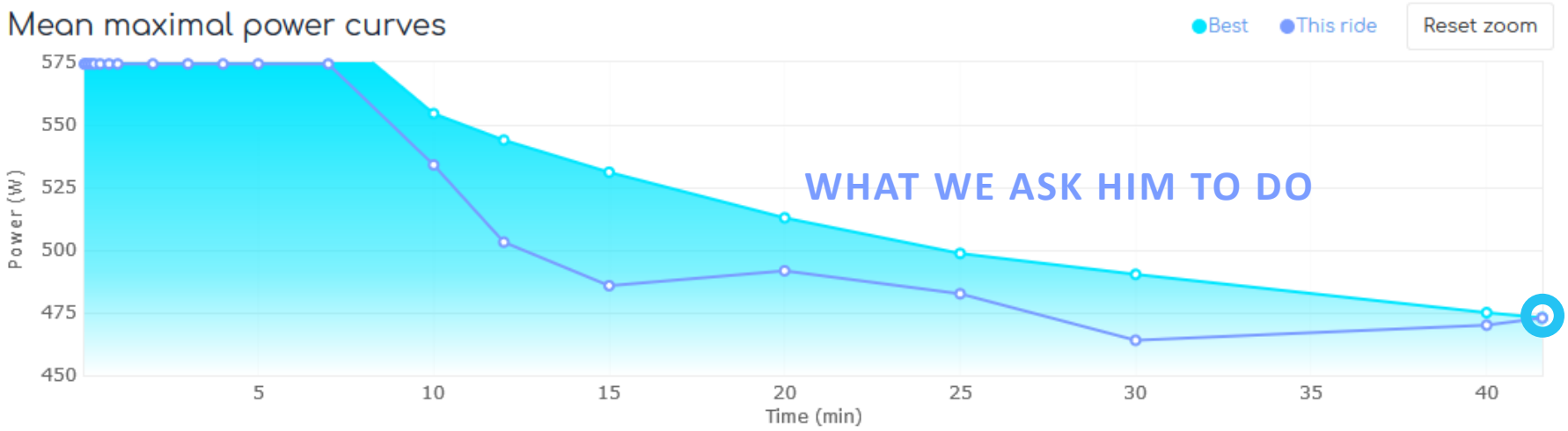
LOOK LIKE INTERVAL TRAINING

Difference	SPLIT 1 6.52km at 1.1%	SPLIT 2 9.12km at -1.0%	SPLIT 3 7.11km at 1.0%	SPLIT 4 5.0km at -1.7%	SPLIT 5 3.41km at 8.9%
 Rider 1	08:18 47.2 kph 546 W	10:37 51.5 kph 371 W	08:58 47.6 kph 510 W	05:32 54.2 kph 349 W	08:14 24.8 kph 574 W



INDIVIDUAL TIME TRIAL

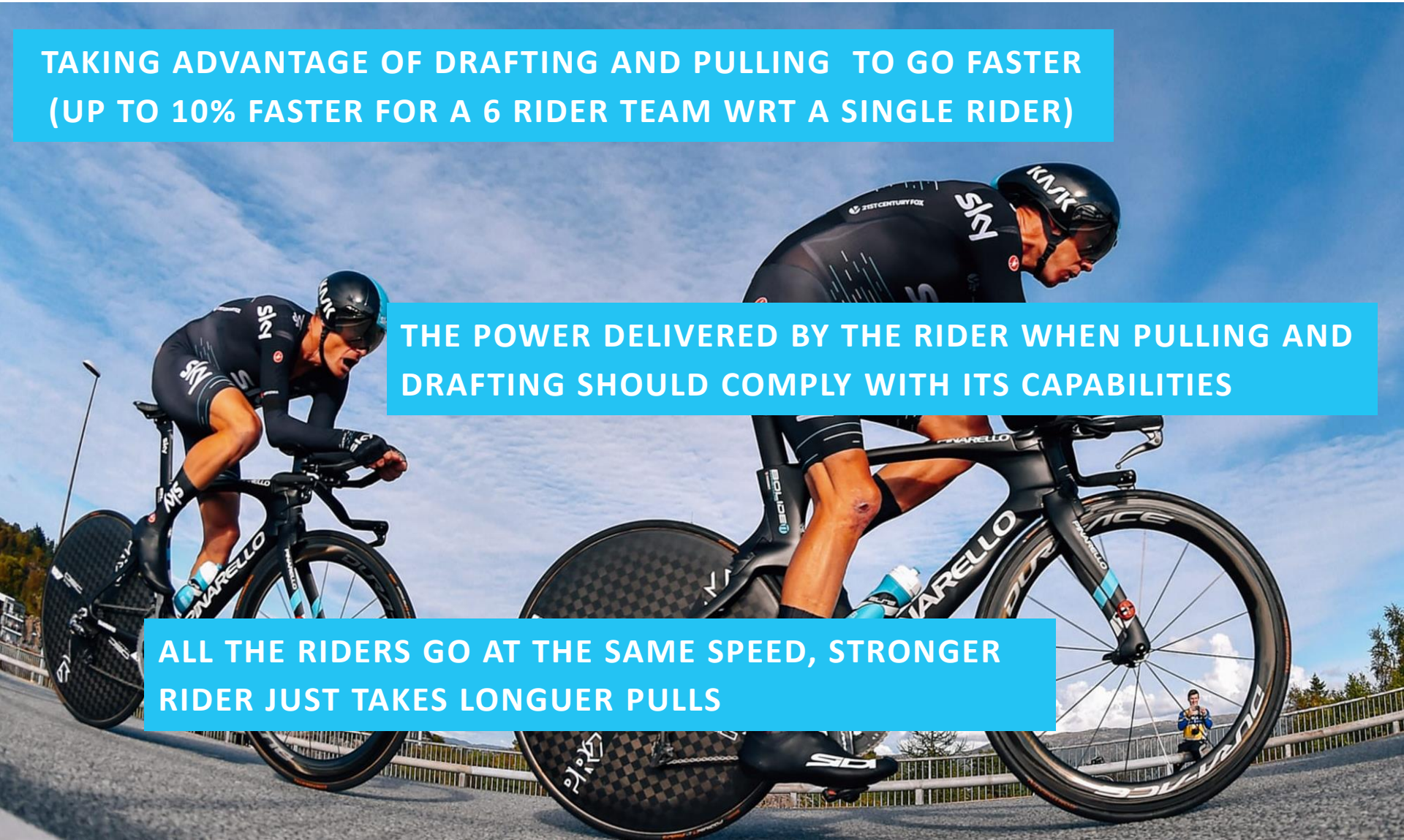
IS IT FEASIBLE?



		Sprint				Anaerobic							VO2 max						Lactate threshold			
		3"	5"	10"	15"	20"	30"	45"	1'	2'	3'	4'	5'	7'	10'	12'	15'	20'	25'	30'	40'	42'
Best	W	1,779	1,579	1,440	1,305	1,184	1,052	961	870	731	685	649	621	589	554	544	531	513	499	490	475	473
	W/Kg	25.41	22.55	20.57	18.64	16.91	15.03	13.73	12.42	10.44	9.78	9.27	8.87	8.42	7.92	7.77	7.59	7.33	7.12	7.00	6.79	6.76
	Kg	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
This ride	W	574	574	574	574	574	574	574	574	574	574	574	574	574	534	503	486	492	483	464	470	473
	W/Kg	8.20	8.20	8.20	8.20	8.20	8.20	8.20	8.20	8.20	8.20	8.20	8.20	8.20	7.63	7.19	6.94	7.02	6.89	6.63	6.71	6.76
	Kg	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
	%	32.28	36.38	39.88	44.01	48.50	54.58	59.76	66.03	78.60	83.89	88.47	92.50	97.42	96.31	92.52	91.47	95.88	96.78	94.63	98.95	99.99

TEAM TIME TRIAL

PULLING & DRAFTING = GOING FASTER



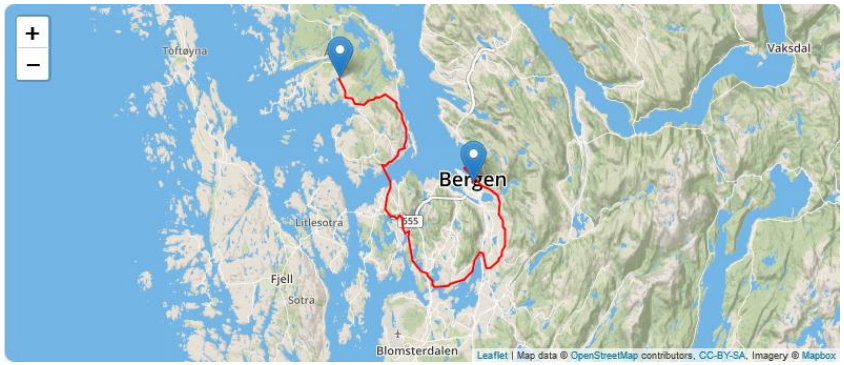
TEAM TIME TRIAL

SIMULATION PARAMETERS

6 VIRTUAL PRO RIDERS

Name	Mass	CdA (m^2)	Max power (40 min)
Rider 1	73 kg	0.225	475 W
Rider 2	78 kg	0.234	470 W
Rider 3	75 kg	0.227	412 W
Rider 4	68 kg	0.210	374 W
Rider 5	59 kg	0.184	359 W
Rider 6	63 kg	0.191	385 W

2017 WORLD TTT (BERGEN)



TEAM TIME TRIAL

THE DIFFERENT TESTED SCENARIOS

BEST STRATEGY VS FINISHING WITH THE WHOLE TEAM: 51S SAVED

IT IS WORTH
DROPPING RIDERS

Ranking	Race Duration	Gap	Finishing Riders	Dropped Riders	Rider 1	Rider 2	Rider 6	Rider 5	Rider 3	Rider 4
1	47:40	+00:00	4	Rider 4 - Rider 3	Finisher	Finisher	Finisher	Finisher	->22km	->28km
2	47:44	+00:00	4	Rider 4 - Rider 3	Finisher	Finisher	Finisher	Finisher	->28km	->28km
3	48:04	+00:25	4	Rider 4 - Rider 3	Finisher	Finisher	Finisher	Finisher	->38km	->28km
4	48:05	+00:25	5	Rider 4	Finisher	Finisher	Finisher	Finisher	Finisher	->22km
5	48:05	+00:26	5	Rider 4	Finisher	Finisher	Finisher	Finisher	Finisher	->28km
6	48:06	+00:26	4	Rider 4 - Rider 5	Finisher	Finisher	Finisher	->38km	Finisher	->28km
7	48:06	+00:27	4	Rider 4 - Rider 3	Finisher	Finisher	Finisher	Finisher	->31km	->28km
8	48:22	+00:42	5	Rider 3	Finisher	Finisher	Finisher	Finisher	->22km	Finisher
9	48:23	+00:43	5	Rider 3	Finisher	Finisher	Finisher	Finisher	->28km	Finisher
10	48:26	+00:47	5	Rider 4	Finisher	Finisher	Finisher	Finisher	Finisher	->38km
11	48:31	+00:51	6	-	Finisher	Finisher	Finisher	Finisher	Finisher	Finisher

BEST STRATEGY

ALL RIDERS FINISHING

TEAM TIME TRIAL

DETAILS OF A STRATEGY

BEST RIDER TAKES LONGER PULL

WEAKEST RIDER ACTUALLY CONTRIBUTES BUT ONLY FOR 21.8km

47:40 | 53.64 kph | 4 riders | Rider 4 - Rider 3 | Pull time

	SPLIT 1 21.8km at -0.1%	SPLIT 2 6.7km at -0.2%	SPLIT 3 2.8km at 4.3%	SPLIT 4 6.8km at -2.1%	SPLIT 5 4.5km at -0.1%
	24:58	07:14	04:29	06:08	04:51
	52.3 kph	55.6 kph	37.7 kph	66.7 kph	55.8 kph
Rider 1	27 s	29 s	47 s	25 s	28 s
Rider 6	13 s	15 s	13 s	17 s	16 s
Rider 2	14 s	16 s	7 s	16 s	16 s
Rider 5	8 s	9 s	3 s	12 s	10 s
Rider 3	6 s	DROPPED	DROPPED	DROPPED	DROPPED
Rider 4	2 s	1 s	DROPPED	DROPPED	DROPPED

CONCLUSION

TIME TRIAL MODELLING

MODELLING IS A POWERFUL SOLUTION TO SAVE TIME ON TIME TRIALS

TO OPTIMALLY DETERMINE THE EQUIPMENT AND THE PACING STRATEGY

MODELS ARE ONLY TOOLS TO HELP COACH/SD MAKING DECISIONS

CONCLUSION

FURTHER INNOVATIONS

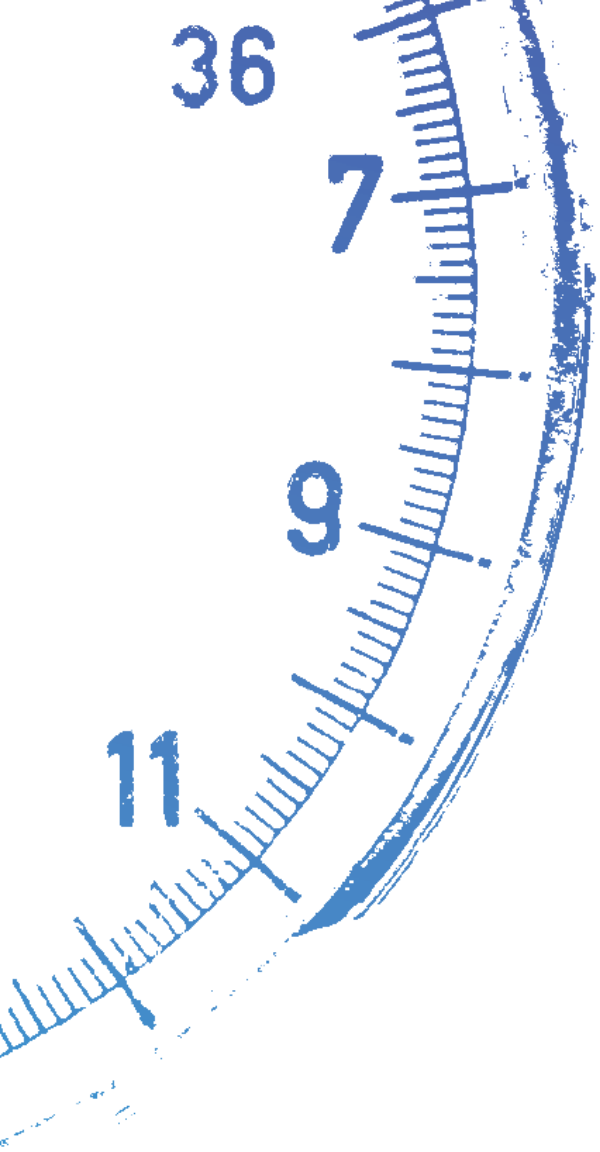
TTT ALGORITHM MODELS THE DYNAMIC OF RIDING WITHIN A GROUP

THIS PAVES THE WAY OF MANY APPLICATIONS

PELOTON VS BREAK-AWAY STRATEGY

OPTIMAL TEAM TRAIN/PACE FOR PREPARING A SPRINT

OPTIMAL TRAIN/PACE IN THE LAST CLIMB OF A MOUNTAIN STAGE



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THANK YOU FOR YOUR ATTENTION

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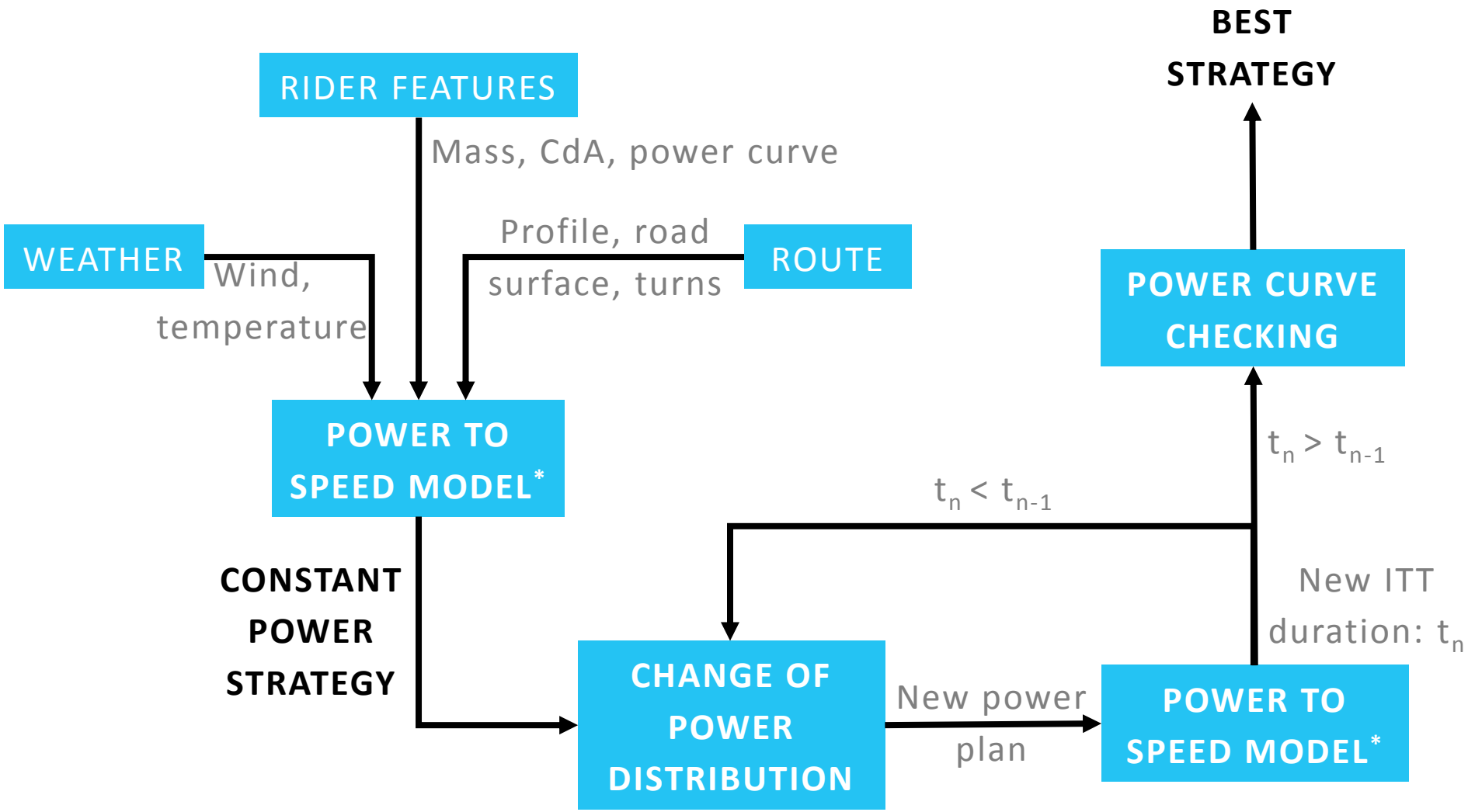
CONCLUSION

GUIDELINES

INDIVIDUAL TIME TRIAL

HOW IT WORKS



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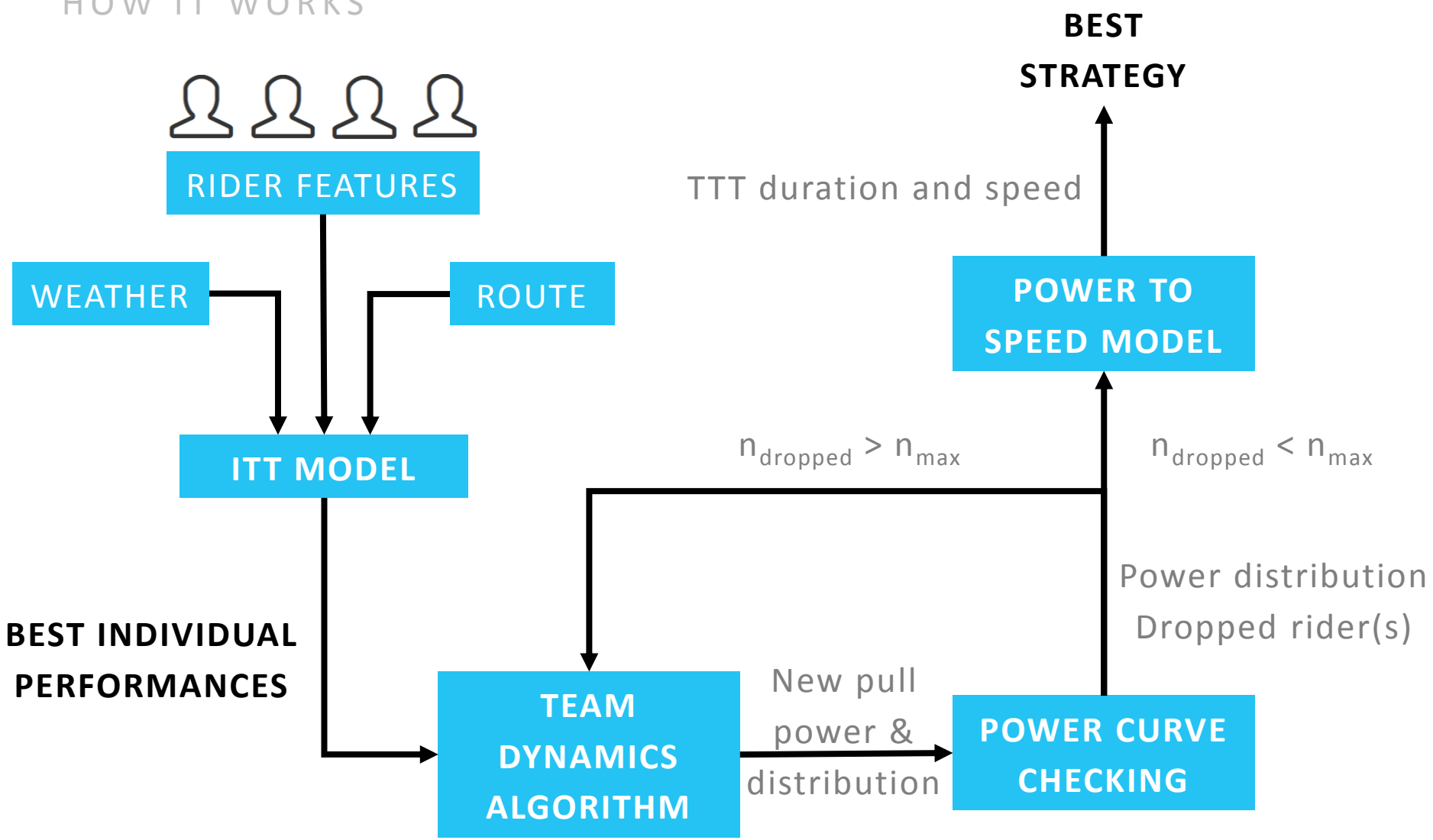
TEAM TIME TRIAL

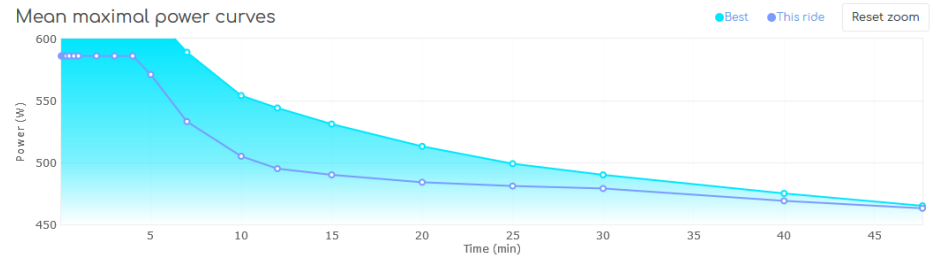
HOW IT WORKS



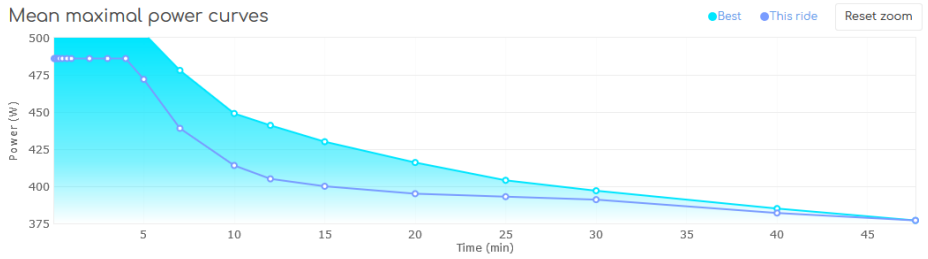
TEAM TIME TRIAL

FEASABILITY

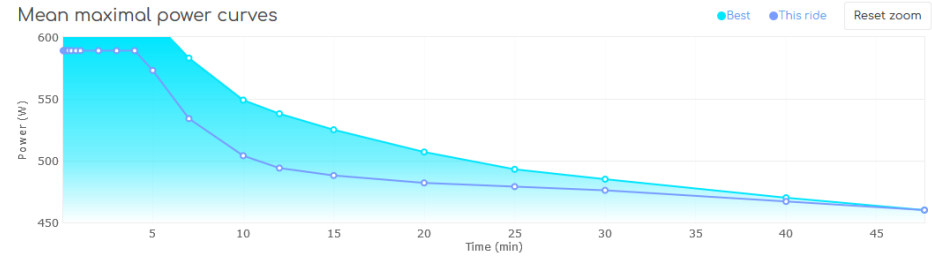
Rider 1



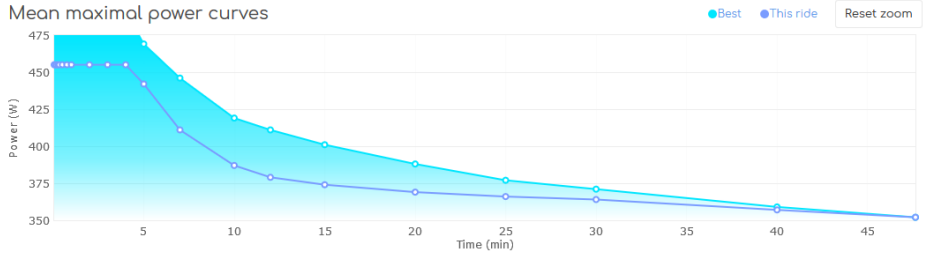
Rider 6



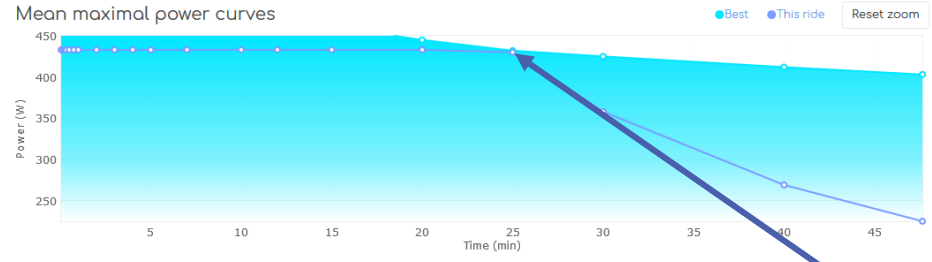
Rider 2



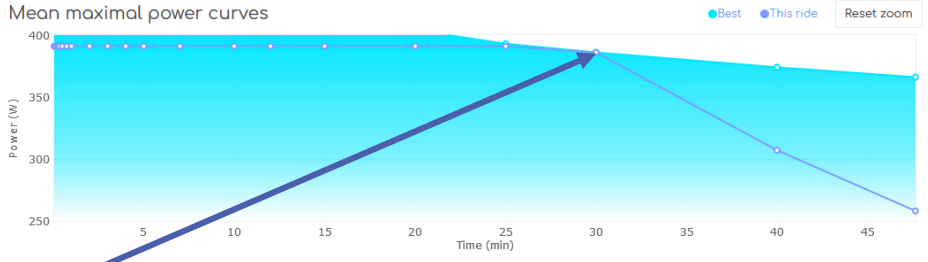
Rider 5



Rider 3



Rider 4



RIDERS START BEING DROPPED

DATA ANALYSIS

THE CURRENT SITUATION

SESSION ANALYSIS

TP

today's plan

SOCIAL NETWORK

GARMIN

CUSTOMIZED TRAINING PLAN

TP

cts

RACE/PACING STRATEGY

BEST BIKE SPLIT

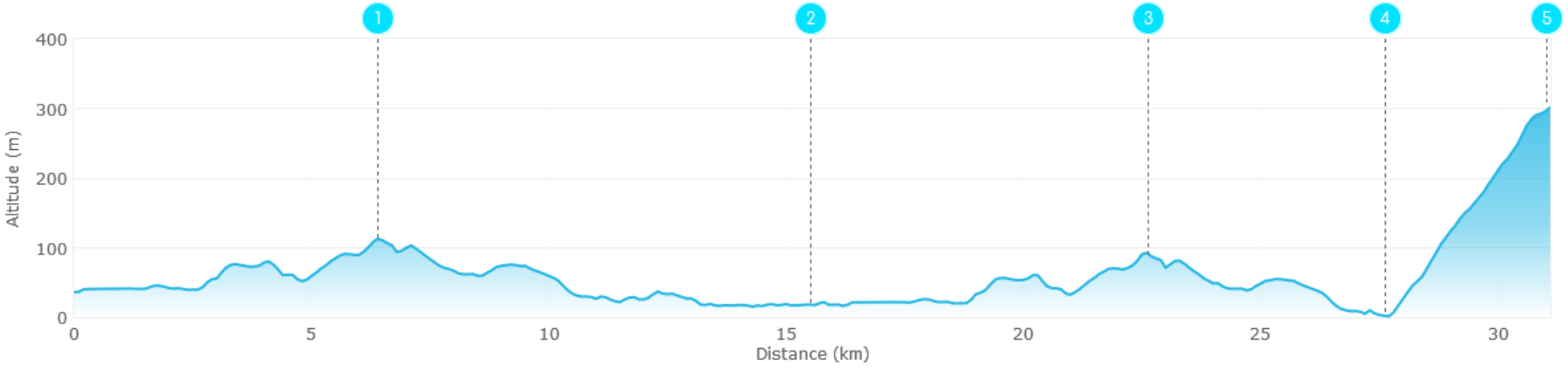
Cycling Power Lab

INDIVIDUAL TIME TRIAL

PACING DETAILS

Race intervals

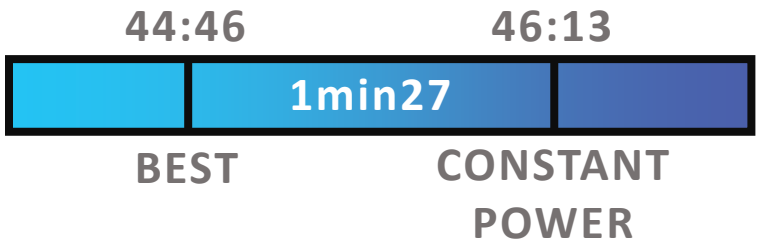
Interval Distance	Total Distance	Interval Time	Total Time	Interval Speed	Average Speed	Interval Power	Average Power	Grade
6.52km	6.52km	08:18	08:18	47.2kph	47.2kph	546W	546W	1.1%
9.12km	15.64km	10:37	18:55	51.5kph	49.6kph	371W	448W	-1.0%
7.11km	22.75km	08:58	27:53	47.6kph	49.0kph	510W	468W	1.0%
5.0km	27.75km	05:32	33:25	54.2kph	49.8kph	349W	448W	-1.7%
3.41km	31.16km	08:14	41:40	24.8kph	44.9kph	574W	473W	8.9%



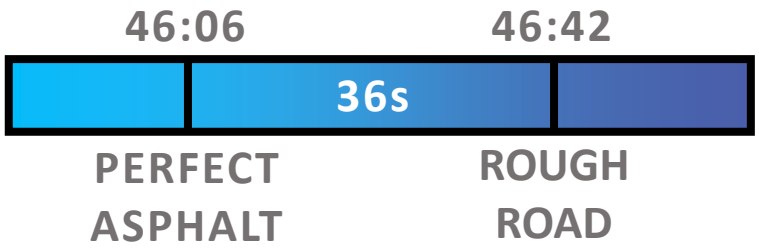
WEATHER EFFECTS

PREDICTION ACCURACY

PACING STRATEGY



ROAD SURFACE



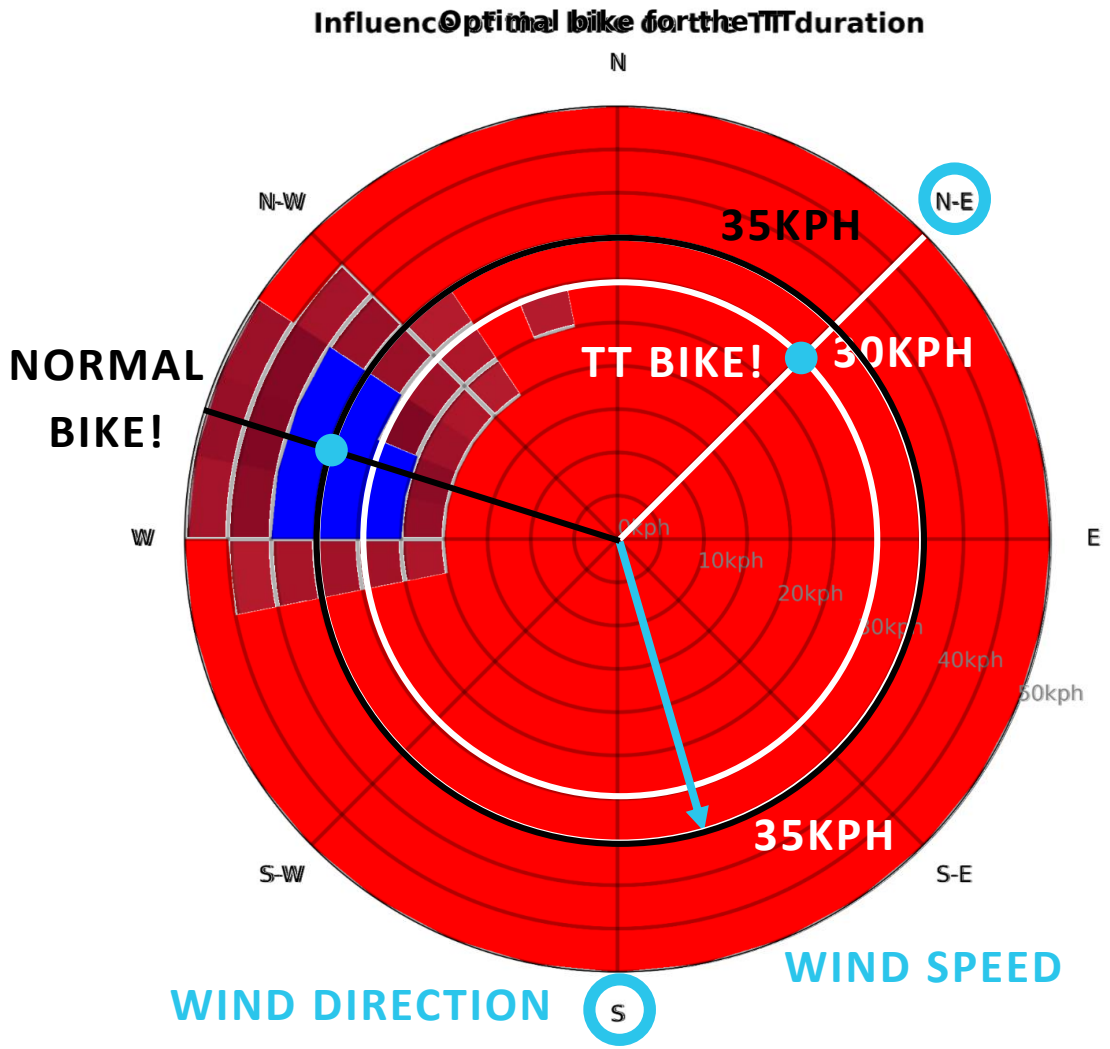
POWER CURVE

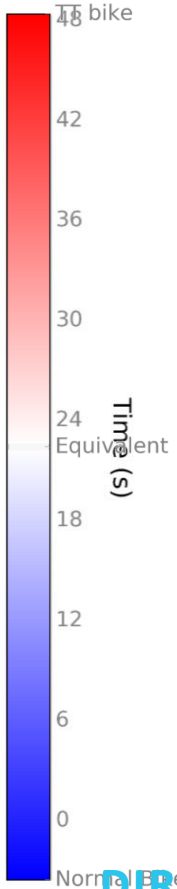
WIND SPEED

WIND DIRECTION

INDIVIDUAL TIME TRIAL

DOES THE WIND CHANGE THINGS?





ANEMOMETER

DIRECTION:
WNW

SPEED:
30KPH

TEAM TIME TRIAL

HOW IT WORKS