CyclingPowerLab

Williams

Cycling Power Lab Component Analysis For Williams Cycling Wheel Systems 58 (2014) & 85 (2014)

Cycling Power Lab models cycling and triathlon performance by applying mathematical/physics models to real world athlete, course and environmental data with the goal of answering many of the performance related questions aspirational bike riders should be asking in sporting events increasingly decided by marginal-gains. This report was commissioned by **Williams Cycling** to evaluate the performance of the **2014 Wheel System 58** and **2014 Wheel System 85** aerodynamic wheelsets given recent test data from the A2 Wind Tunnel and relative to competitor products.

Highlights

Wind Tunnel Drag Data

Test data suggests the **Williams 85** generates on average 71% less drag than a standard alloy wheelset at yaw angles between 0 and 20 degrees. The **Williams 58** generates 62% less.

Aerodynamic Watts @ 25mph

At sea level air densities the **Williams 85** demands, as an average of values at 0-20 degree yaw angles, 6 watts of power to overcome aerodynamic resistance in steady state cycling at 25 mph. The **Williams 58** demands 7 watts. By comparison a “box” section alloy wheel demands 19 watts.

Theoretic Time-On-Course Savings

In a model scenario where a 70 kilo (154 pound) rider with a 300 watt power output (similar to many amateur cyclists) participates in the 2014 US Pro Time Trial Championships – Chattanooga TN use of the **Williams 85** results in a time saving of 1:18 compared to the same ride with a box alloy wheelset. Use of the **Williams 58** results in a time saving of 1:09.

In a model scenario where a 70 kilo rider with a 300 watt power output participates in the IronMan World Championship - Kona use of the **Williams 85** results in a time saving of 7:51 compared to the same ride with a box alloy wheelset. Use of the **Williams 58** results in a time saving of 7:00.

Aerodynamic Value Analysis

At the time of writing the 2014 Williams 85 and/or 2014 Williams 58 wheelsets are available direct-to-consumer at USD 1,199. When evaluated in terms of “upgrade cost-per-watt” either wheel system is up to 3X cheaper than similar competitor wheelsets considered in this analysis. When evaluated in terms of cost of theoretic time-on-course savings Williams wheelsets are equally appealing.

1 – Test Scenario & Data

Williams and competitor wheels were tested at the A2 Wind Tunnel during a same-day test session in June of 2014. All wheels were tested without skewers and fitted with Continental GP 4000S clincher tyres inflated to 100 PSI. For comparison drag data were normalised to values corresponding with ISO Sea Level air having density 1.225 kg/m3 (29.92 hg) and bike axis airspeed of 48.28kph (30mph).

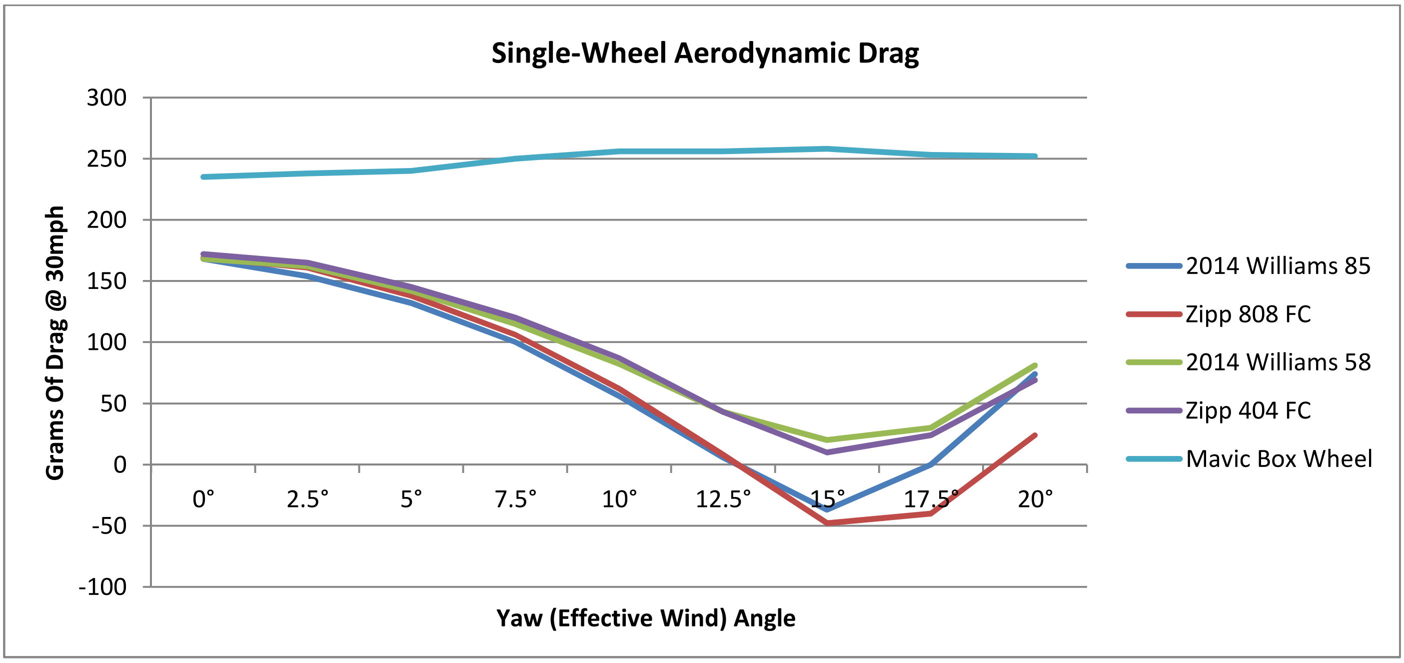
Test data, adorned with individual wheel weights, is presented numerically as under:

	Grams Weight		Grams of Drag at Yaw Angle								
	Front	Rear	0°	2.5°	5°	7.5°	10°	12.5°	15°	17.5°	20°
2014 Williams 85	816	1022	168	154	132	100	56	6	-37	0	74
Zipp 808 FC	815	980	169	161	138	106	62	8	-48	-40	24
2014 Williams 58	729	960	168	162	142	115	82	43	20	30	81
Zipp 404 FC	715	875	172	165	145	120	87	43	10	24	69
Mavic Box Wheel	-	-	235	238	240	250	256	256	258	253	252

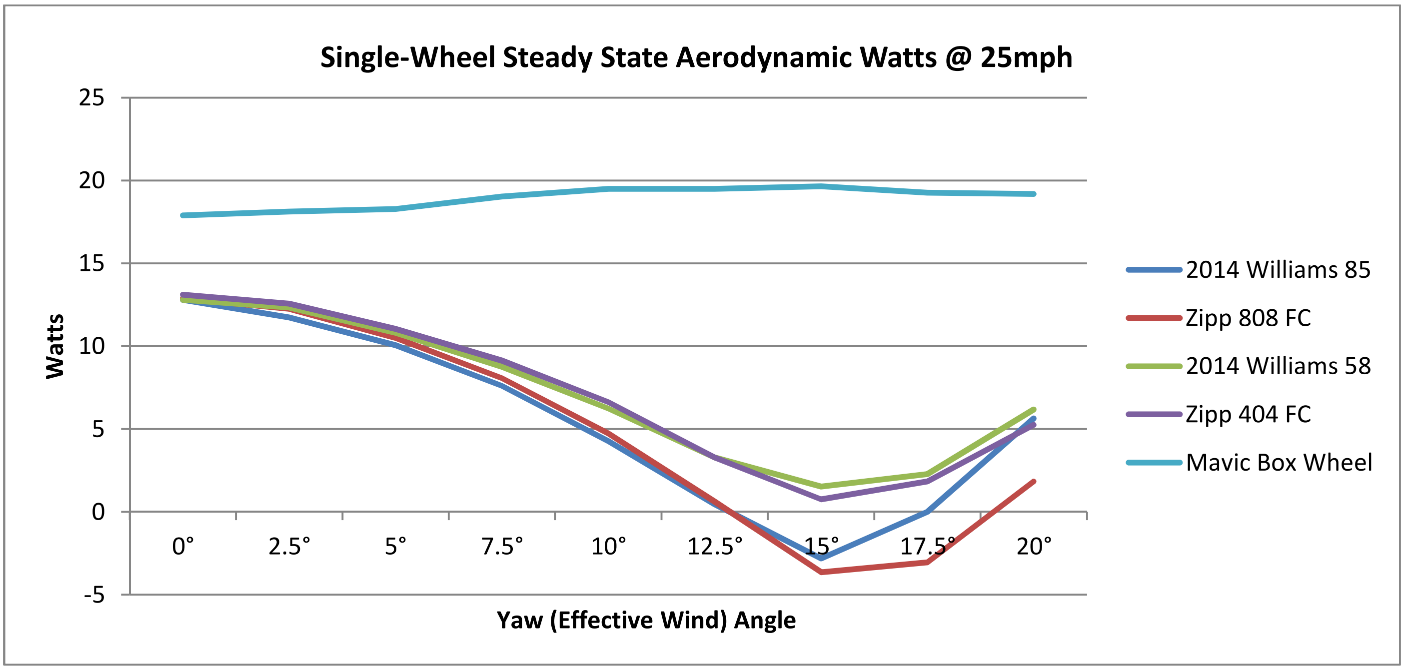
2 - Drag Data Interpretation

The raw drag data in section one is presented graphically and demonstrates:

- Profound performance differentials between the a baseline “Box Wheel” and aerodynamic choices
- Outperformance of deeper section wheels (e.g. Williams 85) versus mid-depth wheels (e.g. Williams 58).
- Performance of the deep and mid-section 2014 Williams wheels broadly matches that of the deep and mid-section products from Zipp, only diverging slightly at yaw (effective wind) angles exceeding 15 degrees.



As an alternative measure of aerodynamic quality which has increasing meaning to the growing population of cyclists riding with power meters we can convert drag data, via component CdAs, to steady state aerodynamic watts. That is, the watts of power required to move an object with the defined drag property through the air at a defined constant speed. Setting bike speed equal to 40.23kph (25mph) and air density to ISO sea level of 1.225 kg/m3 (29.92hg) suggests the following charted values.



As a frame of reference typical amateur cyclists can sustain a power output of 200-300 watts for an hour, very good ones can sustain 300-350, while elite and professional riders may sustain 350-400+. This implies that in some circumstances the choice of an aerodynamic wheelset over a baseline “box” wheelset offers effort savings or speed gains equivalent to 10% or more of sustainable power.

3 - Time Savings

To consider time savings attributed to wheel choice in a meaningful way which erases the doubt that a manufacturer has simply defined a test scenario which most benefits their wheel performance it is insightful to consider examples of real event courses, under real or probable event weather conditions. Cycling Power Lab has modelled two well-known events, the **US Pro Time Trial Championship** - **Chattanooga TN** and the **IronMan World Championships - Kona HI**. Several assumptions underpin this modelling and have been chosen to correspond with typical cyclists riding typical race bikes:

- Rider weight 70kg (154 pounds), Bike Weight 8kg (17.6 pounds)
- Sustainable Power Output 300 watts
- Aerodynamic Drag Area (CdA) 0.25 metres squared, Coefficient of Rolling Resistance (Crr) .003
- The frame &/or rider shield the rear wheel such that only 60% of its drag impacts forward speed.

The following table highlights the details and conclusions from this modelling.

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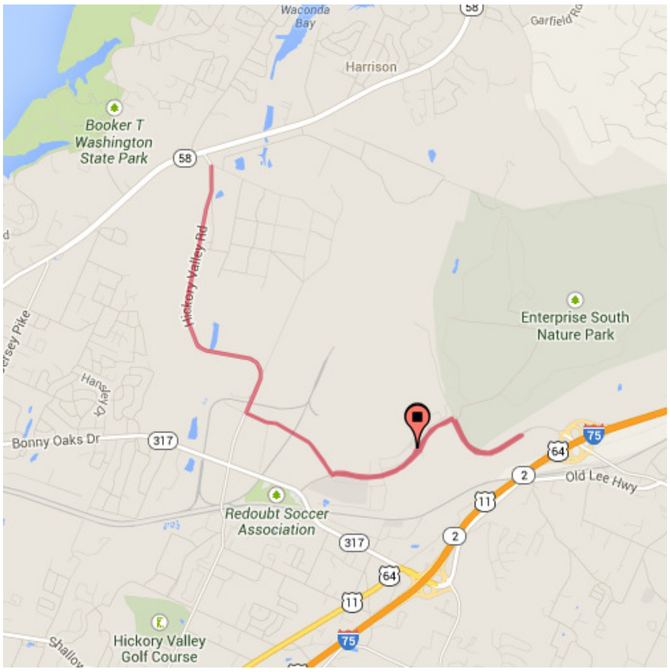
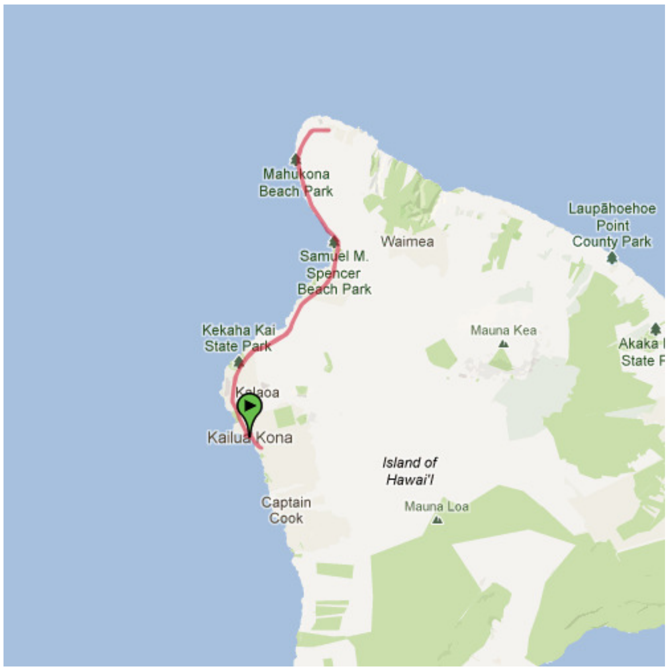
Event Modelling – Scenarios

<table>
<tr><th>USA Cycling 2014 Time Trial Championship (Elite Men)
Chattanooga, TN</th><th>2014 Ironman Triathlon World Championships
Kona, Hawaii</th></tr>
<tr><td>
</td><td>
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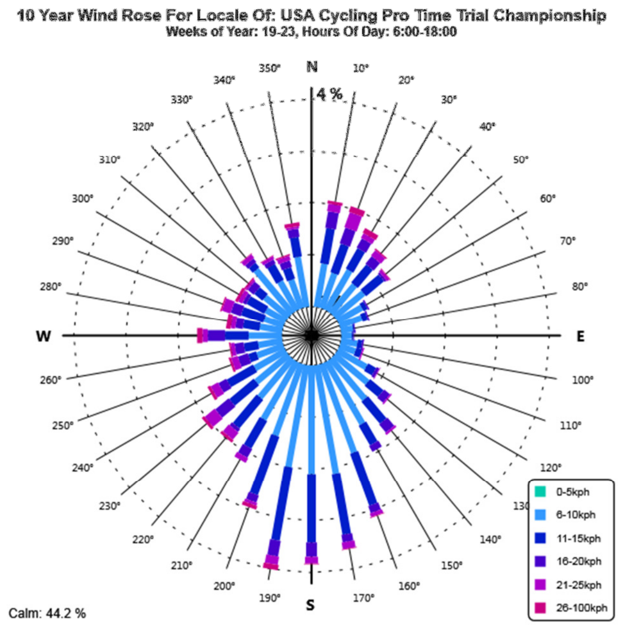
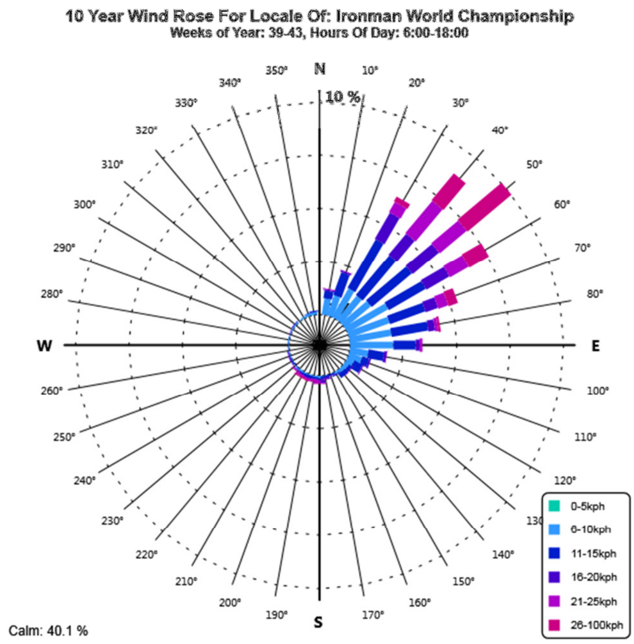
<tr><td>
</td><td>
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<tr><td>Probable Wind 190° 11-15kph</td><td>Probable Wind 50° 11-15kph</td></tr>
<tr><td>Gradient Adjusted Scenario 190° 10kph (6.2mph)</td><td>Gradient Adjusted Scenario 50° 10kph (6.2mph)</td></tr>
</table>

Event Modelling - Pace Estimates

"Box" Wheels 45:02	"Box" Wheels 4:28:34
Williams 58 43:53 (-1:09)	Williams 58 4:21:34 (-7:00)
Zipp 404 FC 43:54 (-1:08)	Zipp 404 FC 4:21:40 (-7:03)
Williams 85 43:44 (-1:18)	Williams 85 4:20:43 (-7:51)
Zipp 808 FC 43:45 (-1:17)	Zipp 808 FC 4:20:51 (-7:43)

In our model scenarios the aerodynamic wheelsets from Williams Cycling or Zipp clearly promise significant time savings relative to baseline "box" wheels while the performance differential between the tested mid-section wheels (Williams 58 and Zipp 404) or the tested deep-section wheels (Williams 85 and Zipp 808) is small and often in favour of the Williams wheelset.

Readers interested in (re)evaluating these or other event scenarios can do so interactively at the Cycling Power Lab website. To model performance on the US Pro Time Trial course visit http://cyclingpowerlab.com/pem=32300f0f and to model performance at Kona visit http://cyclingpowerlab.com/pem=ba7bf466

4 - Value Analysis

The decision to purchase a particular wheelset is a lot like choosing any other bicycle component – the lightest, fastest, industry leading components are always available at a premium – but many consumers look for a compromise of price and performance which best meets their needs. It has long been possible to evaluate lightweight components in terms of "dollar cost per gram saved" and we present some similarly transparent aerodynamic value analysis of the wheelsets featured in this report.

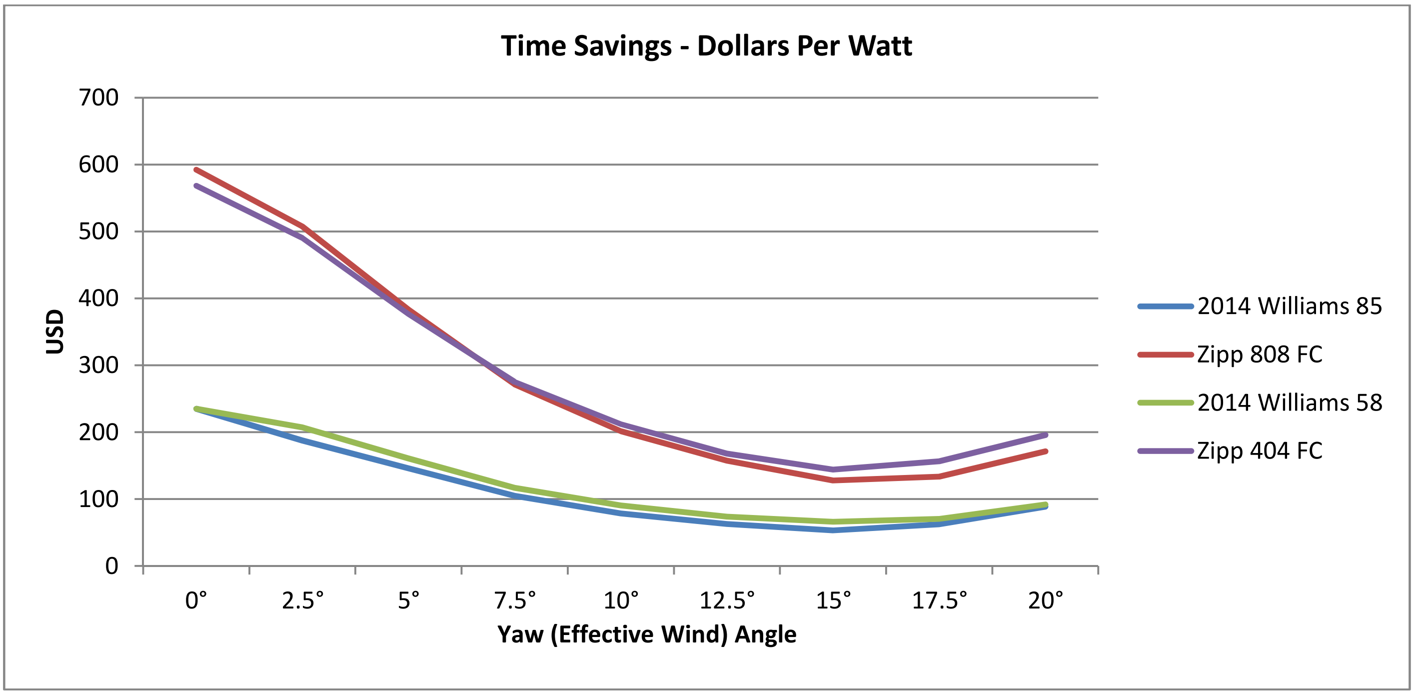
Methodology

All bicycles need wheels hence the decision to invest in a mid or deep section aerodynamic wheelset is a matter of speed gains, alternatively represented as wattage or time savings on a particular course, achievable by changing from some "baseline" wheelset. In the following analysis we consider the incremental effect of changing from a "box" alloy wheelset to an aerodynamic alternative.

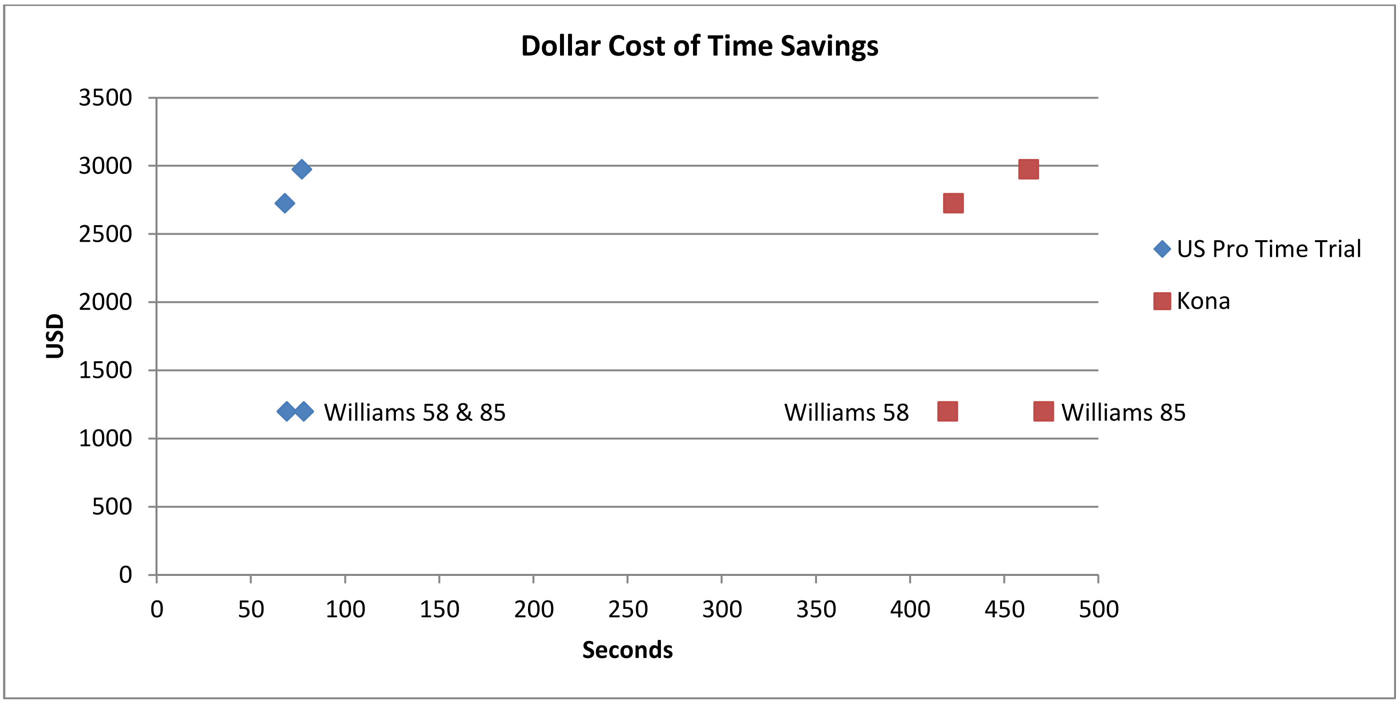
For the purposes of this analysis wheelset prices are taken as:

- 2014 Williams 58 USD 1,199 (direct-to-consumer from http://www.williamscycling.com)
- 2014 Williams 85 USD 1,199 (direct-to-consumer from http://www.williamscycling.com)
- Zipp 404 FC USD 2,725 (typical price from http://www.competitivecyclist.com)
- Zipp 808 FC USD 2,975 (typical price from http://www.competitivecyclist.com)

Firstly, subtracting drag numbers associated with the baseline wheel from alternative wheel choices we compute wattage savings through all yaw angles, then dividing the cost of the upgrade wheelset by these wattage or time savings we reveal dollar cost per aerodynamic watt saved.



Alternatively studying the dollar cost of upgrades versus their time savings in the two event scenarios outlined in section 3 we have:



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