State of Electric Motorcycles 2015

Presented by Kraig Schultz with
Scot Harden, Richard Goff, Craig Vetter

Vintage Motorcycle Days 2015

Video of Presentation
As Given at VMD 2015

https://www.youtube.com/watch?v=lkLlrFDHXSQ

State of Market: 2015

ZERO SR ZF12.5 +Power Tank

- Range: 85-185 miles
- Top Speed: 102 mph
- Fuel Cost Per Mile: $.015
- Battery Life: 415,000 miles
- 0-60mph, 3.3 Seconds
- Price: $15,995

Agenda

- Introduce Presenters (3 minutes)
- Video Showcasing Electric Capabilities (2 minutes)
- Common Questions (Range, Charge Time, Top Speed, etc.) 15 minutes
- One Message from Each Panelist (15 minutes)
- The Future (5 minutes)
- Q&A – Open questions from floor (15 minutes)

Video

- Video Showcasing Electric Capabilities (2 minutes)

The typical before and after impression that riders have once they've test ridden an electric bike. The biases quickly disappear once a rider experiences the pure performance electrics offer. Here is a link to that video: https://youtu.be/hXroWleidvk

Gizmag's Review of LS-218 https://www.youtube.com/watch?v=o3DiAecsh_0

www.zeromotorcycles.com/press

Video showing how police use electric bikes. Over 50 agencies in the US are using Zero Motorcycle, Inc. bikes: http://www.motorcycle.com/features/the-life-electric-you-have-the-right-to-remain-silent.html

Presenters

(Note: All Presenters Own and Ride Electric Motorcycles)

- Kraig Schultz – Sustainable Energy Advocate
- Scot Harden – VP of Global Marketing, Zero Motorcycles, Inc.
- Richard M. Goff, Phd – Professor Virginia Tech.
- Craig Vetter – The Vetter Fairing Company

Kraig Schultz

Grand Haven, Michigan

www.SchultzEngineering.US

Delta-11 Prototype

- Helped design/build 13 Electric Vehicles since 2007
- Ridden 16,000 electric miles
- Recharges Bike with Solar Panels he installed at his home
- My Message: Solar Panels our homes can provide ALL energy for our home and transportation for less $ / month than we pay today!
- My Goal: Bring Jobs and Hope for a better future back to America

Scot Harden

California

Zero Motorcycles, Inc.

- Scot Harden is one of the sports most prolific off-road racing champions and a member of the AMA Hall of Fame. With a career spanning some four decades Harden is noted for the wide range of off road disciplines he mastered. A Multi Time Baja 500 and 1000 Overall Champion, B to V Hare and Hound Overall Winner, ISDE Trophy Team Member, Dakar Rallye competitor (and the first American to win an African Marathon Stage Rallye) plus SCORE, Best in the Desert and AMA Off Road Championships to his credit the longer, the tougher, the more endurance and stamina required the more Harden excelled. Parallel to his racing career Harden is widely known for an impressive executive management career in the motorcycle industry, which includes experience in marketing and communications, media relations, race team management and product planning. He has held executive management positions with some of the most iconic brands in the sport including KTM, Husqvarna, BMW and most recently Zero Motorcycles where he currently serves as VP of Global Marketing.

Richard M. Goff, Phd

Virginia

Virginia Tech

6 Motorcycles + 2013 Zero S

- Richard M. Goff holds a Ph.D. in Aerospace Engineering and is an Associate Professor in the Department of Engineering Education at Virginia Tech. He is the recipient of several teaching, outreach, and best paper awards. His passion is creating mindful, authentic, and engaging learning environments by creating student led engineering design opportunities and bringing educational research results into the classroom.

- Richard has been a motorcycle enthusiast for 50 years. He is an A class Enduro rider, motorcycle commuter, tourist, and adventurer. He is the faculty advisor of the Virginia Tech Motorcycle Fuel Economy Vetter Challenge team and has been riding a Zero DS electric motorcycle for two years.

- The thing I am most excited about with Electric Motorcycles is that they are becoming more accepted. They are the perfect motorcycle to own because they are fun to ride, quiet, require almost no maintenance, use NO GAS, and can sit in your man cave without stinking up the house.

- I'd like to talk to people about how great the Zero has been for me commuting, riding in the Vetter Challenge and riding in the mountains and to Roanoke about 45 miles away. The fact that Harley-Davidson has gotten into the game will assist in the acceptance and adoption of electric motorcycles. Today, you can build an electric motorcycle from scratch, convert a gas bike, or buy very capable bikes (0-60 in 3 seconds, 170 miles on a charge). Riding my Harley is like flying a 51 Mustang. Riding my Zero is like soaring. They each have a special appeal to me.

- If I'm not traveling cross country, the Zero is almost always my first choice in the stable.

Craig Vetter

California

www.CraigVetter.com

Steam-lined Honda Helix

2014 Zero FX

- Inventor of the Wind Jammer Fairing
- Responsible for the Modern Streamlined Motorcycle Movement

The Most Common Questions

- RANGE
- Re-Charge Time
- Top Speed
- 0-60 Time
- Power (Hp and Torque)
- Battery Chemistry
- Battery Size, Battery Weight
- Battery Life (miles, recharge cycles)
- Where to Recharge?
- Fuel Economy: Wh/Mile, MPGe, Cost to Recharge, Cost per Mile
- Price
- Projected market size
- Can I recharge while riding the bike?
- Is Electric a good daily rider?

RANGE – How Far Will It Go?

Kraig & Scot

- Range is affected by these things
  - Speed
  - Battery Size
  - Aerodynamics
- 40 to 300 miles depending on how fast you ride!
- See Next Slides for What Terry Hershner Has Do
- Ben Rich traveled 475 in a 17 hour day during his day, electric motorcycle tour of US

Terry Hershner went 300 miles on one charge at 70mph Summer 2015

John McGuinness Averaged 113mph for 37.7 Miles during 2015 win of Isle of Man Race

Terry Hershner

California

“Electric Terry” on Facebook

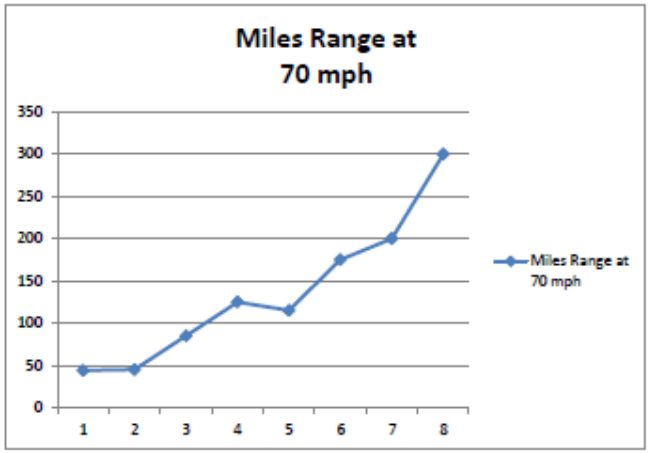
2013 Zero S, 2015 Zero S

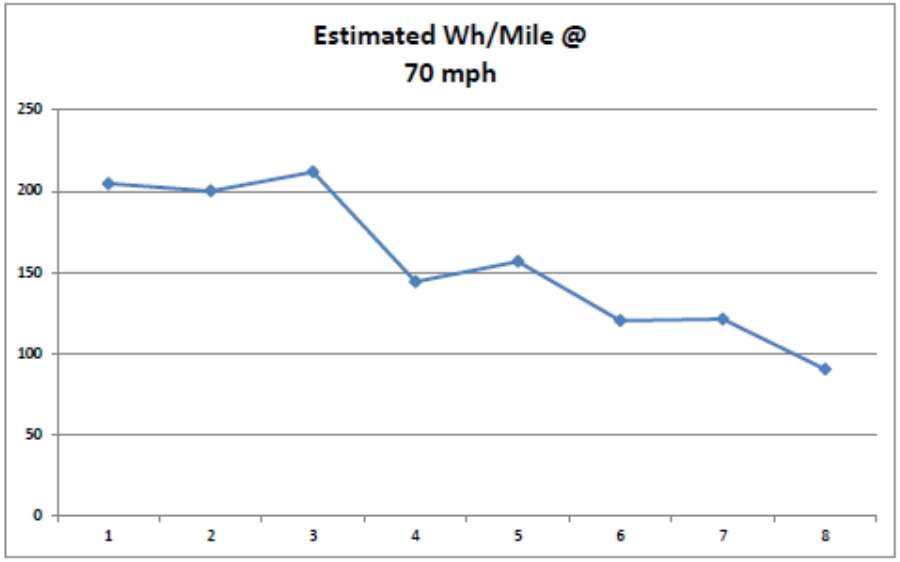
- Ridden all over the country proving electric motorcycles can tour
- Ridden 80,000 electric miles!

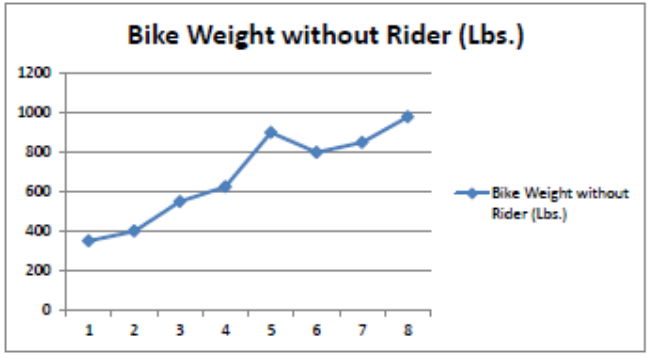
Terry Hershners Progress

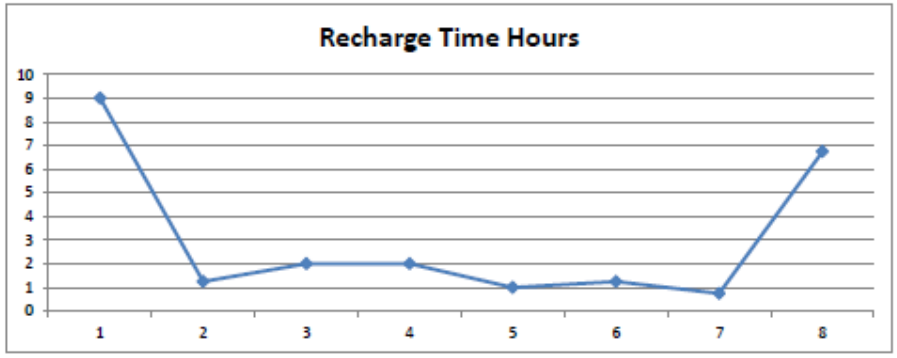
Data from: http://www.craigvetter.com/pages/2015-Streamliner-pages/2015-Terry-Streamliner-history-p86.html
http://insideevs.com/electric-terry-hershner-rides-300-miles-on-zero-motorcycle-on-one-charge/

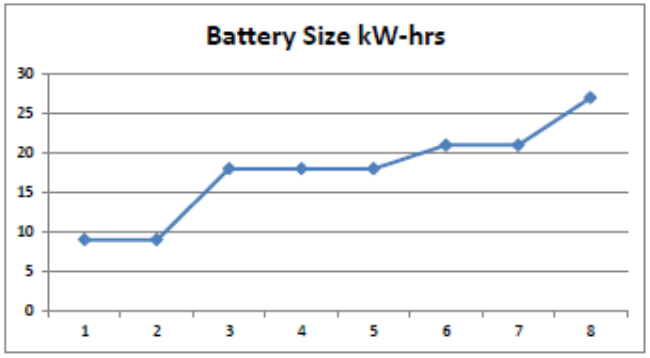
Stage	Battery Size kW-hrs	J1772 Connections	Chargers On Board	Charger Output kW	Recharge Time Hours	Bike Weight without Rider (Lbs.)	Miles Range at 70 mph	Estimated Wh/Mile
1	9	0	1	1	9	350	44	205
2	9	1	5		1.25	400	45	200
3	18	2	4	4	2	550	85	212
4	18	2	6	15	2	625	125	144
5	18	4	8	17	1	900	115	157
6	21	3	6		1.25	800	175	120
7	21	4	9	22.5	0.75	850	200	121
8	27	1	2	4	6.75	980	300	90







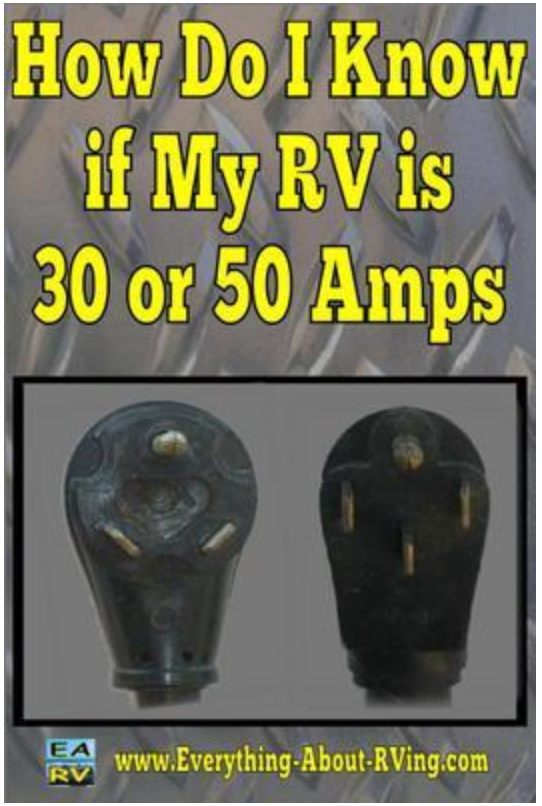




Re-Charge Time

Kraig & Scot

- 30 minutes to 6 Hours depending on your pocket book and location
- Re-Charge Time Is Affected by
  - Charger Size
  - Battery Size
  - Grid Connection Size



Top Speed

Kraig & Craig

- Lightening LS-218 (Land Speed Record = 218MPH)

Source: http://insideevs.com/wp-content/uploads/2014/12/ls-218-specs-graphic2.jpg

Average Speed Racing

Kraig & Scot

- IOM Race Results https://en.wikipedia.org/wiki/TT_Zero

Fastest race lap by year [edit]

(practice & qualifying session laps not included)

Year	Rider(s)	Machine	Lap time	Average speed	
				mph	km/h
2010	Mark Miller	MotoCzysz E1pc / MotoCzysz	23:22:89	96.820	155.817
2011	Michael Rutter	MotoCzysz	22:43:68	99.604	160.297
2012	Michael Rutter	MotoCzysz	21:45:33	104.056	167.462
2013	Michael Rutter	MotoCzysz	20:38:461	109.675	176.505
2014	John McGuinness	Shinden San / Team Mugen	19:17:300	117.366	188.882
2015	John McGuinness	Shinden San / Team Mugen	18:58:743	119.279	191.961

The TT Zero lap speeds have been improving at an average rate of around 4 mph each year since the series began (119.279 mph as of 2015).

Gallery [edit]

2012 Isle of Man TT TT Zero - Michael Rutter on MotoCzysz during

2012 Isle of Man TT TT Zero - (2) Mark Miller Motoczysz Elpc followed

2013 Isle of Man TT TT Zero Practice Session Mark Miller (2)

2013 Isle of Man TT TT Zero Race – Michael Rutter (1) Motoczysz

2014 Isle of Man TT TT Zero Practice Session Bruce Anstey (5)

0-60 mph Time

Kraig

- 2015 Yamaha R1 2.6 Seconds
- 2015 Zero SR 3.3 Seconds
- 2014 Harley Davidson Break-Out 4.6 Seconds

https://en.wikipedia.org/wiki/List_of_fastest_production_motorcycles_by_acceleration

Horse Power & Torque

Kraig & Scot

- 2015 Yamaha R1 https://rideapart.com/articles/2015-yamaha-r1-r1m-specs-closer-look-video
- 2015 Zero SR 3.3 Seconds http://www.zeromotorcycles.com/zero-s/specs.php
- 2014 Harley Davidson Break-Out 4.6 Seconds http://www.cycleworld.com/2013/12/02/harley-davidson-breakout-vs-victory-jackpot-vs-yamaha-star-raider-comparison-review-specs-photos/

Make	Hp	Torque (ft-lb)	0-60
R1	200	83	2.6
SR	67	106	3.3
Break-Out	67	86	4.6

Battery Chemistry

Kraig & Scot

- “Lithium Ion” same technology as in your laptop and cell phone and electric car but improving quickly because there is $ in it!

- Many Promising New Technologies, but we are actually seeing 5-10% Improvement each year in Cost/Watt Hour

- Current State of Art in Zero Motorcycle: NCM (nickel cobalt maganese, with a pure graphite anode) cells. Running at 102Volts

Battery Size & Weight

Kraig

- 100 lbs. of battery = about 5.5 kWh = .16 Gallons of Gasoline
- Typical bike has 11 kWh of battery = 200 lbs of battery
- Battery fills the entire center section of the bike

- Note: 1 gallon of gasoline = 33.7 kWh of Energy

- SOURCES:
- https://evmc2.wordpress.com/2013/12/01/2014-z
- https://en.wikipedia.org/wiki/Miles_per_gallon_
- http://media.zeromotorcycles.com/resources/ow
- http://www.motorcycle.com/features/inside-batt
  video.html/attachment/040715-zero-motorcycles

Battery Life

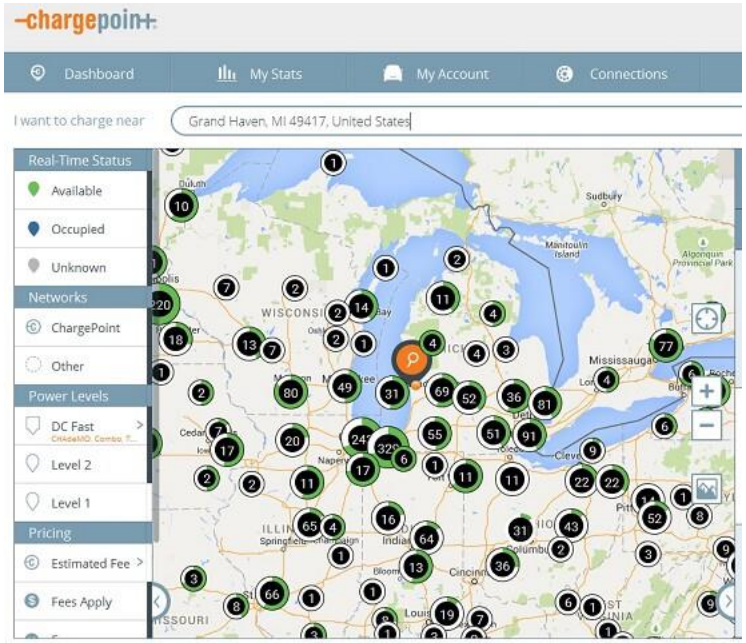
Scot H.

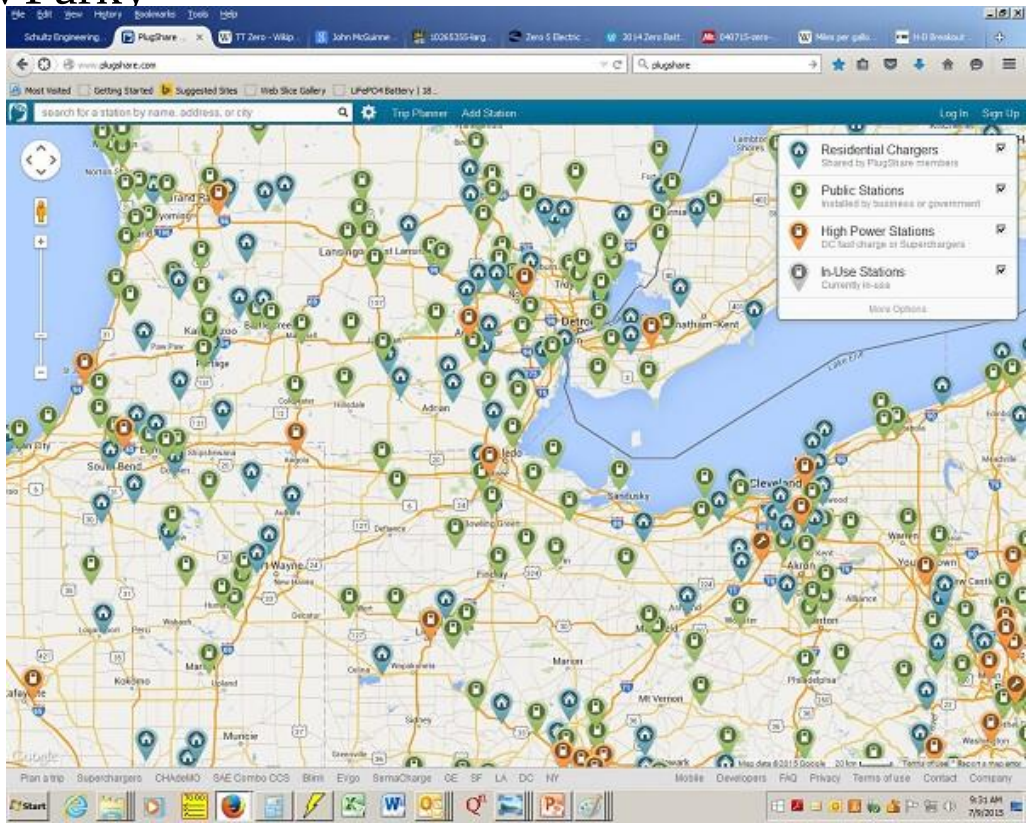
- Battery Life = 300,000 to 400,000 Miles expected
- Terry H. has fast charged his for 76,000+ miles

Recharge Locations

Kraig

- Charge Point https://na.chargepoint.com/charge_point
- Plug Share http://www.plugshare.com/
- Local Park or Camp-Ground RVParky
- Every Building in America





Fuel Economy

Craig Vetter

- Fuel Economy:
  - Watt Hours Per Mile = Wh/Mile
  - Wh/Mile = 100 Wh/Mile Typical Electric Motorcycle
  - 100 Wh/Mile = 337 MPGe
  - $.012 / Mile Cost to Recharge (or free)

  - https://en.wikipedia.org/wiki/Miles_per_gallon_gasoline_equivalent

  - Note: We can make our own electricity with Wind and Solar
  - Compare to Gas Car getting 30mpg at $3.5/Gallon = $.116 / Mile

Price

Scot & Richard

- Zero FX $8,495
- Zero SR $15,995
- Brammo Empulse $17,000 (Note: No longer available)
- Lightening LS-218 $38,000

Can I Charge While Riding?

Kraig

- Solar Racing Teams average way over the speed limit on sunlight http://www.solarracing.org/

- Generators take more power to turn than they generate, so wind turbines or generators hooked to your wheels will drain your battery faster than they charge it.

The solar panels shown provide enough power (100 kWh) for this motorcycle (81 Wh/Mile from the wall) to travel 1,200 miles a month. www.schultzengineering.us

Electric Daily Riding

Richard Goff

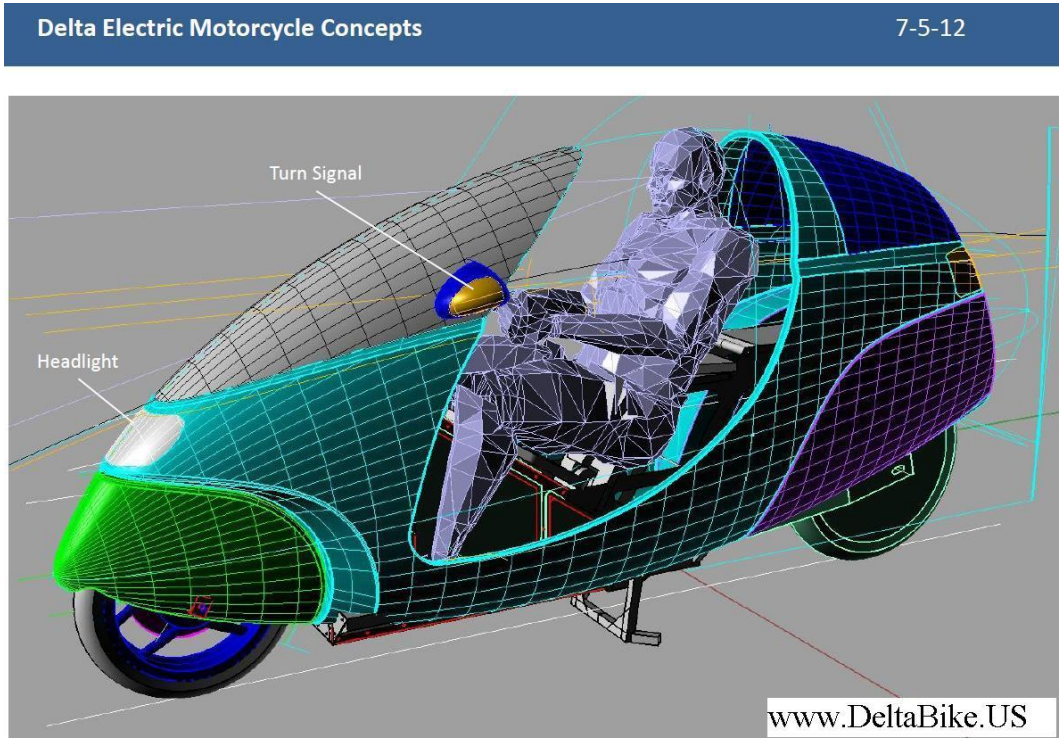
- Richard Owns 7 Motorcycles
- “If I’m not traveling cross country, the Zero is almost always my first choice in the stable.”

One Message from each Presenter

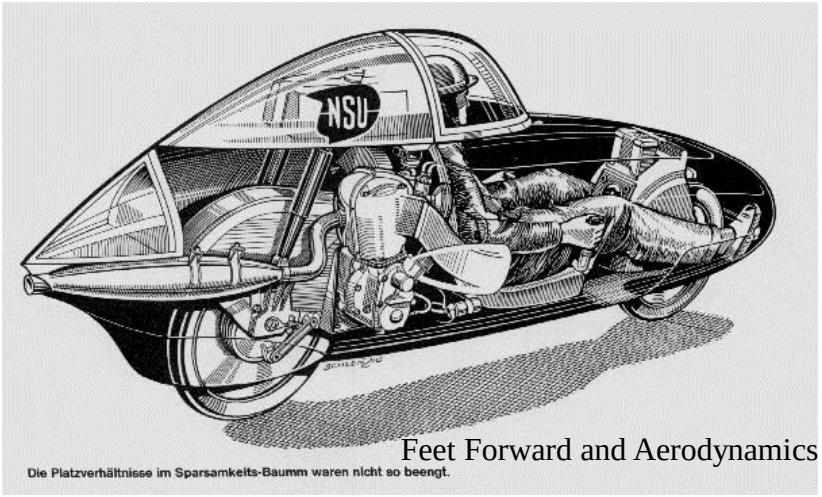
- Craig Vetter – It's the only energy you can produce at home!
- Richard Goff – Take a test ride.
- Scot Harden – "It's about the experience…Thrill, Adventure, Control… It's the closest thing you can find to a magic carpet ride in this day and age. Every time I ride, it's like the first time I rode a motorcycle. That childlike pure joy of doing something that's really cool…and that's what I get when I ride an electric motorcycle."
- Kraig Schultz - Never buy gas again!

The Future: Opportunities

- Range:
  -Aerodynamics
- Cost Per Mile:
  - Aerodynamics
- Performance:
  - Aerodynamics

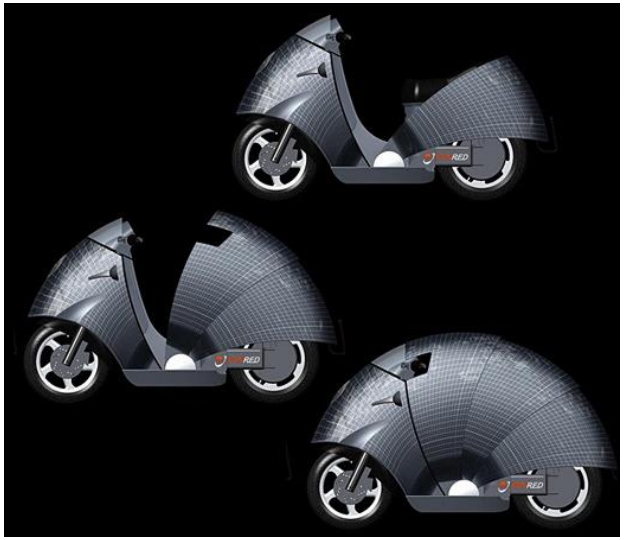


Important Concepts



Feet Forward and Aerodynamics

Electric Drive Train



Changing Shapes

Dustbin Fairing for Sale at Swap Meet this weekend!

1/2 price and no shipping if you take it with you!

Modern Aerodynamic Pioneers

Craig Vetter & Bike

Charly Perethian & Bike

Royce Creasey & Bike

Cedric Lynch & Bike

Alert Jacobs & Bike

Arnold Wagner & Bike

Alan Smith & Bike

Terry Hershner & Bike

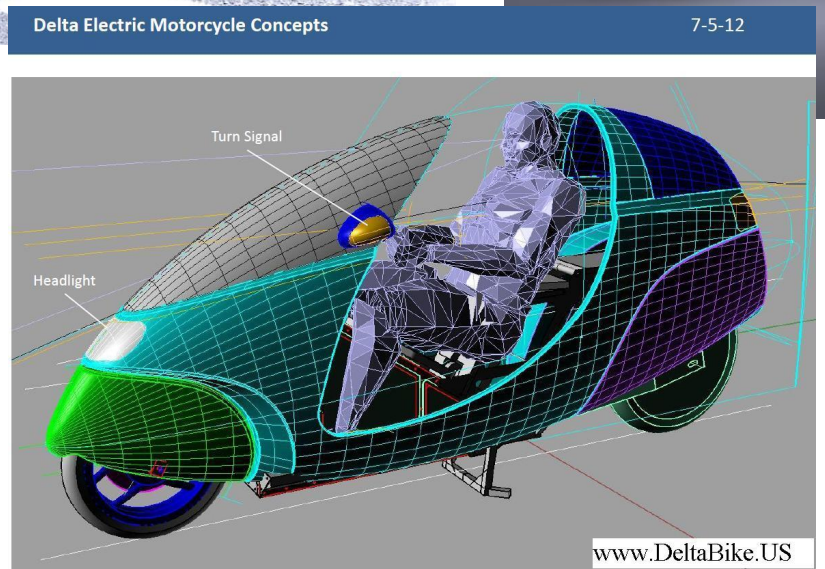
The Future:
Will we Ride on Top?

The Future:

or will we Ride Inside?

AKIRA'S Bike

TRON Bike



View Future Slides from Zero Motorcycle Company

I-Bike: The Future?

Most Important Future Ideas For Electric Bikes

- Faster Recharge times and Public Charging stations are here today!
- Plug-ins at merchants will become like Cable TV at Hotels
- Lightness is as important as Aero in town
- I-Bike – Electric riding will change the way we ride and where we choose to go. Electric Riding is a Social thing – with electronic mapping you will be constantly in touch with fellow I-Bikers, meeting new friends, visiting new places to "Re-Charge" electrically and socially.

150 Mile Ride with Us?

Vetter Fuel Economy Challenge

Racing for the right reasons

Mid-Ohio Sports Car Course, Lexington, Ohio. July 12, 2015

Sunday morning, July 12, 2015: 10AM
Depart the Track
Ride 77 miles to the Hall of Fame Museum
Take a little break
Ride back to the track

There will be a Riders Meeting the evening before
at 5pm behind the Spash Harbor Comfort Inn
Same place as last year

http://www.craigvetter.com/pages/2015-Challenge-pages/2015-VMD-Challenge.html

End of presentation

Questions?

For a Copy of This Slide Show

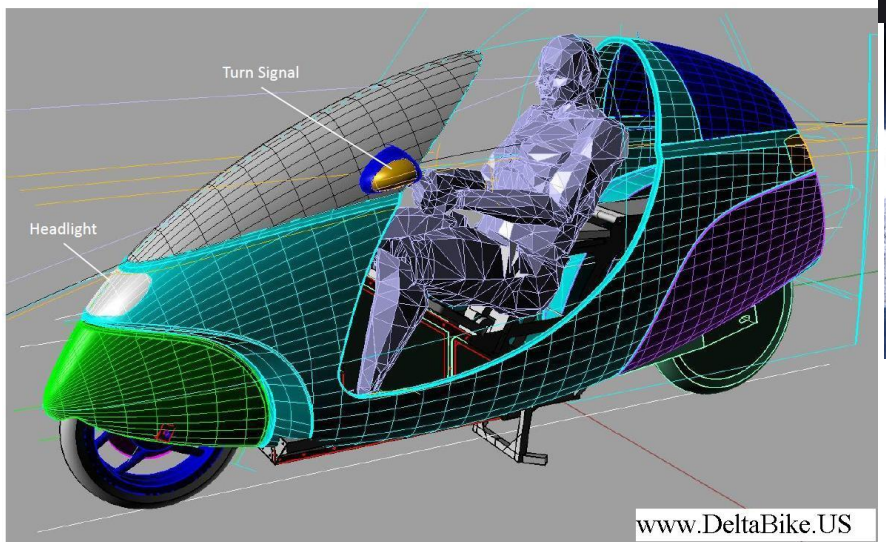
www.SchultzEngineering.US

www.SchultzEngineering.US

Balance of Slides are just resources, and may be deleted or modified for use during presentation

The Future

Delta Electric Motorcycle Concepts 7-5-12



When Will Next Battery Arrive?

"Why wait for a better battery? With LiFePO4 we have a practical commuter vehicle today, and with better Aerodynamics, we can make a practical touring machine."

Kraig Schultz 2012

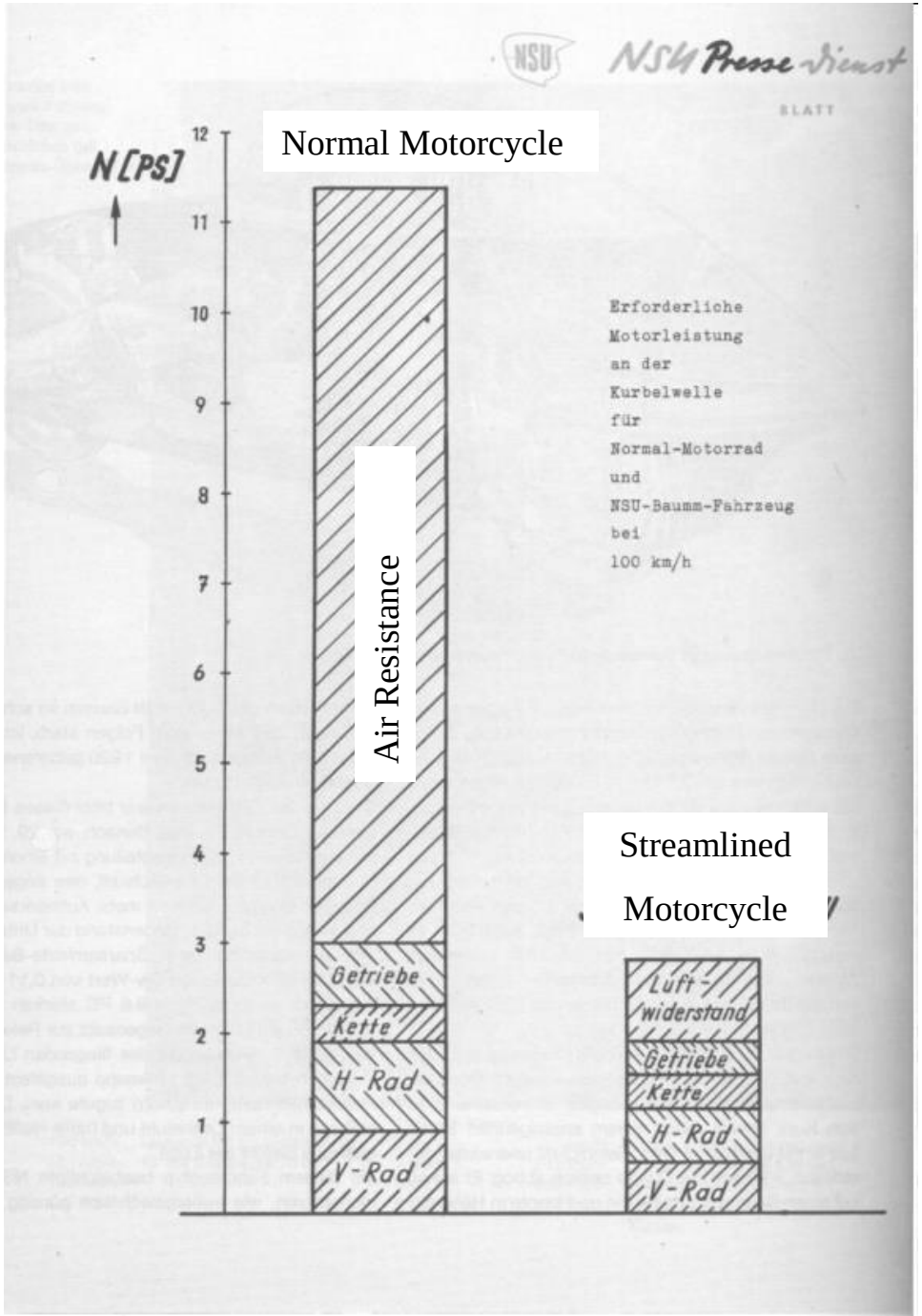
High Efficiency Recipe:

1. Electric Powered
2. Aerodynamic (Small & Sleek)
3. Light Weight
4. Low Rolling Resistance

Historic Aerodynamic Pioneer

Gustaff Baumm & “Flying Hammock” Bike

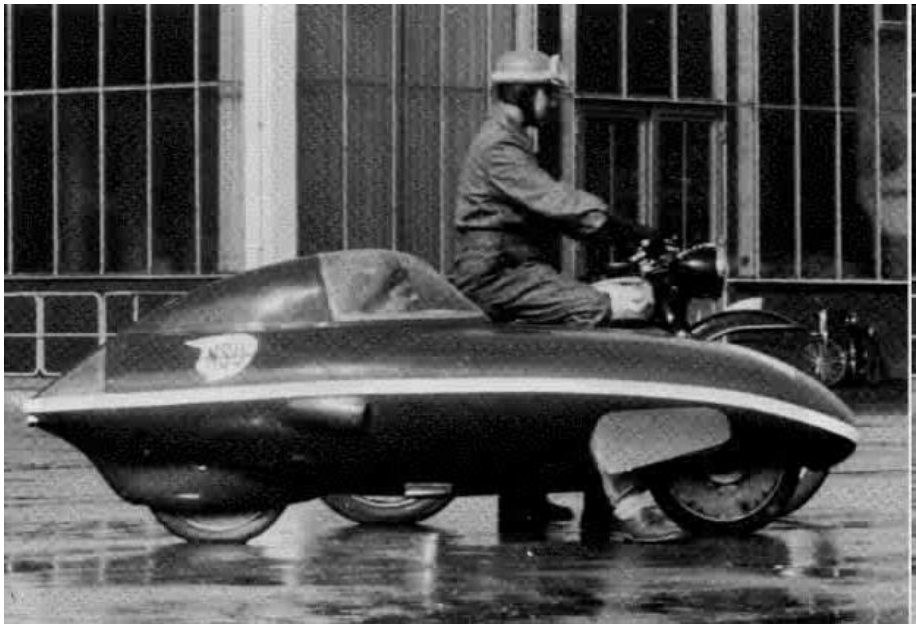
RIP – Tragically Died May 23, 1955 Testing
Race Version of his Bike at Age 36



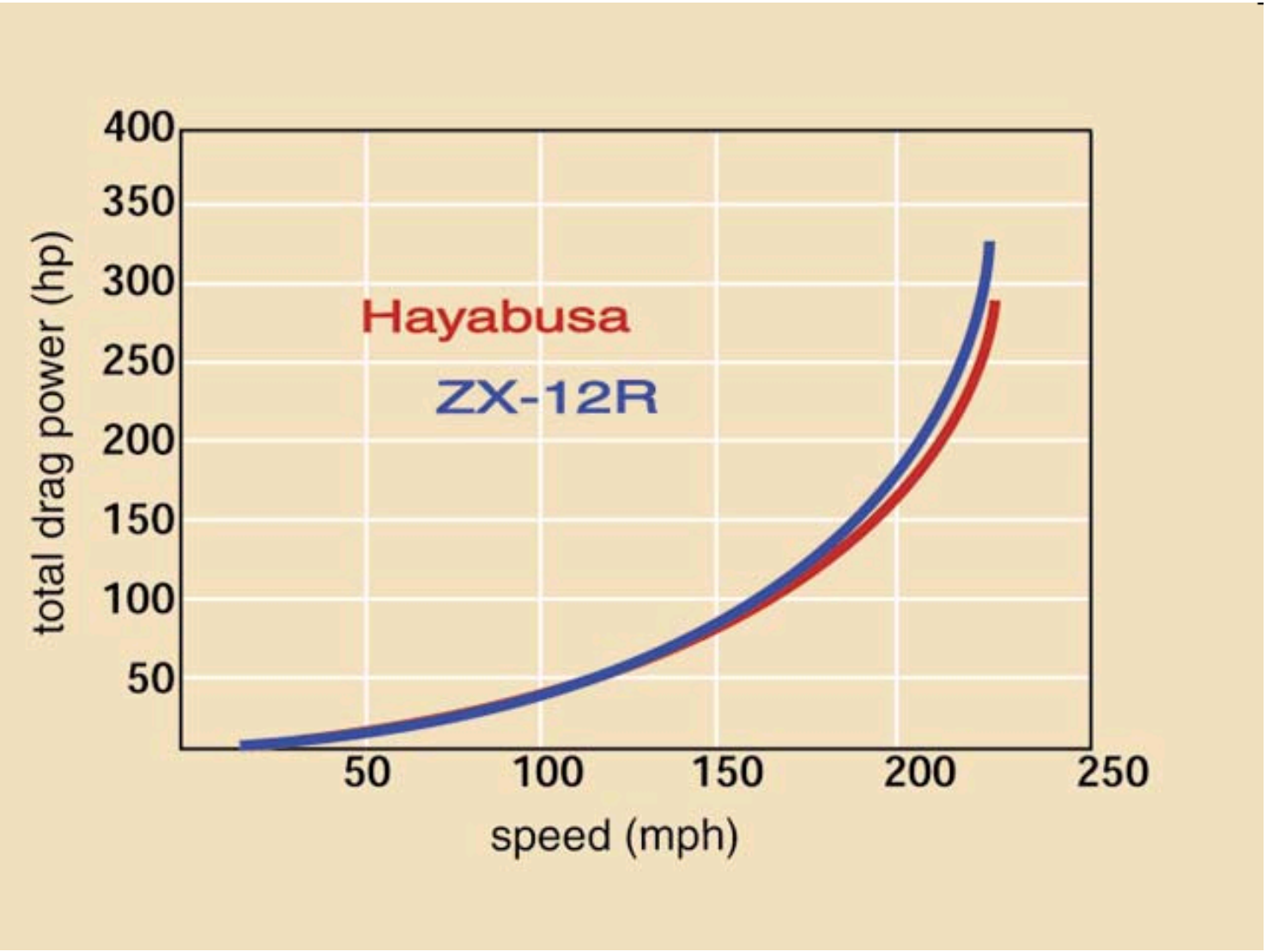
Sources of resistance at 100kph (62mph)

Luftwidersand (Air Resistance)
Getriebe (Transmission)
Kette (Chain)
H-Rad (H-Wheel)
V-Rad (V-Wheel)

Images from: http://www.eurospares.com/graphics/NSU/



Speed Vs. Horsepower



Aerodynamics in Practice

With just Human Power (less than 2Hp),

This vehicle has a top speed over 90mph.

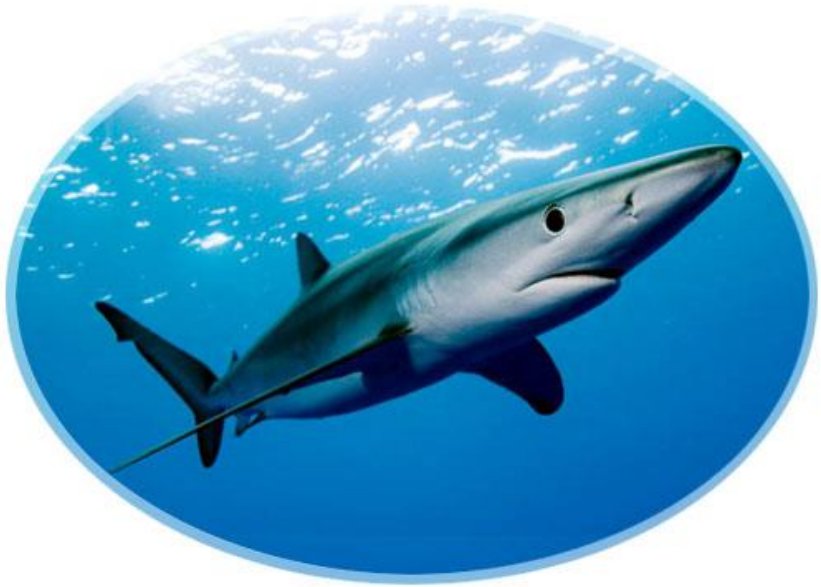
Aerodynamic Drag

$$Drag = \frac{\rho}{2} \cdot A \cdot Cd \cdot V^2$$

P = Density of air
A= Frontal Area
Cd = Coefficient of Drag
V = Velocity

Drag = 1/2(density of air) x (Frontal Area) x (Cd) x (velocity^2)

Aerodynamics: Cd
Cd= Coefficient of Drag= Sleekness

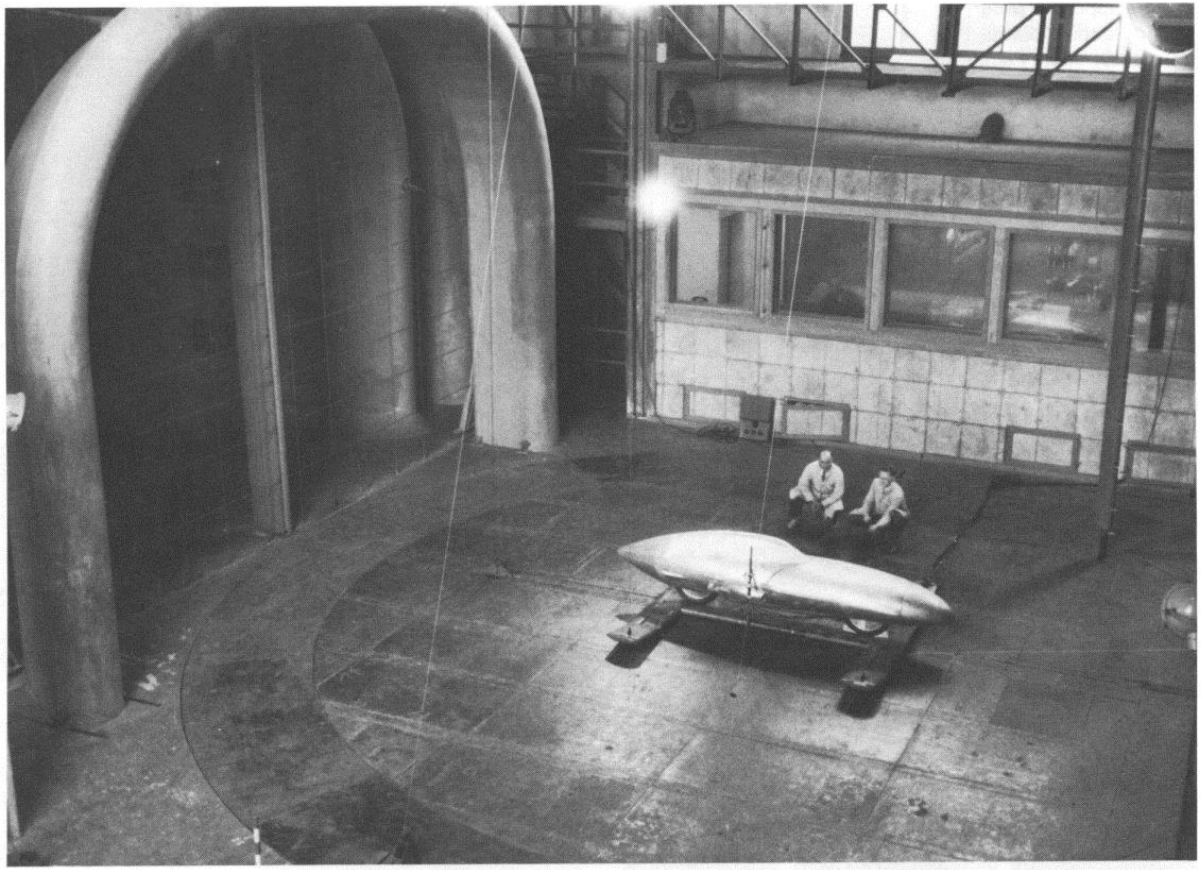


Blue Shark

Delta Wing = Indy Car Concept

Aerodynamics (Cd)

"A vehicles Cd figure, expresses it's resistance as a proportion of that given by a flat disc of the same frontal area. In those terms, the air resistance of the flying hammock was equal to that of a flat disc of 6.75 inch in diameter—say, an old fashioned headlamp glass!" From Exotic Motorcycles, Vic Willoughby



Monatelang suchten die NSU-Ingenieure im Windkanal der TH Stuttgart nach der günstigsten Form. Hier ist gerade der Baumm IV im Examen.

Aerodynamics: Frontal Area

Less Frontal Area = Less Drag

How Far Can You Go?

- 100 Wh/Mile
- 13.5 kW Hr about maximum Battery Pack you can fit on a motorcycle (size and weight)
- 13.5 kW x 70% DoD = 9.5kW Hr
- 9.5kW Hr / 100 Wh/Mile = 95 Miles!

Battery Chemistry's 2012

Chemistry	Wh/kg	Wh/L	Recharge Cycles	$/Wh
Lead Acid	40	75	300-500	$.08
LiFePO4	100	150	3,000-5,000	$.40
Lithium Polymer	150	300	2000-3000	$.60
Lithium Air?	11,000		?	?
Gasoline	12,222	9,667		

LiFePO4 Advantages

- ½ Weight of Lead Acid
- 10x cycle life of Lead Acid
- No Memory, can leave discharged, charge partially
- 85% recharge Efficiency
- Not prone to burst into Flames
- Lowest total $ per Mile

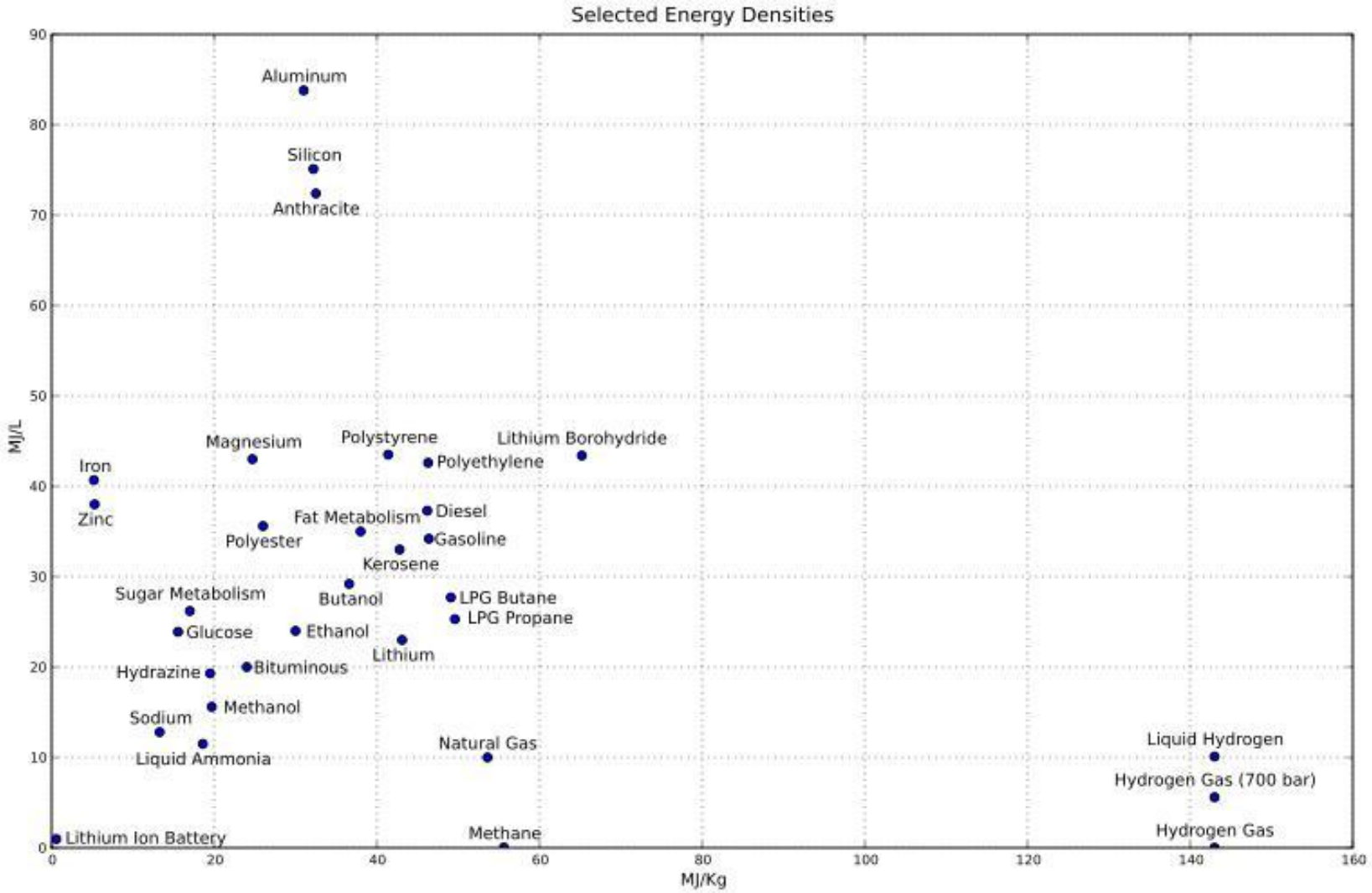
Everything is Relative

- Li Ion Battery's are very powerful
- But, Gasoline holds 100x more power per weight and volume than Li Ion batteries
- ½ gallon of Gas = 300lbs of batteries!
- Fortunately, electric vehicles are 5 times more efficient than Gasoline powered ones

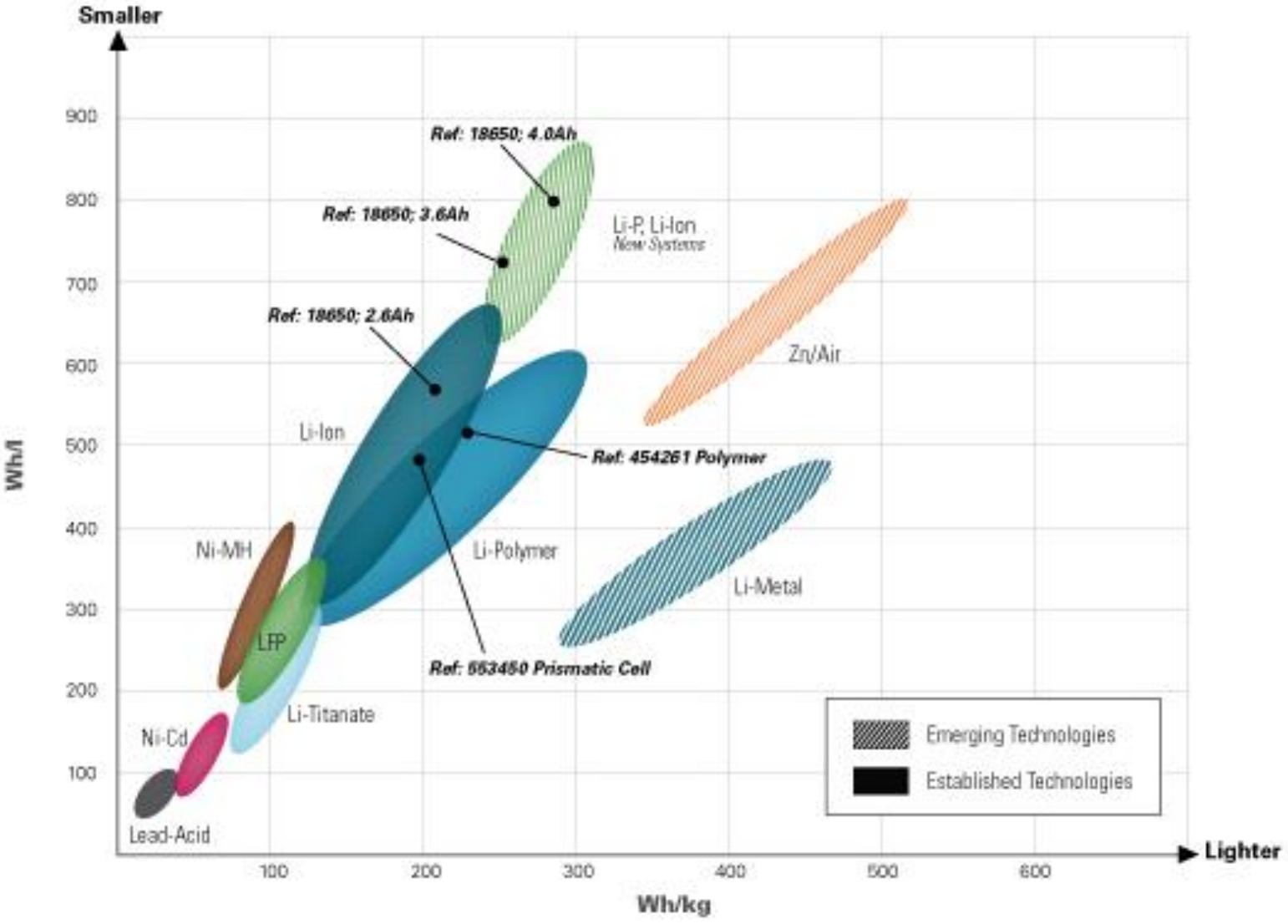
Battery Vs. Gasoline

- Typical Electric Motorcycles use 110 Wh/Mile = 306 MPGe
- 33,705 Watt hours = 1 gallon of gasoline
- 13.5 kW LiFePO4 weighs 300 lbs.

Energy Storage Mediums



Comparison of Energy Densities for Various Battery Chemistries



Tony Helmholdt

Grand Rapids, Michigan
TorkeElectricVehicles on Facebook
2014 Zero DS

- Tony's been converting and riding electric motorcycles since 2008. Tony Helmholdt has converted four electric sport bikes and consulted on the build of numerous others through his electric motorcycle company Torque Electric Vehicles, LLC. Tony also owns and rides a 2014 Zero DS. Tony works full time for Tesla as a regional Service Technician.