

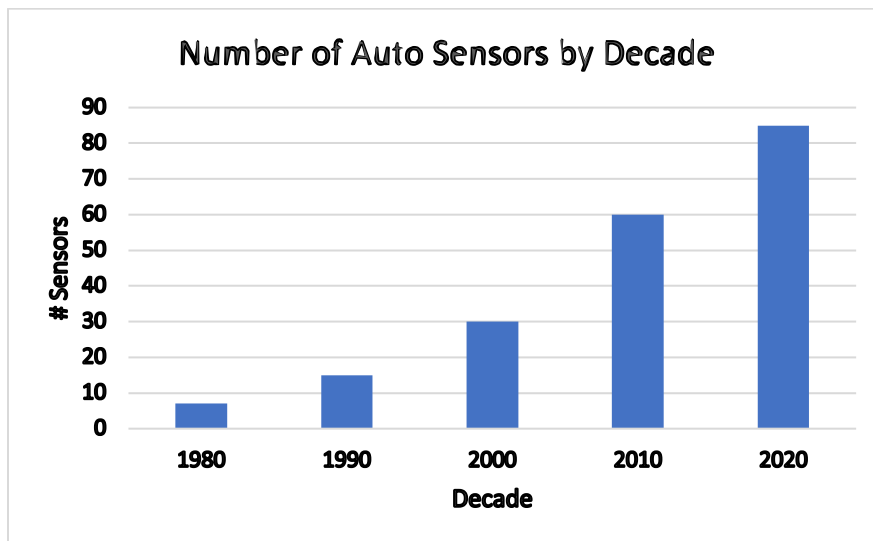
What eBikes Can Learn from Automobiles

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eBikes and automobiles share important commonalities: both are wheel-based forms of transportation and both use microprocessors, batteries, and motors. But despite these commonalities there has been an enormous difference in the marketplace performance of autos and eBikes: while automobiles have enjoyed rising prices, frequent innovations, and sustained growth, for the past four years eBikes have suffered declining prices, me-too product features, and lack of innovation: a perfect recipe for marketplace woes.

How have auto manufacturers achieved their product innovations? One possible answer might be “faster microprocessors”, but that is not the correct answer.

Microprocessors process information thousands of times per second, but a microprocessor’s “smarts” is limited to the information it processes—and *that information comes from sensors*. In the 1980s cars used around 10 sensors, focusing mostly on basic engine management functions like temperature, pressure, and speed monitoring. Since then, sensor usage has roughly doubled each decade, enabling better performance, safety, and features. Today, most cars have nearly 100 sensors. And more automobile sensors are on the way...



While other factors such as software advancements and computing power play a role in achieving higher performance and higher featured autos, *the foundational enabler of improved automobile performance has been sensor proliferation, providing more and more data to microprocessors.*

Contrast sensor proliferation in autos to sensor stagnation in eBikes. Today's core eBike sensors measure bike speed, cadence, and motor power; on more expensive eBikes, a torque sensor measures pedal power. (Some might argue that an eBike brake switch is a sensor, but that's like saying an on/off switch is a sensor). No matter how you count, eBikes of 20 years ago had nearly the same array of sensors as those today. *eBike manufacturers have not followed the sensor proliferation/feature innovation path of auto manufacturers.*

In fact, it is readily apparent that there are five major differences in design philosophy between sensors used in automobiles and those used in eBikes:

1) Auto manufacturers have strategically deployed additional sensors to improve car performance, enable new features, differentiate models and brands, and deliver more value to customers. With the exception of a torque sensor, core eBike sensors do not significantly improve eBike performance, add new features, or differentiate eBike models and brands.

2) Automotive sensor usage has roughly doubled every decade, yet the number of sensors used in eBikes has remained nearly unchanged. While it's unlikely that eBikes can copy the high growth rate of auto sensor adoption, there is substantial opportunity to improve eBike performance by using more sensors.

3) Automobile sensor technologies have improved enormously and costs have dropped; eBike sensor technologies are almost unchanged and costs remain high, particularly for the torque sensor.

4) Sensor fusion, the combining of various sensor data in AI-like microprocessor algorithms to create new performance and feature enhancements, is common in automotive applications but is essentially non-existent in eBikes.

5) Automotive companies have controlled the design, timing, and marketing of sensor innovations. Sensor-based eBike features such as radar, tire pressure, and GPS, have primarily come from add-on accessories made by third-parties, *outside the control of the eBike manufacturer.*

New Sensors for eBikes

Applying auto sensor strategies to eBikes include four elements: 1) adding new sensors to eBike designs, focusing first on core eBike attributes such as motor response; 2) replacing legacy eBike sensors with lower cost alternatives; 3) creating algorithms that combine sensor data to deliver new, premium features; 4) customizing eBike performance by model/brand through proprietary microprocessor algorithms.

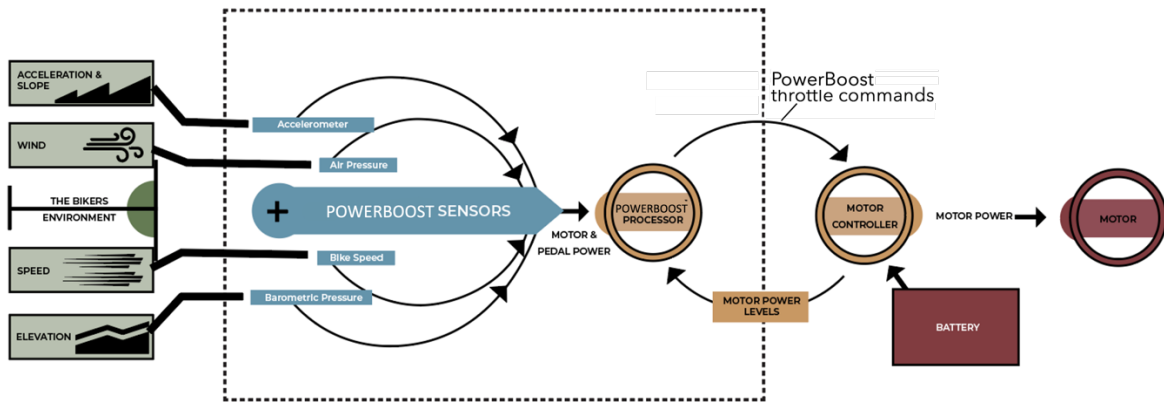
Velocomp LLC (www.velocomp.com) has applied all of these principles in its new PowerBoost[®] system for eBikes.

Velocomp has extensive experience in deploying sensor innovations in cycling. Velocomp disrupted the power meter category 21 years ago with its innovative, patented combination of

accelerometer, air pressure, and speed sensors, reducing the opening price point of bicycle power meters from \$1,500+ to \$299. Velocomp sensor data also enabled a generation of subsequent cycling innovations including left/right leg balance, drafting detection, and aerodynamic drag measurement, all based on firmware algorithm enhancements, *without additional BOM cost*.

Velocomp’s proven sensor innovations have now been implemented for eBikes in a newly-patented system called PowerBoost®. Accelerometer and air pressure sensors provide accurate, real-time environmental data including wind speed, hill slope, and bike acceleration. PowerBoost algorithms combine them to measure the total power opposing the forward motion of the eBike. Measured motor power, subtracted from the total opposing power, yields pedal power—the same pedal power measured by expensive torque sensors. *PowerBoost achieves torque sensor performance without using a torque sensor.*

POWERBOOST® block diagram



Torque sensor performance is not the only advantage achieved by PowerBoost sensors and algorithms. Other benefits are:

- PowerBoost’s reliable, solid-state sensors are produced in very high volumes for smartphone and industrial applications, making it possible to deliver torque sensor performance at a cost savings of \$20-\$40 per unit.
- PowerBoost requires no factory-floor installation and calibration, eliminating the time and cost associated with installing and calibrating torque sensors.
- PowerBoost’s handlebar location allows the same HMI to be used for any eBike design
- PowerBoost adjusts motor output dynamically, 20 times per second, to changes in slope, wind speed, and bike acceleration conditions, making eBike pedaling just like “normal” pedaling, *but easier*.
- PowerBoost adjusts the starting torque of the motor according to slope; steeper slopes cause higher starting motor torque, making start-up from rest easier for the cyclist.
- For cargo bikes, PowerBoost can automatically “weigh” the load being carried, adjusting the response of the cargo bike motor output automatically, as well as displaying the weight of the cargo on the HMI.

- PowerBoost can automatically put the motor into recuperation mode, allowing for efficient battery usage/recharging.
- Since PowerBoost sensors continuously measure environmental data, real-time slope and wind speed can be displayed on the HMI—giving cyclists a better understanding of the current ride conditions they are facing.
- eBike performance and behavior can be further customized by model and/or by brand through proprietary firmware changes resident in the HMI, not the controller.
- PowerBoost sensors are located in the handlebar HMI, away from the deluge of ground water and rain splashing on torque sensor water seals, and eliminating expensive warranty repairs when torque sensor seals fail.



PowerBoost is ready-for-market

AVS Mobility, long-time partner of Velocomp, has implemented PowerBoost sensors and technology in its “RC” line of HMI displays. Starting at around \$40, AVS handlebar-mounted HMIs provide conventional eBike control *and all PowerBoost functionality*. Integrated Bluetooth also allows setup and control from any smartphone, over-the-air firmware updates, and real-time display of environmental data including slope and wind speed.



LCD Version (RC10)



LED Version (RC9)



Logo Version (RC8)

eBike manufacturers can further customize the performance of any RC HMI through simple firmware modifications.

Summary

Buyers embrace cars having exciting electronic features and benefits and auto manufacturers have exploited this fact, using sensors to their great advantage and profit.

The eBike industry can learn from the successful sensor strategies of the automotive industry.

PowerBoost is a sensor-based, ready-for-market eBike system, enabling the next generation of *higher performance and lower cost eBikes*. PowerBoost has taken a page from the automotive playbook and implemented it on two wheels instead of four!

For more information about PowerBoost and AVS HMI displays, contact John Hamann, jhamann@velocomp.com, or Andreas Hoffmann, andreas@avs-electronics.com



PowerBoost

